**PROGRAMMED IMPROVEMENTS
OF THE
ALTERNATING GRADIENT SYNCHROTRON COMPLEX
AT
BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK**

ENVIRONMENTAL ASSESSMENT

MARCH 1994

U. S. DEPARTMENT OF ENERGY

DOE/EA #0909

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1.0 INTRODUCTION

Brookhaven National Laboratory (BNL) is a government owned, contractor operated high energy physics facility which was founded in 1947 to provide a center for nuclear science in the northeastern United States. In 1960, the Alternating Gradient Synchrotron (AGS) was developed and first operated at its full energy of 33 GeV for protons.¹ Originally developed as a proton accelerator, the AGS was adapted to accelerate heavy ions in addition to protons in 1986. Currently the AGS can accelerate protons at an intensity of 20 teraprotons (tp) to energies of 33 GeV and gold ions to 11.7 GeV per atomic mass unit. With these capabilities, the AGS is the only high intensity, high repetition, high energy proton accelerator in the United States and the highest energy accelerator for heavy ions in the world. The injection intensity available to the AGS since 1973 from the 200 MeV linear accelerator (LINAC) injection source has been 150 tp. The AGS lacks the ability to capture and accelerate this intensity, and beam loss and radiation burdens to personnel and equipment prevent operation at this intensity. In 1991, a facility called the AGS Booster was constructed to provide additional intensity capabilities to the AGS and allow the AGS to achieve energies for heavy ions that would permit injection into a relativistic heavy ion collider (RHIC), which is now under construction at BNL (see DOE/EA 0508 for further information). The RHIC accelerator is expected to operate at a maximum energy of 250 GeV for protons with an intensity of 15 tp and a maximum energy of 100 GeV per nucleon of gold at an intensity of 5.7×10^{10} nucleons per second.² Since installation of the AGS Booster, accelerated protons have, at maximum energy, achieved a beam intensity of 25 tp.³ However, technical factors including unacceptable beam loss have kept the average operations of the AGS to about 20 tp. One goal at BNL for AGS operations is to improve the efficiencies of the accelerator system to better utilize the available injection intensities of the 200 MeV LINAC.

High energy physics investigations of target collision products produced by the AGS complex have sought to improve scientific understanding of the basic structure and interactions of subatomic particles. Past improvements in the understanding of the structure of matter have lead to developments in the fields of nuclear medicine, chemistry, biology, and physics. In the field of nuclear physics, the heavy-ion research program has application in understanding the origin of the universe and in characterization of subatomic matter, and its the natural lead-in to the next generation of experiments to be performed at the RHIC. It is believed that better utilization of available intensities at the AGS complex would further assist in these scientific investigations.

2.0 PURPOSE AND NEED FOR ACTION

The purpose and need for DOE to undertake the actions described in this document are to improve the efficiency of the AGS complex. Benefits of this improved efficiency would include optimization of the AGS scientific program, increased high energy and nuclear physics experimentation, improved health and safety conditions for workers and users, reduced impact on the environment and the general public, energy conservation, decreased generation of hazardous and radioactive wastes, and completion of actions required to permit the AGS to be the injector to RHIC. Improved efficiency is defined as increasing the AGS's capabilities to capture and accelerate the proton intensity transferred to the AGS from the AGS Booster. Improved capture of beam intensity would reduce beam losses

which equate to lost scientific opportunity for study and increased potential for radiation doses to workers and the general public. The action would also refurbish magnets used in the transfer tunnel which connects the AGS Complex to RHIC to permit smooth injection of beam into the RHIC accelerator. These magnets were previously used to direct beam to fixed targets for high energy physics studies but have not received proper maintenance to be reliable as injectors to RHIC.

3.0 ALTERNATIVES UNDER CONSIDERATION

The following alternatives describe actions considered to address the need for action or are required to be reviewed in accordance with the National Environmental Policy Act (NEPA). Alternatives do not address the issue of decommissioning and decontamination of the AGS Complex. This issue would be addressed in a subsequent NEPA document when the scope of the issue can be clearly defined.

3.1 NO ACTION ALTERNATIVE

The No Action Alternative would continue AGS operations at present levels for the foreseeable future. Specific actions would include continuation of preventative maintenance and repair of operating components, where repair and maintenance actions do not upgrade operational capabilities or include efficiency improvements. No environment, health, or safety upgrades that have been previously identified would be completed since none of the identified deficiencies would require the facility to discontinue operation. Tasks that would be completed as routine maintenance are listed in regular print in Table 3-1, excluding those actions listed as safety improvements or environmental. Although actions are listed as upgrades, for the No Action alternative these actions would be limited to replacement of in-kind capabilities.

3.2 FACILITY MAINTENANCE WITH ENVIRONMENTAL AND SAFETY UPGRADES ALTERNATIVE

The Facility Maintenance with Environmental and Safety Upgrades Alternative (Maintenance Alternative) would continue AGS operations at present levels and maintain these capabilities for the next 30 years through maintenance of existing facilities where in-kind parts and/or services would be utilized, and safety and environmental upgrades would be completed to bring the AGS Complex into full compliance with applicable environmental, safety, and health regulations and requirements. The scope of this alternative would not permit the actions necessary to allow the AGS to act as an injector into the RHIC. Specific actions that would be completed under this alternative are listed in Table 3-1 in regular print. For each project listed as an upgrade, under this alternative these activities would be completed as routine maintenance to maintain normal machine operations with no operational improvements provided. These tasks are typically actions which would be categorically excluded actions under DOE's Rules Implementing NEPA, 10 CFR 1021, but are listed in this document for completeness and to assist in cumulative impact analysis.

3.3 PROPOSED ACTION

The Proposed Action would improve facility efficiency by upgrading existing AGS machinery to best match the AGS Booster, complete environment, safety, and health upgrades, and install the extraction/injection system through which the AGS would be capable of delivering protons or heavy ion beams to RHIC. Specific tasks that would be completed include all tasks listed in Table 3-1. Those tasks specific to the proposed action only are displayed in bold face print. These upgrades would support AGS operations for the next 30 years. Completion of these tasks would improve beam acceleration systems, beam control systems, beam monitoring systems, and beam extraction capabilities. These actions would also improve facilities used by the experimental community, provide general environment and safety upgrades, and improve general machine operations. The majority of the tasks listed in Table 3-1 would require the replacement of an existing component or system with an improved component. The bold faced action items typically would require the installation of new systems within the developed portion of the AGS Complex. The items listed constitute all reasonably foreseeable actions that would be taken within the AGS Complex from 1993 - 1999 as considered in the development of the BNL Institutional Plan. This list is not meant to be all inclusive as factors beyond current planning such as unforeseen component failures or new scientific breakthroughs could require similar, but not specifically listed actions.

3.4 RELOCATE INVESTIGATIONS TO OTHER FACILITIES ALTERNATIVE

Under this alternative, the Relocation Alternative, the AGS would discontinue operation and proceed immediately to decommissioning and decontamination while all experimental activities were relocated to other proton accelerator facilities. The accelerator complex at Fermi National Accelerator Laboratory would be the only potential candidate to conduct similar research. However, as stated in the introduction, the AGS Complex is the only accelerator system in the world capable of producing high energy, high intensity, and high repetition rate proton beams. The Fermi accelerator system is a high energy, high intensity, low repetition rate accelerator. To collect the necessary information to complete investigations, users would be required to increase data collection time, up to several years. This alternative was determined not to be a cost-effective utilization of available research funds and would not permit the operation of RHIC so it was dropped from further consideration.

3.5 NO MAINTENANCE ALTERNATIVE

The No Maintenance Alternative would continue AGS operations at current operating levels and capabilities with no facility maintenance or upgrades to meet operational, safety, or environmental requirements. Stated simply, the machine would continue to be operated, assuming continued support from the research community, until such a time that continued operation could no longer occur in a safe and environmentally responsible manner at which point the facility would be permanently shut down. Under this alternative operation, the AGS would be expected to last approximately five years. Since this scenario would not meet the needs of both the users of the AGS and the projected users of the RHIC, this alternative was dropped from further consideration.

TABLE 3-1: PROPOSED ACTIVITIES TO BE COMPLETED UNDER THE MAINTENANCE AND PROPOSED ACTION ALTERNATIVES

YEAR	ACTION TO BE COMPLETED	AFFECTED OPERATION
1993	RF Amplifier System Upgrade	Beam Acceleration
1993	RF Power Supply Upgrade	Beam Acceleration
1993	AGS Main Magnet Power Supply Cyclo-Converter	Beam Control
1993	RF Cavity Upgrade	Beam Acceleration
1993	H-10 Septum and Power Supply	Fast Beam Extraction
1993	AGS Longitudinal Damper and Ring Instrumentation	Beam Control
1993	Fast Gamma Transition Jump System	Beam Control
1994	LINAC RF Transmission Line Upgrade	Beam Acceleration
1994	AGS Main Magnet Power Supply Switch Gear & Control	Beam Control
1994	AGS Power Factor Improvement Phase II	Energy Conservation
1994	Electric Power Extension, North Area	User Operations
1994	Experimental Area Water Modification	User Operations
1994	Cooling Water Modification, AGS Buildings 911 & 913	AGS Operations
1994	Modernization of System Controls for Various Areas	User Operations
1994	Upgrade of Booster Electrical Power Service	Booster Operations
1994	AGS Timing Upgrade	Beam Control
1994	AGS Low Field Correction Power Supply Upgrade	Beam Control
1994	AGS Longitudinal Damper	Beam Control
1994	AGS Beam Dump and Scraper	Safety/Beam Control
1994	AGS Controls Network Modernization	Beam Control
1995	AGS Main Magnet Power Supply Switch Gear Upgrade	Beam Control
1995	AGS Ring Equipment Overhaul	Beam Control
1995	LINAC Instrumentation Upgrade	Beam Control
1995	Ring Utility House Equipment Overhaul	AGS Operations
1995	Vacuum Upgrade for Tune Meter and H-20 Septum	Beam Extraction
1995	LINAC RF High Power Anode Supplies	Beam Acceleration
1995	New AGS/Booster High Sensitivity Loss Monitors	Beam Monitoring
1996	Booster Power Supply Reactive Stabilization	Beam Control
1996	LINAC to Booster Line Beam Position Monitor Upgrade	Beam Monitoring
1996	Polarized Proton Slow Quadrupole Power Supplies	Beam Focusing
1996	AGS Ionization Profile Monitor Upgrade	Beam Monitoring
1996	Westinghouse Main Magnet Power Supply Upgrade	Beam Control
1996	Tandem Control	Beam Control
1996	Booster Injection Harps System Upgrade	Beam Monitoring
1996	Booster Injection Automatic Emittance Measurement	Beam Monitoring
1996	Electron Beam Ion Source	Ion Beam Production

TABLE 3-1: PROPOSED ACTIVITIES TO BE COMPLETED UNDER THE MAINTENANCE AND PROPOSED ACTION ALTERNATIVES (CONTINUED)

YEAR	ACTION TO BE COMPLETED	AFFECTED OPERATION
1997	Modernization of Wells	General Operation
1997	Insulate and Heat Building 936	General Operation
1997	Improvements to Building 914 Air Conditioning	General Operation
1997	Elimination of Open Cooling Systems	General Operation
1997	Neutralization Facility for De-Ionizer Regeneration	Environmental
1997	Experimental Area Smoke Detection Upgrade	Safety Improvement
1997	Waste Crusher for Radioactive Material	Environmental
1997	AGS Loss Monitor Electronics Upgrade	Beam Monitoring
1997	Automatic Electrical Safety System	Safety Improvement
1997	Slow Extraction System Instrumentation Upgrade	Beam Control
1997	Air Conditioning Power Distribution System Upgrade	General Operation
1997	Heavy Ion Pre-Accelerator	Beam Acceleration
1997	Heavy Ion RFQ	Beam Acceleration
1997	Target Cave B Shielding Upgrade	Personnel Protection
1998	Elimination of Open Cooling System, Users	User Operations
1998	Radioactive Material Storage Building	Safety Improvement
1998	Move Trailers From Experimental Area	Safety Improvement
1998	Sprinkler Protection, Building 975	Safety Improvement
1998	Remove Polystyrene Fire Hazards	Safety Improvement
1998	Westinghouse Motor Insulation Upgrade	Safety Improvement
1998	Westinghouse Motor Speed Control and Exciter Upgrade	Beam Control
1998	Westinghouse Motor Generator Switch Gear Upgrade	Beam Control
1998	H-20 Septum Upgrade for Efficient Beam Extraction	Beam Extraction
1998	AGS Beam Dump Kicker System	Personnel Protection
1999	Project/Experimental Setup Building	User Operations
1999	Improvements to Ring Air Conditioning	General Operations
1999	Fire Protection, Oil Filled Equipment at RF-MG	Safety Improvement
1999	Cable Tray Fire Protection Upgrade	Safety Improvement
1999	Fire Protection, Wooden Water Cooling Towers	Safety Improvement
1999	Fence Upgrade	Safety Improvement
1999	Westinghouse Motor Generator Lubrication and Cooling	Beam Control
1999	AGS Tune Meter Upgrade	Beam Monitoring
1999	LINAC Beam Analyses Section Upgrade	Beam Monitoring
1999	F-5 Extraction System Upgrade	Beam Extraction
1999	Intense Polarized Ion Source	Beam Production

4.0 AFFECTED ENVIRONMENT

4.1 GENERAL SITE DESCRIPTION

Brookhaven National Laboratory is a multi-disciplinary scientific research center located close to the geographical center of Suffolk County, New York approximately 97 kilometers east of New York City. About 1.32 million persons reside in Suffolk County, about 0.41 million of which reside in Brookhaven Township, within which the Laboratory is situated.⁴ Approximately 8,000 persons reside within 0.5 kilometers of the Laboratory boundary. Although much of the land area within a 16 kilometer radius remains either forested or cultivated, there has been continuing residential and commercial development near the Laboratory during recent years.

The BNL site consists of 21.3 square kilometers of mostly wooded habitats except for a clustered development area of about 6.7 square kilometers. Major facilities found in the developed portion of the site which support research efforts in such fields as high energy physics, nuclear physics, nuclear medicine, chemistry, biology, and ecology are a 60 Megawatt High Flux Beam Reactor, 3 Megawatt Medical Research Reactor, the National Synchrotron Light Source, the Tandem Van de Graaff, the Neutral Beam Test Facility, the AGS Complex, and the RHIC. Major facilities at BNL are highlighted in Figure 4-1. In addition, the facilities which compose or inject into the AGS Complex include the 200 MeV LINAC, AGS Booster, and AGS. The site terrain is gently rolling, with elevations varying between 13.3 and 36.6 meters above sea level.

4.2 AGS COMPLEX, THE PRINCIPAL PROJECT AREA

The AGS accelerator and experimental system are made up of four basic units: the particle injection source; the booster accelerating ring; the main accelerating ring; and experimental target areas. The injection source differs depending upon the particle to be accelerated. Protons are generated as negative hydrogen ions and injected into a radio frequency (rf) quadrupole and accelerated to 750 KeV. The protons are then injected into a 200 MeV LINAC which injects them into the AGS booster. Heavy ions up to gold are initially generated by a Tandem Van de Graaff facility. Particles leave this facility and traverse the 610 meter Tandem to Booster tunnel where they enter the AGS Booster, a 200 meter ring structure, which accelerates protons or higher mass ions for injection into the AGS. Once injected into the AGS, the particles are accelerated within an 800 meter ring, traveling the ring over 300,000 times per second to achieve maximum energy and approach the velocity of light (see Figure 4-2 for a display of BNL's accelerator complex). Particles are accelerated in the main ring in a vacuum chamber by 10 rf ferrite cavity devices spaced around the vacuum chamber providing an accelerating electric field in synchrony with the particles. Particles are maintained in proper orbits by a system of 240 magnet, each of dimensions 1.0 meter by 0.8 meters. The resulting beam of particles can then be deflected completely out of the ring into an experimental area. Typical investigations involve deflecting a beam into a target, generally a small piece of copper, and analyzing the secondary particles generated by the collisions.

The AGS complex includes 60 buildings which provide 56,662 square meters of working space, approximately 16.5% of the available space at BNL. Building

Figure 4-1: Major Facilities at Brookhaven National Laboratory.

Figure 4-2: Brookhaven National Laboratory Accelerator Complex.

construction includes concrete and steel housing. All AGS tunnel structures are of square concrete construction and equipped with radiation shielding consisting of a special concrete/soil mixture. Final earthen shielding atop accelerator tunnels is planted and maintained as herbaceous low growth area. Tree growth is discouraged in these areas since their root systems would compromise shielding of the tunnel and possibly reduce the effectiveness of the earth shield. The AGS complex also includes three supply wells which provide cooling water and recharge basins which receive non-contact cooling water discharges. The complex is located in the north western developed portion of the BNL reservation as displayed in Figures 4-3, 4-4, and 4-5. All AGS facilities were constructed on upland areas well above the 500 year floodplain with minimum depth to ground water near any facility to not less than 8 meters. Further information on the facilities which comprise the AGS complex are provided in Section 11.0.

4.3 BASELINE ENVIRONMENTAL CONDITIONS

The Laboratory lies on the western rim and headwaters of the Peconic River watershed.⁴ Land bordering the Peconic River is regulated by the New York State Department of Environmental Conservation (NYSDEC) up to 0.8 kilometers from the River's banks because of the River's designation under the NYSDEC's Wild, Scenic, and Recreational Rivers Systems Act. That portion of the river which traverses the BNL site has been categorized by the NYSDEC as "scenic." That portion of the Peconic River on BNL also supports a population of banded sunfish, Enneacanthus obesus, a New York State species of special concern. Freshwater wetlands in the north and east quadrants of the site remain in an area once part of a principal tributary to this river system. The Peconic River, wetlands, and other environmentally sensitive areas are identified in Figure 4-6. No wetlands are within the active AGS complex although a small fresh water wetland of approximately 600 square meters has naturally developed adjacent to the 200 MeV LINAC in Recharge Basin H0. This wetland was formed by the combination of paved area directed runoff, cooling water discharges, and a perched water table. The area supports hydrophytic vegetation but has no hydrologic connection to the Peconic River or associated wetlands.

Ground water in the vicinity of BNL moves in a southerly direction although the flow becomes somewhat easterly within the Peconic River watershed. Percolation occurs rapidly into the sandy sediments of the uppermost Pleistocene deposits underlying the Laboratory. The estimated rate of ground water velocity is 30 to 45 centimeters per day. Long Island's Upper Glacial Aquifer has been designated as a sole source aquifer by the Environmental Protection Agency (EPA). About half of Long Island's annual precipitation percolates through the soil to recharge ground water. The other half returns to the atmosphere via evaporation and evapotranspiration. Precipitation for 1992 totalled 115 centimeters, about 9 centimeters below Long Island's last 40 year annual average.⁴

A variety of fish and wildlife habitats can be found at BNL because of its relative lack of development and its location within a river corridor. The predominant oak/pine forest community offers excellent feeding, resting, and nesting opportunities for many species of migratory songbirds. Small mammals common to the northeast can be found in the grasslands and forest edges. Despite the Laboratory's predominantly natural environment, except for occasional transient individuals, no New York State or federally listed or proposed

Figure 4-3: General Location of the Alternating Gradient Synchrotron at Brookhaven National Laboratory

0 600 1200 FT.

Figure 4-4: Alternating Gradient Synchrotron Department Buildings and Tunnels.

Figure 4-5: Plan View of the Alternating Gradient Synchrotron Facilities.

Figure 4-6: Environmentally Sensitive
Areas at Brookhaven
National Laboratory

threatened or endangered species have been observed on site as confirmed in past correspondences with Mr. David Stillwell of the U.S. Fish and Wildlife Service and Ms Nancy Davis-Ricci of the NYSDEC (see Section 12.0).^{5,6} Consultation specific to this project is in process. However, since no new species in the project impact area have been listed or proposed for listing, no impacts to Federal or New York State threatened or endangered species are anticipated.

Representatives of the New York State Historic Preservation Office toured BNL on June 27, 1990. The only areas of historic and/or archaeological significance identified during this field survey were remnant World War I training trenches located immediately north of BNL's Sewage Treatment Plant, the Old Cyclotron Enclosure, and the Old Reactor Building associated with the former Brookhaven Graphite Reactor (see Section 12.0).⁷ None of these areas make up the AGS complex.

4.4 BASELINE ENVIRONMENTAL RELEASES

An environmental report on BNL is prepared annually and made available to the general public. This document provides the results of all environmental monitoring and compliance activities completed. The information in the 1992 site environmental report is summarized here. This report is available for review should additional, detailed information be of interest to the reader.⁴

4.4.1 Radiological Releases

Airborne radioactive effluents at BNL originate predominantly from the Medical Research Reactor, Brookhaven Linac Isotope Production Facility (BLIP), and High Flux Beam Reactor. In 1992, these facilities released 1,490 curies of argon-41, 797 curies of oxygen-15, and 70 curies of tritium. The oxygen-15 releases can also be attributed to the 200 MeV LINAC which provides beam to the BLIP. Of these releases, only tritium is detected at the site boundary where concentrations of 2.7 picocuries per cubic meter were detected in 1992. This concentration resulted in a calculated committed effect dose equivalent of 0.0021 millirem for the maximally exposed individual at the site boundary. Total dose calculated to a resident of the site boundary from the air pathway for 1992 was 0.1 millirem.

Liquid radioactive releases occur from the discharge of BNL's Sewage Treatment Plant (STP) to the Peconic River and from discharges to BNL recharge basins. In 1992 the radionuclides released by the STP were 2.96 curies of tritium, 2.17 millicuries of cesium-137, and 0.067 millicuries of cobalt-60. This discharge resulted in a calculated committed effective dose equivalent to the maximum exposure person residing at the site boundary of 0.04 millirem. Trace quantities of radioactivity were also discharged to BNL's recharge basins. Direct ingestion of recharge water as the sole drinking water source would have resulted in a calculated dose of 0.019 millirem. The on-site potable well system contained average tritium concentrations of, at, or below the maximum detection limit of 300 picocuries per liter, average strontium-90 concentrations of less than 2.08 picocuries per liter, and average cobalt-60 concentrations of 0.13 picocuries per liter. These concentrations resulted in a calculated dose of 0.003 millirem to the maximally effected on-site individual.

Soil, vegetation, fish, and faunal surveys were also conducted in 1992. General soil and vegetation radionuclide concentrations were not discernable from similar control samples collected in Suffolk County. Faunal and fish surveys disclosed presence of the radionuclides cesium-137 and strontium-90 above background levels in the areas of the Hazardous Waste Management Facility, recharge basins, and the Peconic River. None of these radionuclides are attributable to AGS operations. Total dose to the maximally effected individual from the ingestion of fish was calculated to be 0.87 millirem in 1992 (this is a hypothetical pathway since no consumption of fish found on the BNL site occurs). The 1992 collective committed effective dose-equivalent attributable to BNL operations for the population within 80 kilometers was calculated to be 2.6 person-rem. The maximum individual dose equivalent was determined to be 1.01 millirem. By comparison, cosmic and terrestrial sources would produce a dose of about 60 millirem.

4.4.2 Nonradiological Releases

Surface water samples collected from the Peconic River showed that all water quality parameters, anions, metals, and volatile organic compounds were consistent with control data from the Carmans River, a river system located immediately west of BNL but outside of BNL's environmental influence. Silver, cadmium, chromium, copper, and mercury were not detected in any sample analyzed. Trace quantities of lead (to 0.004 milligrams per liter), manganese (0.14 milligrams per liter), and zinc (0.05 milligrams per liter) were found. Iron is prevalent in potable water removed from the western portion of the site because of naturally high iron contents of ground water (up to 17.5 milligrams per liter). Water is treated at BNL's Water Treatment Plant prior to use and subsequent disposal. The flocculation and aeration processes at the Water Treatment Plant also remove trace quantities of trichloroethane present in Potable Well Number 4. Trichloroethane is also present in Potable Wells 10 and 11 but the use of carbon filtration units reduces this concentration to below the drinking water standard of five parts per billion. No releases of trichloroethane can be attributed to AGS activities.

5.0 ENVIRONMENTAL IMPACTS OF THE PROPOSED ACTION AND ALTERNATIVES

Environmental impact is an important criterion used in the alternatives selection process. Environmental concerns associated with the actions under consideration are discussed as impacts from construction activities and impacts from operations. Categories analyzed for potential impact associated with construction activities proposed include land use and ecology, environmental releases, archaeological resources, waste generation, and radiation exposures. Categories analyzed for potential impact associated with operations include water quality including ground water impacts, air emissions, radiation and radionuclide generation, and exposures including health effects and abnormal events, waste generation, and cumulative impacts.

5.1 IMPACTS FROM CONSTRUCTION

Under the No Action Alternative and Maintenance Alternative, similar construction activities would be conducted so impacts associated with these alternatives are discussed as being equal in this section. The primary difference between the Maintenance Alternative and the Proposed Action is the optimization of the replacement components for improved efficiency. Routine maintenance and safety upgrades would be conducted in similar fashions. The

issues associated with construction efforts for the Maintenance and Proposed Action Alternatives are related to changes in quantities of domestic, hazardous, and radioactive waste. The total volume of waste generated under either alternative would be similar.

5.1.1 Land Use and Ecological Disturbance

Under the No Action, Maintenance, and Proposed Action Alternatives, construction activities would be limited to efforts within existing facilities. In some instances such as utility upgrades, trenching operations could be required to install new utility lines while maintaining service with existing utility lines. These work areas would typically occur within the right-of-way of existing utilities and would excavate in previously disturbed areas. All excavated areas would be returned to pre-project conditions.

An investigation was conducted of a proposed excavation area adjacent to an AGS beam-line in August 1992. Soil samples collected contained naturally occurring radionuclides potassium-40, radium-226, and thorium-228 and the man-made radionuclides sodium-22, cobalt-57, cobalt-60, and europium-152. Concentrations present were not sufficient to warrant concern associated with direct exposure and ingestion pathways. Calculations were completed to determine impacts to the affected worker that would be present at the excavation site for inhalation of air containing dust of soil origin. It was determined that the committed dose equivalent rate to the maximally effected individual would be 0.00001 millirem per hour, all of which would be derived from naturally occurring thorium-228. The maximally affected individual would receive approximately 0.02 millirem per year. Using the International Commission on Radiological Protection (ICRP) and National Academy of Sciences (NAS) methods of risk prediction, the additional risk of a worker to contract a fatal cancer would be less than 2 chances in 100,000,000 or 0.000002% per year.^{6,9} Based upon this risk assessment, all soil disturbed during excavation would have no restrictions on future use and would likely remain on location for use as backfill.

5.1.2 Environmental Releases

Construction efforts would not result in the discharge of process effluents or emissions to the environment under the No Action, Maintenance, or Proposed Action Alternatives. The majority of construction efforts would concentrate on the change out of old equipment. To complete this effort a variety of power tools, hydraulic lifting equipment, and other rigging apparatus would be utilized. Despite routine maintenance, occasionally hydraulic equipment could leak hydraulic and/or lubricating fluids due to the pressure placed upon mechanical components. Should such a leak occur, BNL personnel would follow Laboratory procedures to respond promptly to a release and clean up the release to prevent discharge to environmentally sensitive areas such as wetlands or ground water. Maintenance of equipment would also limit exhaust emissions and noise from operating motors to within normal construction practices.

5.1.3 Waste Generation

From 1989 to 1992, the AGS facilities have annually generated approximately 1,520 cubic meters of compressed garbage, 760 cubic meters of construction debris, 72 cubic meters of low level radioactive waste, and 5 cubic meters of other hazardous wastes mainly in the form of used oils such as vacuum pump oil. There would be no worker or public exposures associated with these small quantities of hazardous wastes. Under the No Action and Maintenance Alternatives this trend would be expected to continue. Under the Proposed Action Alternative the amount of lost beam would be reduced for maximum operating intensities and energies from 25% to 3%. This would translate into a reduction of low level radioactive waste generation because the reduction of equipment exposures would decrease the frequency with which the equipment would require replacement. This reduction of radioactive waste has an important economic impact to BNL operations since radioactive waste disposal costs are currently 270 times greater than nonradioactive waste disposal costs. Over time, total volume of radioactive waste generated would decrease by up to 20% as equipment maintains its reliability due to decreased radiation exposure.

Under the No Action, Maintenance, and Proposed Action Alternatives component changeouts would generate hazardous waste as a one time generation. Replacement of power supplies would require the removal of capacitors containing polychlorinated biphenyls (PCBs). Because the manufacture and commercial resale of PCBs and PCB containing products was banned by the Toxic Substances Control Act in 1979, replacement components under both alternatives would not contain PCBs. The removed equipment would generate approximately 40,000 kilograms of PCB waste. Also, rf systems in the AGS now utilize freon. The Clean Air Act Amendments require the phase out of freon so under each alternative, approximately 210 liters of freon would be removed and disposed off-site at an approved facility.

5.1.4 Radiation Exposure to Occupational Workers and the Public

Since the early 1970s the major portion of the AGS radiation burden has been associated with equipment failures and maintenance. Substantial effort and expense have been committed to improving the operational reliability and serviceability of beam-line components and this continues to be effective in reducing the radiation burden. In 1973, when fewer protons were accelerated at an intensity of 1 tp, the AGS Department radiation workers (maintenance workers and experimenters) incurred 575 person-rem from working on equipment.¹⁰ During 1992 more protons were accelerated at an intensity of 17 tp, yet only about 25 person-rem were incurred during operation, maintenance, and beam-line refurbishing activities.¹⁰ Under the No Action and Maintenance Alternatives the AGS would expect to maintain the current level of incurred doses to radiation workers at 25 person-rem per year. The proposed action would improve proton intensity to 60 tp and increase component reliability. In addition, proton losses into beam-line components would decrease and equipment failures would be reduced. Thus, radiation exposures experienced by maintenance workers would be reduced to 10 - 15 person-rem per year.

The public, including BNL nonradiation workers, are not permitted to enter areas containing beam-line components where radiation exposures can be incurred. Under some situations, nonradiation workers can be escorted into these areas by trained personnel that would limit exposures of nonradiation personnel by practicing time and distance protection practices. Removed radioactive beam-line components are packaged at the AGS and shipped to BNL's Hazardous Waste Management Facility where they are stored pending final disposal at the DOE/Westinghouse Hanford Facility in Richland, Washington. Removed components are shipped and would continue to be shipped in accordance with DOE and Department of Transportation (DOT) requirements/regulations. These regulations require the exposure of any occupied space not to exceed 2 millirem per hour. Surveys of the cab of the truck loaded at BNL for transport to Richland, Washington, typically show that exposure in the cab is less than 0.5 millirem per hour. On the average, BNL transports 27 truckloads of radioactive waste (current generation plus backlog) annually, 60% of which is generated by AGS, to Richland. The driver is permitted five business days to complete delivery of the material. Assuming the driver makes all 27 deliveries and does not leave the truck during the five days the waste is transported, the driver would incur 972 millirem per year related to delivery of AGS radioactive wastes. Such a dose over a 30 year career would increase the average persons potential for contracting a fatal cancer by 2.4%. However, given the scheduling of shipment, the frequency of shipping, and the use of several contractors to complete shipments, it is highly unlikely that the same driver would be used more than four times annually at most, resulting in a 3 in 1000 (0.3%) increased potential of that person to contract a fatal cancer.

5.2 IMPACTS FROM OPERATIONS

Under the No Action, Maintenance, and Proposed Action Alternatives, the AGS Complex would be presumed to continue operations for up to 30 years.

5.2.1 Water Quality

Impacts on water quality can be examined in terms of discharges to recharge basins, extraction of ground water, and contamination of ground water.

5.2.1.1 Water Discharges

In 1992, the AGS Complex discharged 5.2 million liters per day (MLD) of noncontact cooling water to recharge basins. Recharge Basin NO received 3.26 MLD and Recharge Basin HN received 1.94 MLD.⁴ Waters discharged contained a polyelectrolyte and a dispersant, chemical additives used to maintain iron in solution thus preventing the clogging of heat exchangers. These discharges are authorized under BNL's New York State Pollutant Discharge Elimination System (SPDES) Permit #0005835 issued by the NYSDEC. Analysis of these recharge basins disclosed trace quantities of radioactivity in the form of beryllium-7 and manganese-54 discharged to Basin HN that can be associated with AGS operations. The average concentrations found were 23.4 picocuries per liter for beryllium-7 and 0.32 picocuries per liter for manganese-54. The source of these radionuclides is suspected to be the result of high energy particle interactions in closed-loop cooling water of AGS and LINAC facilities

and activated components experiencing corrosion and subsequent loss of corroded material in discharges. Radioactivity is known to occur in 13 of the 21 closed cooling water systems in operation at the AGS. If a person utilized Basin HN as a sole source of drinking water (this basin is not used as a potable water supply), the person would have experienced a committed effective dose equivalent of 0.003 millirem for 1992. Discharges generated in 1992 were based upon 8 weeks of AGS operations. Under the No Action, Maintenance, and Proposed Action Alternatives, operations are expected to be maintained at approximately 20 weeks per year. Discharges of beryllium-7 and manganese-54 would be expected to increase to approximately 60 and 0.8 picocuries per liter, respectively. These discharges would produce an annual committed effective dose equivalent of 0.006 millirem from beryllium-7 and 0.002 from manganese-54 for a total of 0.008 millirem to the affected individual. Using the ICRP and NAS methods of risk prediction, the additional risk an affected individual would run in contracting a fatal cancer would be 9 chances in one billion. This dose rate is well below the Safe Drinking Water Act standard of 4 millirem.

In addition to beryllium-7 and manganese-54, radionuclides detected in past AGS cooling water releases include tritium, sodium-22, and zinc-65. All AGS releases from cooling systems are contained and sampled prior to discharge under current operations. Water that complies with New York State Ambient Water Quality Standards and Safe Drinking Water Act standards for discharge is released to Recharge Basins HN or HT. If radionuclide presence in cooling water requires restricting discharge to the environment, the water is collected and piped or trucked to BNL's Waste Concentration Facility where it is distilled to reduce volume, and solidified for storage at BNL's Hazardous Waste Management Facility pending final disposal at an approved DOE facility. This practice would continue under all alternatives considered. The BNL Hazardous Waste Management Facility has been equipped with secondary storage sheds so both adequate space and containment is available for both present and future distilled and solidified radionuclide containing water, generated at an expected rate of 10 cubic meters per year.

The AGS also releases approximately 60,000 liters of water per year used to regenerate ion exchange columns which purify cooling systems, 10 to 20 liters of water per day from accumulated compressor condensates, and floor drains which have the potential to receive hundreds of liters of water from failed equipment.¹⁰ Floor drains are connected to sumps which are alarmed and manually pumped-out into tanks for sampling and proper disposal. No water is pumped directly to drainage rings or the site sanitary system unless it is sampled and approved for discharge under BNL's SPDES permit. The ion exchange effluent may contain metals such as copper, iron, and aluminum, and some slight radioactivity as reported in the preceding paragraphs. The primary water from cooling systems may contain metals, radioactivity, or oil contamination, but these systems are closed, and sampled prior to release. This sampling is done as required as opposed to the release of noncontact cooling water which receives only periodic sampling for characterization purposes. All of these discharges are expected to be the same for all alternatives under consideration during operations.

5.2.1.2 Extraction of Ground Water

The AGS complex utilized 5.2 MLD of water for operations or 33% of the 15.91 MLD pumped by BNL in 1992. The calculated margin of safe yield that can be extracted by BNL from the underlying aquifer is 19.7 MLD.⁴ The AGS well system is capable of pumping up to 9.0 MLD. Because the AGS is serviced with a closed loop cooling system, essentially all of the water pumped for AGS cooling purposes is returned to the aquifer through discharge to Recharge Basins HN and HO. Therefore the AGS has no net effect on the Margin of Safe Yield available in the aquifer under all alternatives under consideration.

Operation of the AGS wells impacts ground water directional flow. When the AGS is not operating, the ground water flow at BNL is in a southeasterly direction. The AGS well fields, located in the western portion of the property and west of the influences of other BNL wells and the Peconic River, tend to rotate ground water flow to the south when operating. The primary impact of this action is not directly related to the AGS but environmental concerns in different areas of BNL. Several sources of ground water contamination have been found on the BNL facility, most associated with past practices at BNL's Central Steam Facility, Sewage Treatment Plant, Hazardous Waste Management Facility, and Landfills.¹¹ With ground water flow direction varied, it increases the difficulty of containing plumes of contaminated ground water on the BNL reservation. This circumstance would continue for all alternatives during operations. Variability in operation of BNL's potable well system would impact plume delineation regardless of AGS well operations. Continued generation and storage of hazardous waste at BNL's Hazardous Waste Management Facility does not impact contamination related to past practices. The installation of self-contained secondary storage sheds and a sealed concrete floored building, complete with secondary containment, have eliminated the potential for new environmental releases.

5.2.1.3 Contamination of Ground Water

Many of the secondary particles created near the beam targets are stopped in the soil below the target caves. These radiations interact with the nuclei of silicon and oxygen atoms present in the soil. The types of radionuclides created by these processes are tritium, beryllium-7, carbon-11, nitrogen-13, oxygen-15, and sodium-22.¹⁰ Once present in the soil, these radionuclides move downward to the ground water by traveling with rain water. The rain water joins the ground water and moves to the site boundary. Because the percolation and assimilation in ground water of radionuclides takes months to occur, only the longer lived radionuclides, tritium (half life of 12.3 years) and sodium-22 (half life of 2.6 years) contribute to potential exposure of the BNL and general public populations through ingestion of radiologically contaminated ground water.

For the 1992/1993 running period, an average of 5×10^{12} protons per second were available during the 8 week period of operation with a total of approximately 1.3×10^{19} protons being accelerated.¹⁰ The beam distribution listed in Table 5-1 occurred between targets, and the calculated annual average on-site and off-site soil-water activity concentrations are presented. Based on the dispersion equation given by Till, the calculated off-site

contamination in ground water contributed by the generation of tritium and sodium-22 radionuclides is reported.¹² These are worst case values using Target Cave B as the generation point for the No Action Alternative. Assuming 100% consumption of water by a person residing at the site boundary from a well at the site boundary, this release would result in an off-site dose of approximately 0.000008 millirem per year or 0.0002% of the Safe Drinking Water Act standard of 4 millirem per year

Table 5-1 Potential Contamination in Ground Water

Target Cave or Loss Point (Proton Energy)	Proton Loss or Protons on Target for FY93	Annual Average Tritium Conc. in Soil Water Near Loss Point	% of DOE ALARA Guide for Tritium	Annual Average Sodium-22 Conc. in Soil Water Near Loss Point	% of DOE ALARA Guide for Sodium-22	Annual Average Tritium Conc. in Ground Water Off-site	% of EPA or NYS Standard for Tritium	Annual Average Sodium-22 Conc. in Ground Water Off-site	% of EPA or NYS Standard for Sodium-22
	# of Protons	pCi/L	%	pCi/L	%	pCi/L	%	pCi/L	%
Injection (1.5 GeV)	4E+16	2E+04	2E-01	2E+03	4E+00	3E-02	1E-04	6E-02	2E-03
Transition (7 GeV)	6E+16	1E+02	1E-03	2E+01	4E-02	1E-04	7E-07	4E-07	1E-07
Extraction (24 GeV)	2E+17	1E+03	1E-02	2E+02	4E-01	1E-03	7E-06	4E-06	1E-06
Studies (10 GeV)	2E+16	4E+03	4E-02	4E+02	6E-01	5E-03	3E-05	2E-05	4E-06
A (24 GeV)	5E+17	2E+04	2E-01	3E+03	6E+00	3E-02	1E-04	6E-05	2E-05
B (24 GeV)	3E+16	1E+05	1E+00	1E+04	2E+01	1E-01	7E-04	4E-04	1E-04
C (24 GeV)	4E+16	3E+04	3E-01	4E+03	6E+00	4E-02	2E-04	1E-04	3E-05
D (24 GeV)	4E+16	1E+03	1E-02	2E+03	4E+00	1E-03	7E-06	4E-06	1E-06

and 0.02% of BNL's total impact through ground water ingestion. From the ICRP and NAS risk prediction model, this exposure would increase the maximally affected individuals chances of contracting a fatal cancer by 6 chances in 1,000,000,000,000 (one trillion). For the No Action and Maintenance Alternatives, all parameters would remain constant except the run period which would increase to 20 weeks, the normal operating period for the AGS. The subsequent increase in dose to the maximally affected individual would be increased 250% to 0.00002 millirem per year. This exposure would increase the chances of this individual contracting a fatal cancer by 2 chances in 100,000,000,000 (one hundred billion).

Under the Proposed Action Alternative, the run period would also increase to 20 weeks and the beam intensity would increase from 15 tp to 60 tp. However, beam losses would be cut from 25% to 3%. This would result in a subsequent dose to the maximally affected individual of 0.00001 millirem per year. This exposure would increase the chances of this individual contracting a fatal cancer by 1 chance in 100,000,000,000 (one hundred billion).

The DOE Order 5400.5 limits for tritium and sodium-22 are 1×10^7 picocuries per liter and 5×10^4 picocuries per liter, respectively. An exposure at these respective limits would produce a dose rate (no pathway identified) to an individual of 500 millirem per year and create a 1 chance in 20 of that person contracting a fatal cancer for a 30 year AGS lifetime. On the basis of Table 5-1, Target Cave B was at 20% of the DOE limit for sodium-22 for conditions relative to the No Action Alternative but was not operated at full intensity. Should Target Cave B receive full energy and intensity available under any of the alternatives proposed, this facility would exceed the DOE limit for sodium-22. To avoid this situation under the No Action and Maintenance Alternatives, the AGS Department would continue to use administrative controls to limit sodium-22 generation in ground water. Under the Proposed Action, additional shielding would be installed at Target Cave B so that in the event user demand for additional beamlines receiving high intensity beam is realized, Target Cave B could service this need. With additional shielding in place, generation of sodium-22 would be expected to be similar to that presently calculated for Target Caves C and D, or 8% of the current limit. At the site boundary this would calculate to a dose of 0.00000004 millirem annually to the maximally affected individual, billions of times below what can be measured in terms of public health impacts.

On the basis of a dilution model by Till, the maximum concentrations of sodium-22 and tritium that would reach the closest well on site are 2 pCi/L and 100 pCi/L, respectively under the No Action and Maintenance Alternatives. The on-site potable wells are located upgradient of the ground water flow pattern estimated to be applicable to the areas beneath the AGS Complex and are at a minimum distance of about 200 meters from any specific target cave or loss point. Assuming 100% consumption of water from this well by an on-site person, this release would result in an on-site dose of approximately 0.04 millirem per year which is 100 times below Safe Drinking Water Act standard of 4 millirem per year. According to the site baseline information provided in Section 4.4.1, only tritium was detected in on-site potable supply wells. Given this information and the half life of sodium-22, it is probable that the contamination viewed in on-site potable supply wells does not originate from the AGS.

5.2.2 Air Emissions

Air emissions can be reviewed in terms of nonradioactive air emissions and potential radioactive air emissions. Nonradioactive air emissions are generated primarily from activities which support machine operations radioactive air emissions are directly related to air activation products originating from accelerator and user activities.

5.2.2.1 Nonradioactive Air Emissions

The AGS Complex operates machinery which generate point source air emissions. Eleven of these air emission points currently possess or have pending authorization from the NYSDEC under 6 New York Code of Rules and Regulations 201.⁵ These air emissions are related to the following processes: blueprint generation; spray painting; soldering; degreasing; sand blasting; cutting; electroplating; and magnet curation. Emitted materials include ammonia, volatile organics, silver solder, inorganic acids, and particulates. All facilities are operated within permitted levels and are believed to have no synergistic impact on the surrounding environment. Permitted processes make up approximately 15% of the permitted air emission points at BNL. Emissions from these sources is expected to remain constant for all alternatives as emissions are related to facility maintenance rather than user request. After 5 years these releases would probably not occur under the No Action Alternative.

5.2.2.2 Radioactive Air Emissions

The secondary particles produced by beam losses interact with the nuclei of nitrogen, oxygen, or argon atoms in air to produce small amounts of radioactivity. Ventilation does not routinely occur at the AGS Complex during normal running periods and would be used only in the event of an emergency; short-lived airborne radioactivity is normally left to decay *in situ*.

Table 5-2 gives the maximum off-site dose equivalent and activity concentration for each radionuclide of interest under the Proposed Action. The very short-lived radionuclides nitrogen-13, oxygen-14, oxygen-15, and aluminum-28 would be removed from air due to decay in transit to the site boundary. The values in Table 5-2 would reflect the total proposed output of the AGS under the Proposed Action Alternative. Details of the calculation are given in the AGS Safety Analysis Report.¹³ The dose for a 20-week running period is indicated; however, the calculated off-site dose estimates are greatly overestimated; given use of the following assumptions: 1) the AGS operates such that ventilation is on and contaminated air is released; 2) weather conditions optimize for 20 weeks to the greatest level of off-site dose; and 3) a constant wind direction occurs for 20 weeks.¹⁴

For energy conservation, air is recirculated rather than continuously exhausted which allows for decay of very short-lived radionuclides. However, for purposes of this calculation only, air is assumed to be completely released outdoors through the ventilation system, which would be against operating procedure. This provides an upper estimate of potential airborne environmental release.

Table 5-2: Projected Air Activation, Releases, and Dose Off Site from Operation of the AGS Under Proposed Action Maximum Intensities and Energies¹⁰

Nuclide	Half-Life	Tunnel Activity Release Rate ($\mu\text{Ci}/\text{yr}$)	Maximum Off-Site Conc. ($\mu\text{Ci}/\text{cm}^3$)	Maximum Off-Site Dose Equivalent mrem
Tritium	12.3 yr	1.7E-03	1.7E-13	7E-05
Beryllium-7	53.3 d	3.3E-02	3.3E-12	3E-03
Carbon-11	20.4 min	7.3E+01	7.5E-09	2E-01
Sodium-22	2.6 yr	6.7E-06	6.7E-16	2E-05
Phosphorous-32	14.3 d	1.7E-03	1.7E-13	7E-03
Sulfur-35	87.0 d	2.5E-04	2.5E-14	3E-05
Argon-41	1.8 hr	5.0E+00	5.0E-10	8E-02

Immediately after machine operation, the radioactivity concentrations in air inside the target areas of beam lines translates into several hundred millirem per hour for immersion in a cloud of nitrogen-13 and oxygen-15, but these radionuclides decay quickly so that protective measures for the expected air-induced activity are not necessary. A 15-minute delay before entering the target area is required under AGS operating procedure to permit decay of short lived radionuclides. After this period, entrance is permitted only under emergency conditions and with health physics professionals monitoring. Typically, entrance into these areas only occurs several days after shutdown and work occurs several months after machine operation to conduct refurbishment operations.

5.2.3 Radiation and Radionuclides

There are no worker or public exposures to non-ionizing radiation such as rf since these exposures are designed out using appropriate construction techniques. There are low-level exposures to the more penetrating ionizing radiations and these are discussed in detail.

5.2.3.1 Direct Radiation

Although the Laboratory site is considered to be a limited access facility, service personnel from off site and BNL nonradiation workers may work or visit near the AGS. Laboratory policy for such personnel is to restrict the annual dose to less than 25 millirem per year or 2% of the DOE limit of 500 millirem per year to the maximally affected nonradiation worker/visitor.¹⁵ For off-site personnel the Laboratory limit is reduced to 5 millirem or 5% of the DOE allowable limit of 100 millirem from all pathways.¹⁵ Sources of radiation exposures to laboratory and off-site personnel would be derived from neutrons and photons. High energy neutrons emerge from the top of the shield and

contribute to the dose equivalent on the ground several hundred to several thousand meters away through interactions in the air column above the shield. These high-energy particle interactions in the air above the accelerators and target caves produce lower-energy neutrons and photons which can interact back at the surface. This is known as "sky shine" radiation.

To determine if the existing shielding would be sufficient to meet laboratory policy limits for all alternatives under consideration, the following assumptions were used to calculate the necessary shielding thickness dictated by the policy:

- 1) An annual total of 2.4×10^{20} protons would be accelerated at an average intensity of 60 tp for 20 weeks (this is the maximum planned annual proton run for the foreseeable future under the proposed action),
- 2) Upward neutrons from a point source of protons would emerge from a shield surface area of 1.9×10^6 square centimeters. The effective area of the neutron emission was measured using plots of measured radiation levels versus position both transversely and longitudinally outside the shield top.¹⁶

On the basis of these assumptions, the laboratory policy limits would be met by ensuring that the planned locations for beam loss have at least 300 centimeters of heavy concrete above them, or the equivalent thickness of other materials. Currently, the experimental areas are typically shielded with at least 360 centimeters of heavy concrete over target caves and over the switchyard. On the basis of these thicknesses, the AGS experimental areas are designed presently to produce exposures that would be less than 10% of the Laboratory policy limits under the Proposed Action Alternative and approximately 3% of Laboratory policy limits under the No Action and Maintenance Alternatives. To protect AGS staff, close-in radiation levels dictate the thickness of shield. Thus, shield thickness in use at AGS would normally be greater than the minimum thickness needed to protect the public.

Figure 5-1 displays the annual dose from "sky shine" radiation as a function of distance from the proton losses in the AGS Ring under the proposed action. One-third of these annual doses apply to the No Action and Maintenance Alternatives. Personnel working at close distances are not located in offices any closer than 100 meters relative to the location of these losses in the AGS Ring. Most site personnel are located beyond 500 meters, and the site boundary is approximately 1,400 meters distant at its closest point. Details regarding the Figure are given in the AGS Safety Analysis Report.¹³

5.2.3.2 Activation of Materials

Stopping high-energy particles can initiate sub-microscopic reactions in beam pipes, magnets, targets, and the beam stops. These interactions produce secondary particles such as neutrons, protons, and pions. At each interaction point, the nuclei of atoms struck by the high-energy primary or secondary particles fragment resulting in a range of lower mass nuclei, some of which are radioactive. Some particles are absorbed by the struck nuclei, changing the mass of the struck nucleus making it unstable or radioactive.

Figure 5-1: Annual Sky Shine Dose Equivalent Versus Distance from the AGS Ring.

The materials used in construction of the AGS experimental areas are limited in number, the most important being iron, steel, copper, aluminum, concrete, oil, and plastic. These metals and materials are generally not used in their pure form; that is, they have welds, or they are alloyed with other metals, or they are parts of beam-line components. Thus, irradiation produces a variety of radionuclides in any given accelerator item. On the basis of recent studies on the AGS radioactive waste stream, nuclides ranging in half life from days to years are formed in these materials and are reported in Table 5-3.

Measurements made over the last three years indicate the activity concentration in the waste removed from experimental areas has ranged from 1 to 5 nanocuries per gram. After several months of decay, the predominant and longest-lived nuclide was cobalt-60. This radionuclide has a half-life of 5.3 years.

Studies of beam loss and the resulting production of radioactivity at the AGS Ring have provided a prescription to predict the residual exposure rate resulting from the decay of this mix of radionuclides in iron and copper. The following exposure rates in Table 5-4 would be typical following the end of a 20-week running period at the AGS for all alternatives under consideration. Normally, the AGS Department experiences a long shutdown period of 4 to 8 months between running periods. During this period, irradiated targets are placed in shields in order to prevent unnecessary exposure.

Table 5-3: Radionuclides Produced During Irradiation of Accelerator Components

Nuclide	Irradiated Material				
	Plastic/Oil	Concrete	Aluminum	Iron/Steel	Copper
Beryllium-7	X	X	X	X	X
Sodium-22	X	X	X	X	X
Scandium-46	X	X		X	
Manganese-54	X	X	X	X	X
Cobalt-56				X	
Cobalt-57	X	X	X	X	X
Cobalt-58		X	X		X
Iron-59				X	
Cobalt-60	X	X	X	X	X
Zinc-65		X	X	X	X
Gallium-68	X		X	X	X
Selenium-75				X	
Zirconium-88	X				
Niobium-95m			X	X	
Silver-110m		X	X	X	X
Tin-113	X			X	
Antimony-124				X	
Antimony-125	X			X	
Barium-133	X		X	X	X
Cesium-134	X	X	X	X	X
Bismuth-207	X			X	

TABLE 5-4: Maximum Target Radiation Level for a 20 Week Irradiation Period

Target	Exposure Rate, Rem per Hour, at 30 Centimeters After Decay Time of:		
	One Day	One Month	Six Months
A	42	15	5
B	33	12	4
C	84	30	10
D	84	30	10

5.2.3.3 Summation of Health Effects

Using the information provided in Sections 5.2.1 through 5.2.3.2, health effects resulting from AGS operations under the most intense use, the proposed action, were estimated. Estimates were prepared using the recommendations in Report 60 prepared by the ICRP.⁸ This report uses the most recent risk estimates in the

Biological Effects from Ionizing Radiations Report issued by the NAS.⁹ Assumptions used in the estimate were: a member of the general public resides on the site boundary closest to each facility, 24 hours a day, 365 days a year; and occupancy is continuous for the projected life of the proposed operations. Calculations determine that the total radiation dose to this individual over a 30 year period would be 15 millirem, largely from sky shine, from AGS operations. This dose would be 3 orders of magnitude below respective background levels. Using the ICRP and NAS methods of risk prediction, the additional risk of a person residing at the site boundary to contract a fatal cancer would be less than 1 chance in 80,000 or 0.00004% per year. Realistically, given this information no radiation health effects are expected to occur.

5.2.4 Abnormal Events

Abnormal events which could occur during operations under all alternatives considered are the potential for fire, loss of contaminated cooling water, and beam fault. As facilities deteriorate and do not receive maintenance, these occurrences could take place with increased frequency under the No Action Alternative and reduced frequency under the Proposed Action. These events are evaluated for impact on workers and the public from the direct exposure pathway. Exposure from the ingestion and inhalation pathways would not occur under these events.

5.2.4.1 Incidence of Fire

Welding gases and flammable/explosive gases are utilized in the AGS experimental facilities to assist user research activities. These gases are used and stored according to National Fire Protection Association codes and standards applicable to experimental installations.¹⁷ Gases are stored in compressed gas cylinders which meet DOT specifications. Users are limited to using 45 to 90 kilogram cylinders during running periods. In the event that a flammable gas is leaked from a cylinder, an extremely remote possibility given the routine inspections conducted on cylinders, a spark could ignite the gas. The AGS facilities are equipped with fire detection and suppression systems which would immediately activate to control and extinguish a resulting fire. Combustible loading in the experimental areas consists of magnets, power and control cables, and beam diagnostic equipment. None of the materials are highly flammable, and with the possible exception of small amounts of control cable, all would be expected to self extinguish upon de-energizing of electric power. Induced radioactivity is deeply entrained in magnets and concrete shielding, and is not dispersible in a fire. Therefore, no impacts other than lost experimental opportunities during facility repair are anticipated.

In the event a fire does result which would require fire/rescue personnel to respond, individuals involved in the response could receive direct radiation exposures estimated to be up to 200 millirem per event. This exposure would increase the potential for affected response personnel to contract a fatal cancer by 2 chances in 10,000. Water used in firefighting operations would be contained in sumps and tested for radioactivity to determine the appropriate method of disposal.

5.2.4.2 Loss of Contaminated Cooling Water

There are no gaseous, liquid, or dispersible quantities of radioactive materials available in AGS facilities with the exception of the radioactivity induced in magnet cooling water. In primary beam line areas where the cooling water might escape confinement due to failed seals or soft piping, water detection mats underneath the magnets alarm and alert the watch personnel. Experience has shown that the induced radioactivity in the cooling water systems generally does not exceed 300,000 picocuries per liter for tritium and 3,000 picocuries per liter for beryllium-7, the primary radionuclides of concern in these releases. Up to several hundred gallons of water can be leaked to the concrete floor, an occurrence that takes place 2 - 4 times annually. Released water would be accumulated within AGS sump areas, samples would be collected, and depending upon radioactivity present, would be discharged to BNL's sanitary system or collected for disposal through BNL's Waste Concentration Facility depending upon allowances under BNL's SPDES permit.

Collection of water from the sump areas to a tanker vehicle for transport to BNL's Waste Concentration Facility would require up to 12 hours to complete. Assuming a worker leaned against the tanker for the entire collection period, this worker would incur from direct exposure approximately 0.0001 millirem per event. This person would experience an increased potential of contracting a fatal cancer of 3 chances in 100,000,000,000 from this exposure.

5.2.4.3 Beam Faults/Losses

Not all protons would be stopped at the targets or at well defined loss points except under the proposed action where beam loss would be directed into the proposed beam dump and scraper. Some may be lost during transport. The design goal of no more than 20 millirem per full-fault event is adhered to in the design of shielding and radiation monitoring systems. Typically, the shielding on the transport lines would allow at most 5000 millirem in 1 hour at the proposed performance goal of 60 tp. Such radiation fields would occur only at contact with the shielding and would not be detectable at the BNL site boundary. These areas are further protected by radiation monitors that turn the radiation source off within 9 seconds of detecting a fault condition. Thus, the AGS design guideline of no more than 20 millirem per event is met through a combination of shields, radiation monitors, and beam interlocks.

Based on archival operating records, beam faults occur when magnet power fails, or when beam-line components are mis-aligned and placed into the beam path. Such beam faults would be detected by radiation monitoring systems and would automatically shut the beam off. Given the length of these events, 9 seconds or less on the basis of the speed of the detector/interlock system, and the frequency of these events, several times during an annual running period, the maximally affected worker in an adjacent area would receive an exposure (all from direct radiation) of 0.00025 millirem per year. The maximally affected individual residing at the site boundary would receive an exposure of 0.00005 millirem per year. Potential to contract a fatal cancer would be increased for the maximally affected worker by 2 chances in 10,000,000,000 per year and 4 chances in 100,000,000,000 for the site boundary resident.

5.2.5 Hazardous and Domestic wastes

Approximately 70 cubic meters of radioactive waste would be produced annually at AGS under the No Action and Maintenance Alternatives. This would be decreased to approximately 50 cubic meters over time under the Proposed Action Alternative. This would amount to 30 - 35% of the radioactive waste projected to be generated at BNL. Waste stream items include vacuum pipes, cables, vacuum-pump parts, and similar debris. These items generally measure less than 100 millirem per hour at 30 centimeters. Beam stops, target assemblies, shield blocks, and magnets are reused over many running periods. The longest half-life associated with these radioactive materials is 5.3 years for cobalt-60. These waste items are expected to diminish to background radiation levels within 10 half lives; that is, within 50 years. Radioactive wastes are packaged and transported to BNL's Hazardous Waste Management Facility where they are stored with other radioactive wastes generated at BNL facilities pending disposal at the DOE/Westinghouse Hanford Facility in Richland, Washington. Hazardous waste facilities are undergoing upgrades at BNL and are expected to continue to be capable of handling all radioactive wastes generated at the AGS as well as all BNL facilities. An Environmental Assessment is currently being prepared to address NEPA requirements for future management of hazardous wastes at BNL.

Non-radioactive construction debris such as wood, wire, and concrete block is produced at the rate of about 10 cubic meters per week during periods when beam line refurbishing work is normally done. Other solid waste is generated at a rate of 3 - 5 cubic meters per week. This material is monitored for radioactivity, removed, and picked up for burial at the Town of Brookhaven landfill. This waste is part of the BNL annual solid waste stream of approximately 1.35 million kilograms.

The AGS Complex is responsible for approximately 10% of the 54,000 kilograms of nonradioactive hazardous waste generated annually at BNL. The majority of this waste consists of disposal of old components containing mercury or PCBs, vacuum pump oils, and degreasing chemicals. These wastes are anticipated to be the same under all alternatives considered. Disposal is accomplished via the services of a group of firms presently under contract to BNL. Disposal services are typically comprised of incineration, landfilling, and/or resource recovery, depending on the particular waste stream involved. These operations are performed at various permitted facilities around the United States.

Besides the packaging of wastes for disposal, BNL has instituted an aggressive waste minimization program which includes inventory control, material, and process substitution, waste segregation, toxicity reduction, and recycling. The AGS operation has included much of the waste minimization program activities in daily functions. This program is still in the developmental stage and quantification of waste reduction is not available but is projected to be 10 - 30% of the effected waste streams.

5.2.6 Cumulative Impacts

The AGS Complex is an operating facility which contributes to the cumulative impact of BNL operations on the surrounding environment. The effects recognized for the Proposed Action Alternative are limited to minor changes in radioactive

and solid waste generation, radiation exposures to occupational workers, and changes in site boundary radiation doses from ingestion of ground water containing the radionuclides tritium and sodium-22 generated by AGS operations. As noted in Section 5.1.3, the AGS Complex generates approximately 72 cubic meters of low level radioactive waste annually. Under the Proposed Action this total volume would gradually decrease by up to 25% over time because of the requirement to change out components less frequently. Because construction and operational changes principally occur within the developed complex, no cumulative physical environmental impacts can be associated with the proposed action or any other of the considered alternatives.

The annual radiation exposure experienced by all radiation workers at the AGS is expected to remain at 25 person-rem under the No Action and Maintenance Alternatives. This figure has dropped substantially since 1973 when workers incurred 575 person-rem. Under the proposed action this collective dose is expected to decrease by up to 60%. In this sense the proposed action has two benefits to BNL, increased beam intensity to meet user demands and reduction of personnel exposures.

During 1992, the maximum committed effective dose equivalent to an occupant of BNL's site boundary generated by BNL activities was 1.0 mrem of which 0.038 mrem was attributable to the water pathway. The collective population committed effective dose equivalent was 2.6 person-rem of which 0.02 person-rem was attributable to the water pathway. Including operation of the proposed Booster Applications Facility and RHIC, under all actions considered, the dose to the public would remain unchanged for BNL at the level of significant figures reported. For comparison purposes, regulatory standards for annual doses to the maximum affected individual for the water pathway is 4 millirem and for all pathways is 100 millirem. The collective population committed effective dose equivalent attributable to external radiation from natural background is about 291,000 person-rem per year plus an additional 97,000 person-rem per year attributable to internal radioactivity from natural sources.⁴

Under current administrative constraints, the maximally affected radiation worker may potentially receive direct exposure of 1,000 millirem per year. If this individual were to receive this exposure each year over an entire thirty year career, this 30,000 millirem exposure would increase the worker's chances of contracting a fatal cancer by 2.5%. The average exposure to a radiation worker at AGS has been measured to be 40 millirem per year. This exposure rate is expected to decrease marginally under the Proposed Action. Over a thirty year career, this 1,200 millirem exposure would increase the average persons potential for contracting a fatal cancer by 1 chance in 1,000. For comparison purposes, the current rate of incidence of contracting a fatal cancer in the general population is approximately 1 chance in 5.

5.2.7 Impacts on Scientific Programs

The scientific community at BNL has expressed interest in conducting experimentation at higher beam intensities than currently available from the AGS. Under the No Action and Maintenance Alternatives, the fixed target program could continue indefinitely (30 years). However, without the completion of the extraction system for RHIC, no RHIC operations would occur. Eventually science

would exhaust investigation potential under the current energies and programs would leave the AGS. Although the projected life of the facility under this alternative is 30 years, lack of scientific support could shut the facility down within this time frame. The Proposed Action Alternative is best suited to meet user requirements. The availability of higher beam intensities is expected to attract additional investigations. Also, with injection into the RHIC, a new area of heavy ion collision investigations becomes available. This alternative is expected to keep scientific support over the projected 30-year machine life.

6.0 SUMMARY

The AGS Complex currently accelerates protons to 28 GeV with a beam intensity of 20 tp. The protons available from the 200 MeV LINAC can generate a beam intensity of 150 tp. To increase the efficiency of the AGS and/or address the requirements under NEPA, alternatives under consideration include No Action, Maintenance, and Proposed Action. Alternatives requiring use of other accelerator facilities and discontinue all maintenance were dropped from further evaluation because they would not be a cost-effective utilization of available research funds and would not meet program objectives. The No Action, Maintenance, and Proposed Action Alternatives would provide for the routine maintenance of existing facilities. However, the No Action and Maintenance Alternatives would replace components to maintain current operating levels and the Proposed Action would replace components with state-of-the-art equipment that would match the AGS Booster and permit generation of beam intensities to 60 tp. Because the construction activities would be similar in terms of equipment to be replaced, waste generation would be similar to current waste streams: 1,520 cubic meters of compressed garbage, 760 cubic meters of construction debris, 72 cubic meters of low level radioactive waste, and 5 meters of hazardous waste. Under the Proposed Action Alternative, better control of beam intensity produced would lower the amount of low level radioactive waste generated. Better beam control is also expected to decrease worker radiation exposures by up to 60%. Contributions of tritium and sodium-22 to drinking water under the No Action Alternative would result in a calculated annual on-site dose of 0.04 millirem and an annual off-site dose of 0.000008 millirem, both of which are well below the Safe Drinking Water Act standard of 4 mrem. Based upon the lack of sodium-22 detected in on-site potable wells, it is suggested that the observed radionuclides in this system do not originate from AGS. Dose attributable to the Maintenance and No Action Alternatives would be 0.00002 millirem and 0.00001 millirem, respectively. No measurable incremental cancer deaths would be attributable to any of the alternatives from the drinking water pathway. Radioactive air emissions are not anticipated to occur because all air in the AGS Complex is recirculated as an energy conservation measure. Air activation products, all of which are short lived, are permitted to decay in place. The majority of radiation exposures to the public would result from sky shine which is anticipated to be 2.5 millirem to BNL nonradiation workers and 0.5 millirem to BNL site boundary inhabitants at maximum exposure under the Proposed Action Alternative. The No Action and Maintenance Alternatives would result in annual doses of 1.3 millirem to BNL nonradiation workers and 0.15 millirem to BNL site boundary inhabitants at maximum exposure. The calculated total radiation dose to a resident of BNL's site boundary over a 30 year period would be 15 millirem under the proposed action (highest exposure scenario). This exposure would yield a likelihood of contracting a fatal cancer by 1 chance in 80,000. The annual collective dose related to all existing and proposed BNL operations would not exceed the 1992 calculated dose of 2.6 person-rem. All alternatives under consideration in this document would have no impact on the calculated person-rem exposure. Under the No Action and Maintenance Alternatives, the scientific community would have access to a facility which would meet current demands but would fail to service foreseeable research needs including injection into the RHIC. For additional information see the Environmental Assessment for the RHIC (DOE/EA 8508). The Proposed Action would achieve improved AGS efficiency, provide greater opportunities to the scientific community, and provide an injector for RHIC. A summary of impacts associated with the considered alternatives is provided in Table 6-1.

TABLE 6-1

Summary of Impacts of Alternatives Considered

Category of Impact	No Action Alternative	Maintenance Alternative	Proposed Action Alternative
(All Rates Are Annual Unless Otherwise Indicated)			
Habitat Loss	NONE	NONE	NONE
Wetlands/Surface Water	NONE	NONE	NONE
100 Year Floodplain	NONE	NONE	NONE
Ground Water Use	NONE	NONE	NONE
Ground Water Extraction	9.0 MLD	9.0 MLD	9.0 MLD
Historic Resources	NONE	NONE	NONE
Endangered Species	NONE	NONE	NONE
Solid Nonhazardous Waste	2,300 CUBIC METERS	2,300 CUBIC METERS	2,300 CUBIC METERS
Hazardous Waste	5,400 KILOGRAMS	5,400 KILOGRAMS	5,400 KILOGRAMS
Radioactive Waste	70 CUBIC METERS	70 CUBIC METERS	50 CUBIC METERS
On-site Water Pathway Dose	NONE	NONE	NONE
Off-site Water Pathway Dose	0.000008 MILLIREM	0.00002 MILLIREM	0.00001 MILLIREM
Cancer Risk	0.0000000006%	0.000000002%	0.000000001%
On-site Air Pathway Dose	NONE	NONE	NONE
Off-site Air Pathway Dose	NONE	NONE	NONE
On-site Direct Exposure, Public	1.3 MILLIREM	1.3 MILLIREM	2.5 MILLIREM
Off-site Direct Exposure, Public	0.15 MILLIREM	0.15 MILLIREM	0.5 MILLIREM
Radiation Worker Total Dose	25 PERSON-REM	25 PERSON-REM	10 - 15 PERSON-REM
Lifetime Radiation Worker Dose	1.2 - 30 REM	1.2 - 30 REM	1.2 - 30 REM
Cancer Risk	0.01 - 2.5%	0.01 - 2.5%	0.01 - 2.5%
Total Off-Site Collective BNL Dose	2.6 PERSON-REM	2.6 PERSON-REM	2.6 PERSON-REM
Scientific Programs	SHUTDOWN	PHASE OUT	FULL SUPPORT

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8.0 ACRONYMS

AGS	Alternating Gradient Synchrotron
ALARA	As Low As Reasonably Achievable
BLIP	Brookhaven LINAC Isotopes Producer
BNL	Brookhaven National Laboratory
CFR	Code of Federal Regulations
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
GeV	Giga (Billion) Electron Volts
ICRP	International Commission on Radiological Protection
KeV	Thousand Electron Volts
LINAC	Linear Accelerator
MeV	Million Electron Volts
MLD	Million Liters Per Day
mrem	Millirem
NAS	National Academy of Sciences
NEPA	National Environmental Policy Act
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
PCBs	Polychlorinated Biphenyls
rf	Radio frequency
RHIC	Relativistic Heavy Ion Collider
SPDES	State Pollutant Discharge Elimination System
tp	Teraprotons
uCi/yr	Millicuries Per Year
uCi/cm ³	Millicuries Per Cubic Centimeter

9.0 DEFINITIONS

Activated materials - Material made radioactive by the bombardment with neutrons, protons, or other nuclear particles.

Alloy - Homogeneous mixture of more than one metal.

Anion - A negatively charged particle.

Beam dump - Location at which accelerated particles can be directed where particles will lose energy.

Collective dose equivalent - The summation of the absorbed radiation dose received by all individuals in a population group.

Corrosives - Aqueous solutions having a pH below 2.0 or above 12.5.

Cosmogenic - Generated by a stream of ionizing radiation of extraterrestrial origin.

Curies - A unit of activity equal to 3.7×10^{10} atoms per second disintegrations.

Direct exposure - Radiation encountered through proximity to an external source.

Dispersion equation - Computer program used to simulate the release of a substance or radionuclide.

Energy - Ability of a particle to give a push/pull in a collision.

Environmentally sensitive area - Habitats, structures, or other areas afforded special protection under environmental rules and regulations.

Evapotranspiration - Form of respiration employed by plants where water is removed from the soil and oxygen is released through the leaves.

GeV - One billion electron volts.

Hazardous waste - A solid, liquid, semisolid, or gaseous material which may pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed.

Hydrophytic - A plant requiring immersion in water during the majority of the growing season to survive.

Ions - Charged atomic particles.

Intensity - Number of particles per unit time.

Low level radioactive waste - Solid, liquid, and gaseous materials from nuclear operations in the range of 1 microcurie per gallon or cubic foot.

9.0 DEFINITIONS (CONTINUED)

Millirem - A special unit of absorbed dose equivalent equal to the absorbed dose in rads multiplied by a quality factor.

Nucleon - A proton or neutron especially as part of a nucleus.

Percolation rate - Speed at which one material can pass or ooze through another material.

Person-rem - Unit of population exposure obtained by summing individual absorbed dose values for all people in the population.

Pions - A subatomic particle of the meson family.

Quadrupole - A magnet with magnetic poles on four sides, used to focus beams of charged particles into a smaller area.

Radio frequency - A range in which radio waves are transmitted.

Radioisotope - A naturally occurring or artificially produced radioactive isotope (same element, different atomic weight) of an element.

Radionuclides - Any radioactive form of an element.

Scraper - A large concrete or metal block with a passageway where anything failing to enter the passageway is stopped.

Secondary particle - The resulting unit of matter which exits from the collision of two larger units of matter.

Sky shine - Radiation reflected back to earth by the atmosphere above a radiation-producing facility.

Sole source aquifer - A layer of ground water determined to be the only available source of drinking water to a defined region or population.

Subatomic particles - Units of matter which can be extracted from an atom.

Teraprotons - 1,000,000,000,000 protons or 10^{12} protons.

Transient - Passing from one location to another.

Waste minimization - Effort by hazardous waste generator to reduce the volume and toxicity of waste whenever possible as required under EPA regulation 40 CFR 262.

10.0 LIST OF AGENCIES CONSULTED

New York State Department of
Environmental Conservation
Stony Brook, New York
(516/751-7900)

New York Natural Heritage Program
Delmar, New York
(518/783-3901)

New York State Historic
Preservation Office
Albany, New York
(518/474-0479)

Suffolk County Department
of Health Services
Hauppauge, New York
(516/853-3077)

U.S. Army Corps of Engineers
New York, New York
(212/264-4662)

U.S. Department of Energy
Chicago, Illinois
(708/252/2556)

U.S. Department of Energy
Upton, New York
(516-282-3424)

U.S. Environmental Protection Agency
New York, New York
(212/264-5170)

U.S. Fish and Wildlife Service
Cortland, New York
(607/753-9334)

U.S. Geological Survey
Syosset, New York
(516/938-8830)

11.0 DETAILED DESCRIPTION OF AGS FACILITIES

The following provide additional information on the facilities considered to make up the AGS complex:

200 MeV Proton Linear Accelerator, Building 930

The 200 MeV LINAC enclosure is 140 meters long, 4 meters wide, and 5 meters high. The beam line is at least 1 meter below grade. From the end of the LINAC, a 3 meter by 3 meter tunnel extends 95 meters to connect with the AGS. An additional spur tunnel 4 meters wide, 3 meters high, and 17 meters long leads to the Brookhaven Linac Isotopes Producer II (BLIP) facility, the Radiation Effects Facility, the Neutral Beam Test Facility, and a beam stop. Another 17 meter long tunnel transports the LINAC beam into the AGS Booster and it is called the LINAC/Booster Junction. Protons would be injected from the LINAC into the Booster at 200 MeV. They are extracted from the Booster and injected into the AGS at 1.5 GeV.

AGS Tunnel, Building 913

The AGS is a circular enclosure containing 240 electromagnets and other components composing the AGS. The AGS mean circumference is 800 meters. The structure is of concrete, 5.4 meters square in cross section, with 0.3 meter thick walls. The accelerator reference system has 12 sections called "superperiods," designated A through L in counterclockwise order, each consisting of 20 main magnets combining dipole and quadrupole fields.

AGS Experimental Area, Building 912

Building 912 is the AGS Experimental Building. It is the largest structure and the functional focus of the accelerator complex. This building is of high-bay steel-frame construction that covers 16,350 square meters. The building is shaped like two contiguous rectangles, one 64 meters by 150 meters, the other 61 meters by 116 meters. These areas are further delineated as East Experimental Area, East Experimental Building Addition, North West Area, Target Building, East Experimental Building Addition Annex, and North Experimental Building Addition. The area houses the G Superperiod of the AGS, the Slow External Beams including the Switchyard, and all of the Slow External Beam experimental setups.

Accelerator Equipment

The main ring magnets, 240 in number, serve to bend the beam into the circular orbit, and because the magnet pole shape creates a quadrupole component, also provides the strong focusing capability. Additional, discrete, dipole, quadrupole, and sextupole magnets are used for control of the beam. The main ring magnets are powered from a rotating motor-alternator set. The rotational stored energy in the motor and alternator rotors is very large in order to provide the pulsed power needed when the magnet system is energized. Particle acceleration is provided by a rf system which detects the beam frequency, amplifies it, and drives a series of ferrite loaded cavities which transfer energy to the beam. A high vacuum system is needed in the magnet beam chambers. Residual gas molecules can increase the beam size due to collisions with gas

molecules and subsequent scattering leading to beam loss. Elaborate instrumentation is needed to control the beam for injection, acceleration, and ejection to the final user. The beam position in the vacuum chamber must be monitored for normal operation, and means provided for troubleshooting if problems occur in any portion of the operating cycle. If the accelerated beam has to be dumped for any reason, it must be done with a minimum of risk to personnel or equipment. For this reason a beam dump and catcher are used to localize and contain the energy of the beam.

A detailed description of magnets, power supplies, vacuum systems, rf systems, radio frequency quadrupoles, beam transport components, beam instrumentation, and monitoring components, accelerator controls, experimental area magnets and power supplies, electrostatic beam separators, and typical experimental setups may be found in the AGS Safety Analysis Report. Brief descriptions of the beam dump, target caves, beam stops, and water systems are given here because these systems are potential sources of on-site and off-site radiation exposures from operation of the AGS.

Beam Dump and Catcher

A fully functional facility presently does not exist but is proposed as part of routine operations of the AGS under the proposed action. A beam dump would be installed at J10 in the AGS. It is intended to serve as the preferred repository for any beam that might be lost in the machine. Thus, ideally, all residual radiation would be in the dump rather than being spread around the ring. The dump would be a solid block of steel with a rectangular opening through it for the beam. The upstream end of the dump would have a protruding lip on the inside, which can be used to "scrape" the beam, removing the outermost particles. A fast kicker magnet would kick the beam onto the face of the dump to give high efficiency (greater than 90%) absorption.

The primary load on the dump would come from firing the dump kicker each spill after extracting and thus putting in the dump the 1 or 2% of the beam that could not be extracted. The second load on the dump would come from AGS studies when the beam would be impossible to extract and would be sent to the dump.

Target Caves

Target caves house and shield the primary production targets. Secondary particles, which are the focus of most experiments at AGS, are produced through interactions of the primary protons with the nuclear fields in the atoms of the target material. Targets are frequently made of metal by virtue of their refractory characteristics, thermal conductivity, and high volumetric density of nucleons.

The target cave is the terminus of the primary beam transport. Beam is transported through a series of quadrupole magnets providing control of the size of the beam, dipole magnets controlling beam direction, and instrumentation measuring beam intensity, position, transverse distribution or profile, and beam loss. Beam interactions remote from the production target are minimized by confining the beam to a pipe evacuated of air.

Target caves are constructed of heavy concrete and steel shielding with labyrinthine entry passages and elaborate security circuitry and procedures to prevent personnel exposure. This circuitry includes crash buttons and door switches which inhibit AGS operation, and door locks with access mode controlled by the AGS Main Control Room.

Primary and Secondary Beam Stops

Primary and secondary beam stops are the sinks used to absorb the energy and concomitant radiation from beams which have completed their utility. These dumps are typically made of ilmenite loaded concrete, occasionally steel. The design often incorporates a recessed entry area, or reentrant cavity, which greatly reduces radiation shine perpendicular to the direction of the incident beam on the face of the stop. The length and transverse dimensions of the stop are designed to assure that the radiation generated is sufficiently attenuated.

Primary beam stops may handle beam intensities up to the full capacity of the AGS, entailing an average energy dissipation of up to 90 kilowatts for the SEB experimental area. Secondary stops terminate a relatively small analyzed beam of particles from a production target. Since analysis entails selection of a specific charge, or charge-to-mass ratio, and momentum bite of the total flux of secondary particles, the "selected" secondary beam is orders of magnitude lower in intensity, and often lower in energy, than the primary beam, with consequently smaller beam stop dimensions.

Build up in time of residual radiation in primary beam stops is a significant design consideration. Dose rate levels of the order of tens of rem per hour are not uncommon, thus requiring attention to the reliability and maintainability of any nearby components.

Water Systems

Several dedicated deionized cooling water systems are distributed through the magnet enclosure, Bldg. 913, supplying magnets and rf cavities. Additional systems are routed through the enclosure to cool external devices.

Chilled water and domestic water are also distributed. Leaks from these systems are collected by a network of floor drains which discharge to five sumps located under the enclosure. Currently, pumps are turned off and sumps are alarmed with level indicators in order to analyze liquid losses to determine proper disposal methods. Water in the sumps is pumped to the site sanitary system or to drainage rings outside the enclosure. A program is currently underway to eliminate the drainage rings. The distribution systems are also being upgraded to expand distribution and capacity of experimental cooling systems and component cooling systems such as systems servicing the rf cavities. These upgrades are intended to improve cooling systems and do not result in additional water usage or facility expansion.

In addition to the facilities described above, the AGS complex includes mechanical equipment buildings, electrical substations, power supply buildings, gas bottle storage areas, a concrete block yard, a steel yard, storage tanks, warehouses, systems control facilities, magnet fabrication facilities, component test facilities, a transfer line to RHIC, and various other facilities for the support of the AGS and associated experimental programs.

12.0 COORDINATION CORRESPONDENCE

It should be noted that the proposed action would take place indoors within existing structures or on previously disturbed areas approximately 0.5 kilometers from any environmentally sensitive areas.

Rec'd 12/

Thomas C. Jorlin
Commissioner

New York State Department of Environmental Conservation

Wildlife Resources Center
Information Services
700 Troy-Schenectady Road
Latham, New York 12110-2400

December 7, 1993

Christine Barker
Lawler, Matusky & Skelly Engineers
One Blue Hill Plaza, PO Box 1509
Pearl River, New York 10965

Dear Ms. Barker:

We have reviewed the New York Heritage Program files with respect to your recent request for biological information concerning the ecological assessment of the Brookhaven National Laboratory property in Brookhaven, Suffolk County.

Enclosed is a computer printout covering the area you requested to be reviewed by our staff. The information contained in this report is considered sensitive and may not be released to the public without permission from the New York Natural Heritage Program.

Our files are continually growing as new habitats and occurrences of rare species and communities are discovered. In most cases, site-specific or comprehensive surveys for plant and animal occurrences have not been conducted. For these reasons, we can only provide data which have been assembled from our files. We cannot provide a definitive statement on the presence or absence of species, habitats or natural communities. This information should not be substituted for on-site surveys that may be required for environmental assessment.

This response applies only to known occurrences of rare animals, plants and natural communities and/or significant wildlife habitats. You should contact our regional office, Division of Regulatory Affairs, at the address enclosed for information regarding any regulated areas or permits that may be required (e.g., regulated wetlands) under State Law.

If this proposed project is still active one year from now we recommend that you contact us again so that we can update this response.

Sincerely,

Nancy Davis Ricci

Nancy Davis-Ricci, Info. Data Asst.
NY Natural Heritage Program

Enc.

cc: Reg. 1. Wildlife Mgr.
Reg. 1. Fisheries Mgr.
Peter Nye, ESU, Delmar

United States Department of the Interior

FISH AND WILDLIFE SERVICE

3817 Luker Road
Cortland, New York 13045

December 13, 1993

Ms. Christine Barker
Ecotoxicologist
Lawler, Matusky & Skelly Engineers
One Blue Hill Plaza
P.O. Box 1509
Pearl River, NY 10965

Dear Ms. Barker:

This responds to your letter of October 20, 1993, requesting information on the presence of Federally listed or proposed endangered or threatened species in the vicinity of the Brookhaven National Laboratory, Suffolk County, Long Island, New York.

The sandplain gerardia (*Agalinis acuta*) is a Federally listed endangered plant which is typically associated with grassland communities and is known to occur at several locations on Long Island. There is no current record of this species occurring at the Brookhaven National Laboratory. Since we can only provide data on known locations, this information should not be substituted for field surveys to determine the presence or absence of this species, and the need for Section 7 consultation under the Endangered Species Act on activities that could potentially effect this species, if present.

Except for the possible occurrence of the sandplain gerardia or occasional transient individuals, no other Federally listed or proposed endangered or threatened species under our jurisdiction are known to exist in the project impact area. If additional information on listed or proposed species becomes available, this determination may be reconsidered. An updated compilation of Federally listed and proposed endangered and threatened species in New York is enclosed for your information.

The above comments pertaining to endangered species under our jurisdiction are provided pursuant to the Endangered Species Act. This response does not preclude additional Service comments under the Fish and Wildlife Coordination Act or other legislation.

For additional information on fish and wildlife resources or State-listed species, we suggest you contact:

New York State Department
of Environmental Conservation
Region 1
Building 40, SUNY
Stony Brook, NY 11794
(516) 444-0200

New York State Department
of Environmental Conservation
Significant Habitat Unit
Information Services
700 Troy-Schenectady Road
Latham, NY 12110-2400
(518) 783-3932

The National Wetlands Inventory (NWI) maps of the Bellport, Middle Island, Moriches, and Wading River Quadrangles indicates that there are wetlands at Brookhaven National Laboratories. Copies of NWI maps may be obtained through:

CLEARs
Cornell University
464 Hollister Hall
Ithaca, NY 14853
(607) 255-6520

An order form listing the topographic quadrangles that have been mapped in New York State is enclosed for your information. However, while the NWI maps are reasonably accurate, they should not be used in lieu of field surveys for determining the presence of wetlands or delineating wetland boundaries for Federal regulatory purposes.

Work in certain waters and wetlands of the United States may require a permit from the U.S. Army Corps of Engineers (Corps). If a permit is required, in reviewing the application pursuant to the Fish and Wildlife Coordination Act, the Service may concur, with or without stipulations, or recommend denial of the permit depending upon the potential adverse impacts on fish and wildlife resources associated with project implementation. The need for a Corps permit may be determined by contacting Mr. Joseph Seebode, Chief, Regulatory Branch, U.S. Army Corps of Engineers, 26 Federal Plaza, New York, NY 10278 (telephone: (212) 264-3996).

If you have any questions regarding this letter, contact Tom McCartney at (607) 753-9334.

Sincerely,

Mark W. Clough

ACTING FOR

David A. Stilwell
Acting Field Supervisor

Enclosures

cc: NYSDEC, Stony Brook, NY (Regulatory Affairs)
NYSDEC, Latham, NY
COE, New York, NY
EPA, Chief, Marine & Wetlands Protection Branch, New York, NY