DOE–LM/GJ596–2004

Long-Term Surveillance and Maintenance Plan for the Boiling Nuclear Superheater (BONUS) Reactor Facility, Rincón, Puerto Rico

May 2005

U.S. Department of Energy

Work Performed Under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management.

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Acronyms

AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
BONUS	Boiling Nuclear Superheater
CFR	*Code of Federal Regulations*
Ci	Curie(s)
cm	centimeter(s)
cm^2	square centimeter(s)
°C	degree(s) Celsius
°F	degree(s) Fahrenheit
DOE	U.S. Department of Energy
dpm	disintegration(s) per minute
km	kilometer(s)
LM	Office of Legacy Management
LTS&M	Long-Term Surveillance and Maintenance
m	meter(s)
m^2	square meter(s)
MDA	minimum detectable activity
MWe	megawatts net electric capacity
MWt	megawatts thermal; 1 MWt ≈ 3 MWe
PREPA	Puerto Rico Electric Power Authority
PRWRA	Puerto Rico Water Resources Authority
RPP	radiation protection program
SAP	Sampling and Analysis Plan
SCM	surface contamination monitor
µCi	microcurie(s)
µR/h	microroentgen(s) per hour
UST	underground storage tank

1.0 Introduction

1.1 Purpose

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) provides long-term surveillance and maintenance (LTS&M) services for remediated DOE sites and other sites assigned to DOE to ensure that those sites remain protective of human health and the environment. Key components of these LTS&M services include stakeholder participation, site monitoring and maintenance, records information management, and research activities. This LTS&M Plan explains how DOE and the Puerto Rico Electric Power Authority (PREPA), as partners in post-closure care, will maintain protection of human health and the environment and comply with applicable laws and regulations at the former Boiling Nuclear Superheater (BONUS) reactor facility in Rincón, Puerto Rico.

1.2 Background

In 1960, the U.S. Atomic Energy Commission (AEC, predecessor to DOE) entered into a contract with the Puerto Rico Water Resources Authority (PRWRA, predecessor to PREPA) for the construction and operation of the BONUS reactor. The reactor was constructed from 1960 to 1964 through a combined effort of the AEC and PRWRA. The BONUS reactor was one of only two boiling water superheater reactors ever developed in the United States and was established to evaluate the effectiveness of this reactor design. This small-scale, prototype, nuclear reactor design produced saturated steam in the central portion of the reactor core. This same steam was superheated in four surrounding superheater sections in the same core, and then the superheated steam was used in a direct cycle to drive a turbine-generator. Steam characteristics matched the inlet requirements of a standard 17.3 MWe (megawatts net electric capacity) turbine-generator designed for use in a fossil-fueled plant.

The experimental reactor operated intermittently from 1964 to 1968, after which operations were discontinued due to lack of funds, and the facility was decommissioned. Final facility conditions are documented in the *Boiling Nuclear Superheating Power Station Decommissioning Final Report* (PRWRA 1970). Decommissioning activities included (1) removal of all special materials (e.g., nuclear fuel) and certain highly activated components such as control rods and shims from the reactor and disposal of such materials and equipment on the U.S. mainland, (2) in-place entombment of the pressure vessel and associated internal components within a three-story-tall concrete monolith within the enclosed domed building, and (3) decontamination of contaminated systems located outside of the pressure vessel that were left in place. The facility was decontaminated to a safe occupational exposure condition in accordance with standards in place at that time (see Section 2.5 for current DOE standards). These activities were completed in 1970. Following decommissioning, a post-decommissioning surveillance program was implemented at the facility to monitor radiological and physical conditions (PRWRA 1970).

The DOE Office of Environmental Management at Oak Ridge, Tennessee, was responsible for post-closure care of the facility following decommissioning. This DOE office signed a Memorandum of Agreement (DOE 2003c) with the DOE Office of Legacy Management in March 2003. This document established that responsibility would be transferred to DOE−LM when remedial action is completed. As of September 2004, the DOE Office of Environmental Management had not yet completed remedial action (see Sections 2.4, 2.5, and 2.9 for details).

Presently, the former BONUS reactor facility includes the enclosed domed building, which contains the entombed reactor system, and outside support facilities. Only fixed residual radioactive contamination is present in limited and discrete areas of the accessible areas in the enclosed domed building.

Because of the historical significance of the BONUS reactor, PREPA has proposed to use the facility as a museum that will be open to the public. The main level, which has been proposed for public access, has areas of fixed radioactive contamination. These areas have been isolated, shielded, and posted to protect visitors and workers from exposure to unacceptable levels of radiation. DOE conducted an environmental assessment that indicated no unacceptable risk to human health or the environment if the main floor is used as a museum, as long as the facility is maintained in its present condition (DOE 2003a). This conclusion is incorporated in a Finding of No Significant Impact (DOE 2003b).

1.3 Legal and Regulatory Requirements

As the successor agency to AEC and in accordance with the Atomic Energy Act of 1954 (Public Law 83-703, as amended), DOE holds title to and is responsible for the radioactive materials that remain at the former BONUS reactor facility. PREPA owns the land, facilities, and other improvements. Responsibilities for LTS&M of the facility are assigned to DOE and PREPA through the *Memorandum of Understanding between the U.S. Department of Energy Office of Legacy Management and the Puerto Rico Electric Power Authority for the Use, Maintenance, and Control of the Boiling Nuclear Superheater Reactor Facility in Rincón, Puerto Rico* (Memorandum of Understanding) (DOE and PREPA, pending). That document is included as Appendix A to this LTS&M plan. LTS&M activities and other responsibilities assigned to DOE will be carried out by the DOE Office of Legacy Management, Office of Land and Site Management (LM−50).

DOE, as the authorized custodian of the radioactive materials remaining at the BONUS reactor facility, will comply with the following regulation and guidance:

Title 10 *Code of Federal Regulations* (CFR) Part 835, "Occupational Radiation Protection": The rules in this part establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities. Subpart B, paragraph 835.101 states that an applicable DOE activity shall be conducted in compliance with a documented radiation protection program (RPP), as approved by DOE. The content of each RPP shall be commensurate with the nature of the activities performed and shall include formal plans and measures for applying the as low as reasonably achievable (ALARA) process to occupational exposures.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*: This order establishes standards and requirements for the operations of DOE and its contractors with respect to protection of the environment and members of the public from undue radiological risk.

PREPA, in accordance with the Memorandum of Understanding, shall maintain compliance with applicable portions of DOE Order 5400.5 and 10 CFR Part 835 through its annual and quarterly monitoring of the BONUS facility for worker and public safety.

1.4 Policy

LTS&M of the BONUS reactor facility entails a partnership of and acceptance of certain responsibilities by PREPA and DOE. DOE will manage radioactive materials for which it is responsible in accordance with this site-specific LTS&M Plan. DOE will maintain the LTS&M Plan. If DOE proposes changes to the LTS&M Plan that involve PREPA's operations at the BONUS property, DOE will obtain PREPA's concurrence before implementing the changes.

The goal of the LTS&M program for the BONUS facility is to maintain protection of human health and the environment and preserve site information for future custodians. This will entail

- Keeping ionizing radiation exposure to employees, the public, and the environment ALARA;
- Keeping hazardous substances isolated from the environment;
- Maintaining compliance with applicable guidance, regulations, and laws;
- Ensuring that facility activities, events, and conditions are recorded for future stewards;
- Maintaining site records; and
- Responding to questions and concerns from the public and other stakeholders.

End of current text

2.0 Site Conditions

2.1 Area Description

Puerto Rico is located approximately 1,000 miles (1,600 kilometers [km]) southeast of Miami, Florida, and approximately 500 miles (800 km) north of Venezuela. The topography of Puerto Rico is generally mountainous, except for the coastal areas. The BONUS facility is located in the coastal lowlands near Rincón, Puerto Rico, on the western coast (Figure 2−1). Land use in the city of Rincón, located 2 miles (3.2 km) to the southeast of the site, includes mixed residential and light commercial activities typical of a tropical beach community. The two major factories in Rincón are Medical Sterile Products, which manufactures surgical equipment, and Flexible Packing Company, which manufactures cardboard products. The 1997 population of Rincón was around 14,000 (U.S. Census Bureau Website).

The regional climate is classified as tropical marine, consisting of warm temperatures and high humidity throughout most of the year. Near the BONUS facility, the average daily temperature is approximately 80 degrees Fahrenheit (°F) (27 degrees Celsius [°C]). The U.S. Weather Bureau in San Juan, Puerto Rico, has measured all-time maximum and minimum temperatures of 97 °F (36 °C) and 70 °F (21 °C), respectively. Depending upon location, average annual precipitation in the coastal regions ranges between 40 and 150 inches (101 to 381 centimeters [cm]) per year, the northern coast receiving twice as much rain as the southern coast. Precipitation is greatest from April through November; the dry season occurs from December through March. Most of Puerto Rico's rainfall is orographic; that is, moisture-laden air is cooled while ascending over the mountains, causing condensation in the form of rain. The prevailing wind direction in the area is from the east over most of the island, although wind directions in some coastal areas exhibit diurnal variations.

Hurricanes are frequent between August and October. The most destructive hurricanes in the island's recorded history included San Ciriaco in August 1899, Hurricane San Ciprian in September 1932, and Hurricane Georges in September 1998. In each case, the storms crossed Puerto Rico in a generally east-to-west direction and severely damaged the island. The enclosed domed building was designed to withstand wind velocities of 150 miles per hour (240 km per hour) (PWRA 1970). No structural damage has been observed from storms to date, although Hurricane Georges caused flooding of the enclosed domed building basement when storm drains became plugged and the building's basement door seals leaked. The storm water drains, which had debris from the original construction, were unplugged and the rubber door seals were replaced (after being in place for more than 28 years).

2.2 Site Description

The BONUS facility, located on the westernmost coastal point (Punta Higuera) of Puerto Rico near a U.S. Coast Guard lighthouse (Figure 2–1). The facility lies within a 5-acre (2-hectare) fenced area and is surrounded by 137 acres (55 hectares) of undeveloped land primarily vegetated with brush, native pasture, and woodland, formally known as the BONUS site (owned by PREPA) and which served primarily as a buffer zone when the plant was in operation. Warehouses, the chlorination plant, and water tanks were also located in this area. The 6-foot-(1.8-m-) high, chain-link security fence is topped with three strands of barbed wire.

Figure 2–1. Location of the BONUS Facility, Rincón, Puerto Rico

Access through the entrance gate is controlled by a full-time security guard contracted by PREPA, who is stationed in a guard shack (Figure 2–2). All visitors entering the facility must sign in on a log sheet. A paved road within the BONUS site provides access to the lighthouse and the BONUS facility[1]. Exterior lighting illuminates the site at night. Nearby businesses and adjacent beaches are popular tourist destinations. Low-density residential areas abut the PREPA property.

Average elevation of the enclosed domed building is approximately 25 feet (7.6 meters [m]) above sea level. Because of the earthen embankment around the enclosed domed building, the effective ground level is approximately 40 feet (12 m) above sea level. The natural grade slopes down to the sea west of the facility and upward to the mountains on the east side of the facility.

The BONUS facility includes six main buildings—the enclosed domed building, entrance buildings (consisting of the bathrooms and lockers building and the administrative offices building, connected by a breezeway), auditorium (also known as the theater), Training Center, and guard shack—and other smaller support structures and facilities. Figure 2−2 shows the general site layout.

Enclosed Domed Building: The enclosed domed building consists of three levels: the basement (Figure 2−3), main floor (Figure 2−4), and mezzanine. North and south entrances provide access to the main floor of the building. Both entrances are equipped with air-lock chambers between two steel security doors, and all doors are currently operational.

Basement: The basement is directly below the main floor and is posted as a radiological controlled area. The two stairways to this level are posted and barricaded with expanded metal. A barricade of plexiglass and expanded metal on a steel handrail surrounds the area that is open to the main floor for moving fuel from transport trucks to the fuel storage facility. There are no museum displays in the basement. Another entrance (large enough for a truck to enter) is located at the basement; originally used for fuel handling, this entrance is now sealed.

Fixed radioactivity exists throughout this level. Removable radioactivity above the minimum detectable activity (MDA) but below the criteria for unrestricted release specified in DOE Order 5400.5 was identified in some areas of the basement (see Section 2.5) and was removed or fixed in summer 2004 (URS Ltd. report pending). In accordance with the Memorandum of Agreement (DOE 2003c), the DOE Office of Environmental Management at Oak Ridge intends to cover fixed contamination on the floor with concrete before transition to the DOE Office of Legacy Management is finalized. Asbestos pipe insulation exists throughout the basement; however, PREPA asbestos-certified personnel have inventoried the pipe insulation and stabilized it in place (MACTEC-ERS 2002). Asbestos inspections are performed quarterly and air sampling annually by PREPA staff or contractors.

Main Floor: On the center of main floor is the turbine, the access to the basement for fuel handling, and the crane tower. The concrete monolith, which contains the reactor pressure vessel, rises through the main floor from the basement to the mezzanine level. Barricades constructed of

[1] Originally, access to the entire 137 acres comprising the BONUS facility was controlled at a guard shack located at the start of the paved road were it joins with Road 413. Access control was reduced to the 5-acre zone as a request from PREPA to DOE so that the rest of the site (the 0.25 mile buffer zone) could be used for future development. As a result, access to the lighthouse was provided via the paved road and became a tourist attraction. Before that, access to the lighthouse was via the beach.

plexiglass panels mounted on steel hand railing surround the center area and restrict public access due to fixed contamination. The control room, laboratories, support offices, shops, and storage areas are arranged against the outside wall. PREPA stores BONUS records describing plant design, construction, operation, and decommissioning in two climate-controlled rooms on this level, the former Mechanical Shop and Electrical Maintenance Shop.

The main floor has been developed into a museum. Numerous displays recount the history of the BONUS site as well as the development of electric power and nuclear energy. In addition, information concerning the history of PREPA, Nobel Prize winners, scientists, the solar system, and space travel is discussed and pictured in displays. The reactor control room is still intact and, although it is inactive, control lights have been wired to display an operational effect. A computer learning room containing approximately 12 computer stations has been developed for the future purpose of student research in science topics.

Fixed radioactivity exists on the floor in several areas of the main floor. PREPA has placed ceramic floor tile over these areas to reduce exposure and prevent direct contact. Inside the barricaded center area, a concrete block (approximately 6 feet by 2 feet by 10 inches [183 by 61 by 25 cm] thick) and several lead blocks were placed over the fixed radiological contamination with the highest activity. No removable radioactivity above MDAs is present on the main floor or walls.

Mezzanine: The mezzanine is located above the main floor and provides access to the top of what used to be the reactor, which is now a solid concrete monolith. Access to the mezzanine level is restricted. Access to the overhead crane controls also is located on this level. There are no museum displays here. Several areas of fixed radiological contamination have been identified on the mezzanine concrete floor and on the concrete monolith structure. No covering over the fixed radiological contamination exists. No removable contamination above MDAs is present on the mezzanine floor or walls.

Entrance Buildings: These concrete-block buildings consist of the bathroom and locker rooms building and the administrative offices building separated by a covered breezeway. These buildings are located on the south end of the enclosed domed building and may be accessed directly from the parking lot. They serve as the museum's main entrance. The administrative offices building contained offices, restrooms, and a conference room. During plant operations, this building also contained an auxiliary control room. It does not contain radiological contamination.

Auditorium: This concrete-block building is located west of the enclosed domed building. It has an auditorium that is primarily used for training and meetings. During plant operations, it also contained a cafeteria and open-air dining area. It does not contain radiological contamination.

Training Center Building: This concrete-block building is located north of the auditorium. It was used as office space and dormitories for visiting scientists when the facility was in operation. PREPA has no immediate plans for this building but a history museum is being considered for this structure. It does not contain radiological contamination.

Guard Shack: This building, located near the entrance gate, is currently used for site security and access control. It does not contain radiological contamination.

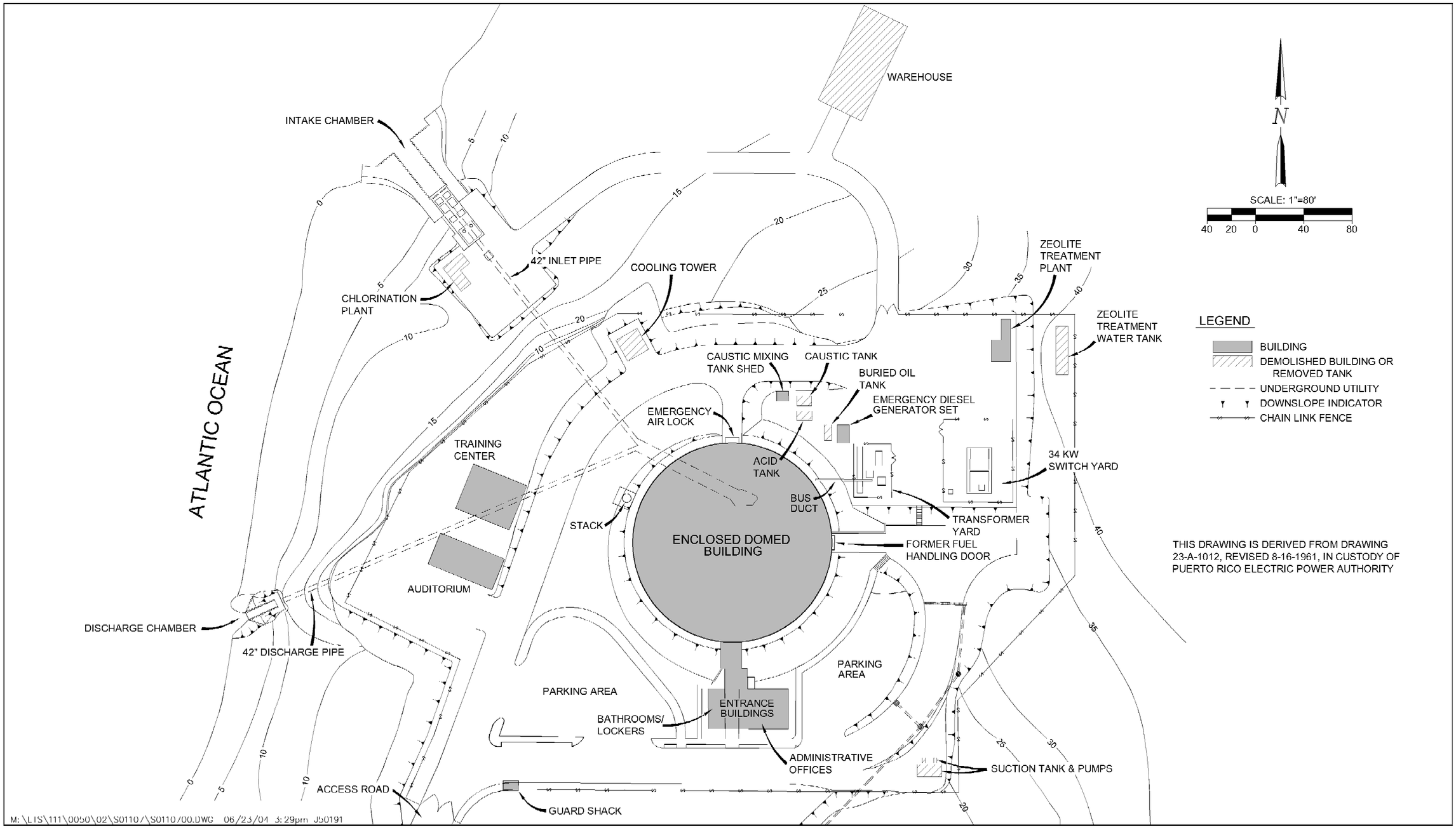

Figure 2–2. Site Layout of BONUS Facility, Rincón, Puerto Rico

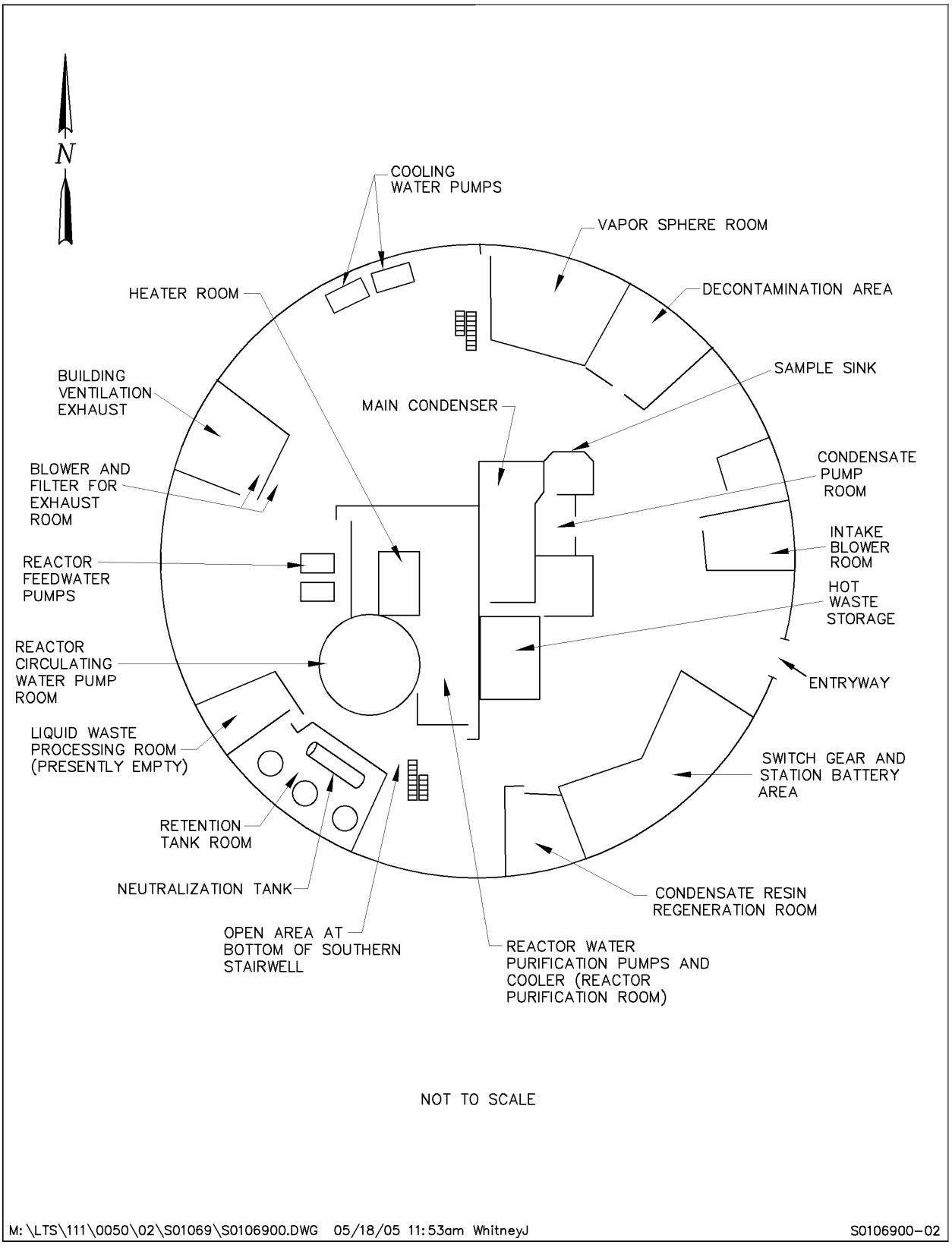

Figure 2–3. Basement Level of the BONUS Enclosed Domed Building, Rincón, Puerto Rico

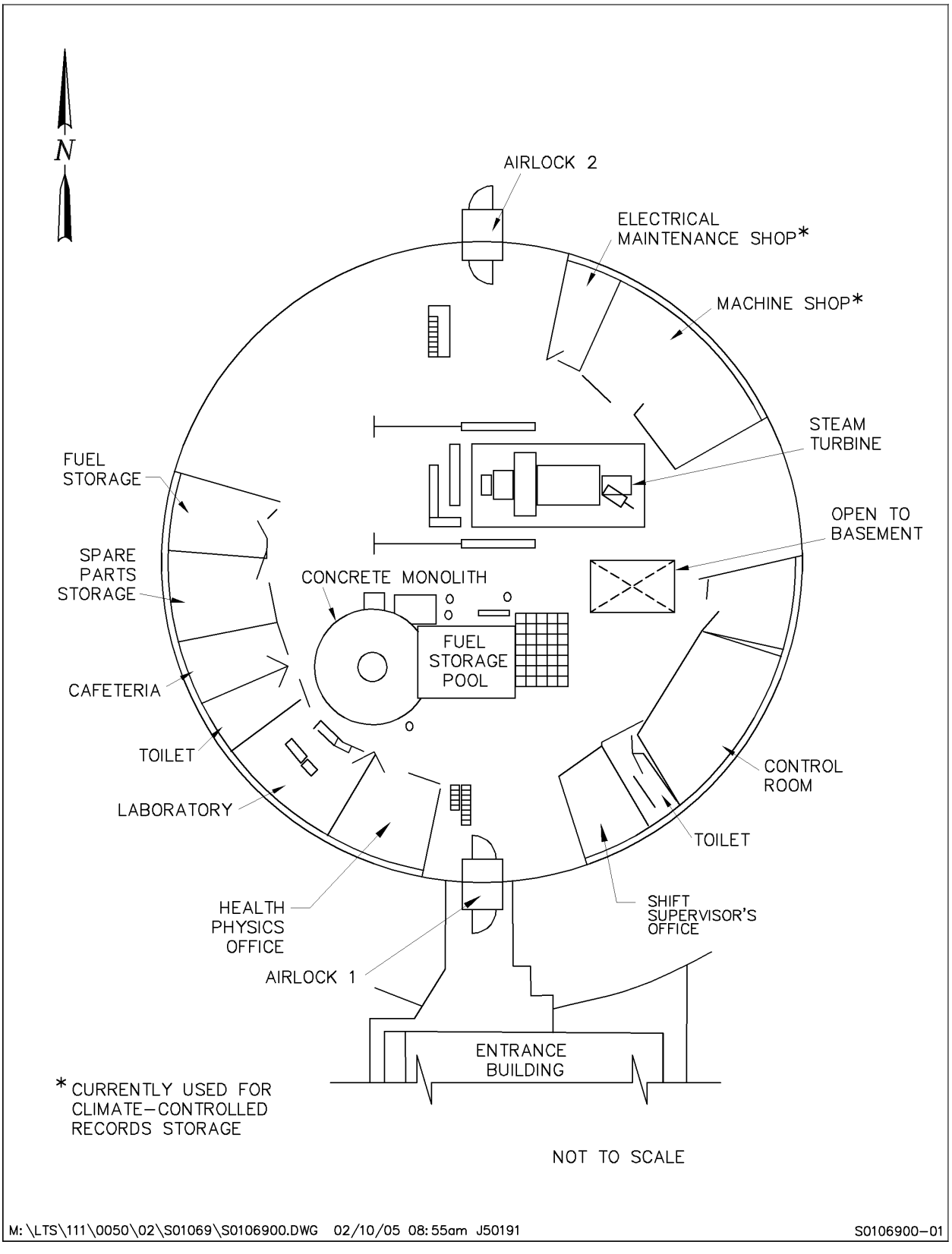

Figure 2–4. Main Floor of the BONUS Enclosed Domed Building, Rincón, Puerto Rico

Other Improvements:

Underground Storage Tanks (USTs): On the west side of the entrance buildings are two concrete USTs, owned by PREPA. The USTs contain trace amounts of radiologically contaminated sludge containing cesium-137. Before responsibility for post-closure care of the facility is transferred to the DOE Office of Legacy Management, the DOE Office of Environment Management intends to fix the contamination by filling the USTs with portland cement grout (DOE 2003c).

Access Road: The access road to the site is 0.66 mile (1 km) long, 26 feet (8 m) wide, and has a maximum grade of 3 percent. It leads from State Road 413 through the lighthouse parking lot, then through the facility entry gate, and ends at the facility parking lot.

Entrance Gate: The entrance gate near the guard shack is 24 feet (7.3 m) wide and is motor-operated.

Security Fence: A 6-foot- (1.8-m-) high chain link fence, topped with three strands of barbed wire, encloses the 5-acre site.

Parking Areas: Two parking lots, west and east of the entrance buildings, can accommodate 100 vehicles. They are constructed with crushed stone base and topped with bituminous asphalt pavement.

Landscaping: Landscaping consists of approximately 27,770 square feet (2,580 square meters [m^2]) of grass that is planted in the areas between the sidewalks, parking areas, and the enclosed domed building.

Former Electric Substation: The electric substation that connected the BONUS facility to the Puerto Rico electric grid is located in the northeast corner of the site. It is still in place but is not operational. A 6-foot- (1.8-m-) high, galvanized steel, chain-link fence with a 12-foot (3.7-m) gate encloses this area.

Water Supply: During site operations, the main source of raw water was Well No. 3, located 675 feet (206 m) south and 293 feet (89 m) west of the enclosed domed building. The well is 60 feet (18 m) deep and was pumped at a rate of 25 gallons (97 liters) per minute. Today, water at the site is provided by the Puerto Rico Aqueduct and Sewage Authority.

Zeolite Treatment Plant Housing: This structure housed the zeolite treatment plant that was used for chemically treating city and well water. It is a reinforced concrete and block structure that measures 29 feet by 16 feet (9 m by 5 m). Only the concrete structure remains today.

Drainage System: This system collects storm water through a series of intercepting catches and basins, directs the flow through underground piping, and discharges it at low points of natural drainage.

Seawater Structure and Tunnels: These structures, located west of the enclosed domed building, received and discharged seawater for condensate water cooling. Rectangular channels beneath the enclosed domed building foundation mat are connected to these structures by 42-inch

(107-cm) reinforced concrete pipelines. Currently, the structures are filled with sand to prevent access to the plant, for security and safety reasons.

Site Lighting: The site's area lighting system is currently powered by PREPA's existing infrastructure outside of the facility.

Fire Protection System: PREPA replaced the original outdoor fire protection system. The current system consists of new fire hydrants, smoke alarms with laser sensors in the main floor of the enclosed domed building, fire extinguishers, emergency and exit lights, and new fire hoses in the entrance and auditorium buildings.

2.3 Location and Access

Figure 2−1 shows the location of the site in relation to local features and roads. Access to the site is through PREPA. The primary contact for accessing the site is:

Acting Supervisor,
Environmental Studies Department
Puerto Rico Electric Power Authority
Rincón, Puerto Rico
(787) 289-4989, -4988
Attention: Arsenio Reyes (or successor)

2.4 Site History

The BONUS facility was developed as a prototype nuclear power plant to investigate the technical and economic feasibility of the integral boiling-superheating concept. It was the eighth nuclear plant constructed in the world. The facility was designed to be large enough to evaluate the major features of the integral boiling-superheating concept in a realistic manner without the high construction and operating costs associated with a large plant. The facility was constructed under the joint sponsorship of the AEC and PRWRA. Startup and initial operations were performed by Combustion Engineering, Inc., but PRWRA had responsibility for long-term operation.

Construction of the facility occurred from 1960 to 1964. The BONUS reactor first went critical on April 13, 1964. The reactor underwent a series of criticality tests and then was operated experimentally at various power levels, first as a boiler and later as an integral boiler-superheater. Full-power (50 megawatts of thermal energy [MWt]), full-temperature (900 °F [482 °C] steam) operation was achieved in September 1965, and tests demonstrated satisfactory operation at 10 percent over-power in November 1965 (West and Fragoso 1966).

The boiling portion of the BONUS reactor contained 64 fuel assemblies at the center of the core. Each assembly contained 32 fuel rods in a 6×6 square array with the 4 central rods omitted. The superheating portion of the reactor consisted of four rectangular sections, one section along each side of the boiling zone. Each superheater section contained eight superheater assemblies, and each assembly contained 32 fuel rods. At normal full-power conditions, the boiling section produced 37 MWt of heat and generated saturated steam at a pressure of 985 pounds per square inch. The superheater section produced 13 MWt of heat. In making four passes through the superheater assemblies, the steam was heated to 900 °F (482 °C). Details of the reactor's

operations are described in *BONUS Operating Experience* (West and Fragoso 1966) and *BONUS Nuclear Electric Generating Station in Puerto Rico* (PRWRA 1965).

Operation of the BONUS facility was terminated in June 1968 because of technical difficulties, which required high cost modifications. Decommissioning of the facility was conducted from 1969 to 1970. During decommissioning, all special nuclear materials (fuel) and certain highly activated components (e.g., control rods and shims) were removed, all piping systems were flushed, the reactor vessel and associated internal components within the biological shield were entombed in concrete and grout, and systems external to the entombment were decontaminated. Many contaminated and activated materials were placed in the main circulation pump room beneath the pressure vessel and entombed in concrete (PRWRA 1970). Piping was cut off at the concrete floor or biological shield, and penetrations were welded shut and grouted. Concrete monolith drawings are in the DOE site record, and final decommissioning conditions are documented in the *Boiling Nuclear Superheating Power Station Decommissioning Final Report* (PRWRA 1970). General decontamination of the facility was performed with the goal of meeting unrestricted use criteria in all accessible areas of the facility (Later radiological surveys determined that unrestricted use criteria were not met). Residual radioactive materials remaining in the facility were isolated or shielded to protect site visitors and workers.

A stainless steel time capsule, containing decommissioning documents and drawings, was placed in the concrete monolith for future recovery. It is located 19.5 feet west and 12.5 feet south of the top of the concrete monolith center located at the mezzanine. A plaque containing the following text, in English and Spanish, was imbedded in the surface of the concrete directly over the time capsule.

> BONUS NUCLEAR POWER FACILITY
> Decommissioned 1970
>
> Entombed in this structure are radioactive materials which could be hazardous if exposed. Entry is prohibited without specific authorization from appropriate officials of the Commonwealth of Puerto Rico. If the structure is breached, vacate the premises promptly and notify the Public Health Department of the Commonwealth of Puerto Rico immediately.
>
> A capsule containing drawings and technical data relative to this facility is buried in the structure. Its location and a description of its contents may be found in the records of the Puerto Rico Water Resources Authority, Main Office, at San Juan, Puerto Rico.

Estimates of the radiological inventory in the concrete monolith following decommissioning and in 2001 are presented in Table 2−1. Estimates of the radiological inventory in the piping and other systems external to the concrete monolith entombment following decommissioning are presented in Table 2−2. Following completion of decommissioning operations, approximately 53,000 curies (Ci) of radioactivity were contained within the concrete monolith, and approximately 0.013 Ci was contained in the form of scale in piping and components external to the concrete monolith (PRWRA 1970). Present-day radiological inventories are reduced, as a consequence of radioactive decay, to less than 900 Ci within the monolith and less than 900 microcuries (μCi) in the external systems. As shown in Tables 2−1 and 2−2, nickel-63 is the predominant radionuclide remaining in the entombed materials, and cesium-137 is the predominant radionuclide remaining in the external systems.

Table 2–1. Estimates of Principal Radionuclides Entombed in the Concrete Monolith

Radionuclide	Half-Life	Activity (Curies)	
		August 1968 (PRWRA 1970)	2001
Cobalt-57	271 days	2,229	0
Cobalt-60	5.27 years	15,581	203
Nickel-63	96 years	840	669
Manganese-54	312 days	1,023	0
Iron-55	2.7 years	33,586	7
TOTAL	-	53,259	879

Source: PRWRA (1970).

Table 2–2. Estimates of Principal Radionuclides in the Decommissioned Systems External to the Entombment

Radionuclide	Half-Life	Activity (Curies)	
		1968 (PRWRA 1970)	2001
Manganese-54	312 days	0.00011	-
Cobalt-60	5.27 years	0.010	0.00017
Zinc-65	244 days	0.0016	-
Silver-110m	250 days	0.0000084	-
Antimony-125	2.77 years	0.000038	-
Cesium-137	30 years	0.0015	0.00071
TOTAL	-	0.013	0.00088

Source: PRWRA (1970).

The design life of the entombment system is 140 years. After that period of time, PRWRA (1970) estimated that the largest contact dose level at any point within the entombment system would be decayed to 0.2 millirem per hour. Table 2–3 lists the activities of the principal radionuclides entombed in the reactor vessel as a function of time.

Table 2–3. Activity of Principal Radionuclides Entombed in Reactor Vessel as a Function of Time (in Curies)

Radionuclide	August 1968	+10 Years	+20 Years	+50 Years	+100 Years	+140 Years
Cobalt-57	2,229	0.184	1.5×10^{-5}	--	--	--
Cobalt-60	15,581	4,154	1,107	21	2.83×10^{-2}	1.43×10^{-4}
Nickel-63	840	778	721	573	392	288
Manganese-54	1,023	0.172	2.88×10^{-5}	--	--	--
Iron-55	33,586	185	1.02	--	--	--

Source: PRWRA (1970).

Radioactive materials that were removed during decommissioning were transported to an approved off-site disposal facility near Oak Ridge, Tennessee. Following completion of decommissioning activities, the AEC and PRWRA entered into another contract in 1971

(AT- (40-1)-4186) (see AEC 1971) for the surveillance and maintenance of the reactor containment system and monitoring of radiation at the facility. This contract terminated the contract (AT-(40-1)-2672) under which the BONUS facility was constructed and operated and, among other provisions, established that (1) at the cost of AEC, PRWRA would conduct radiological monitoring, (2) the radioactive materials would be entombed in place, (3) PRWRA would not disturb the entombed radioactive materials, (4) PRWRA would provide monitoring and maintenance of the containment system, (5) the contract would be self-renewing for periods of 1 year, and (6) PRWRA would comply with AEC requirements for occupational and public safety. Also in accordance with this contract, the components and materials contained within the entombed structure remained the property of DOE. During the 1990s, the contract ceased to be administered, and maintenance and monitoring were performed by the DOE Office of Environmental Management at Oak Ridge. Radiological monitoring and surveillance has continued at the facility to ensure the protection of public health and the environment, even though the potential for radiological exposure of the public is considered to be low.

The DOE Office of Legacy Management and PREPA (the successor organization to PRWRA) have developed a Memorandum of Understanding that establishes an enforceable contractual mechanism and delineates the responsibilities and authorities of the two parties with respect to residual radioactive materials remaining at the BONUS facility (DOE and PREPA, pending). Responsibilities of each organization are outlined in Section 3.0 of this LTS&M Plan.

2.5 Summary of Radiological Conditions at the BONUS Facility

Radiological conditions following decommissioning of the facility are documented in the *Boiling Nuclear Superheater Power Station Decommissioning Final Report* (PRWRA 1970). Following decommissioning of the facility, United Nuclear Corporation collected 284 smears from floor and wall surfaces of the enclosed domed building. Removable beta-gamma activity[2] levels were measured and ranged from nondetect to 418 dpm/100 cm^2. An additional 120 smears were collected at various locations on the entombment structure, and results from these measurements ranged from nondetect to 107 dpm/100 cm^2 beta-gamma; gamma exposure rate measurements[3] at these locations ranged from 10 to 150 microroentgens per hour (μR/h). Soil samples were collected along the beach in the area of the discharge tunnel and close to the enclosed domed building; no radionuclides were found at detectable quantities in any sample.

[2]Radioactivity on building and equipment surfaces is measured in units of disintegrations per minute (dpm) per unit surface area (100 cm^2). Removable activity refers to that portion of the total radioactivity that is accumulated by wiping a cloth or paper "smear" across the surface. DOE has specified criteria for acceptable levels of surface radioactivity for several categories of radionuclides. Because the primary radionuclides of concern (see Tables 2−1 and 2−2) at the BONUS facility emit only beta particles and/or gamma radiation, the beta-gamma category is the appropriate point of comparison. The guidelines for allowable residual surface contamination for unrestricted release for this category of radionuclides are specified in DOE Order 5400.5 as 5,000 dpm/100 cm^2 for total activity and 1,000 dpm/100 cm^2 for removable activity.

[3]Exposure rate is a measure of the ionization produced by gamma radiation in air per unit time, with units of microroentgens per hour (μR/h). Because radiation is always present in the natural environment from cosmic and terrestrial sources, the measured exposure rate should be compared to a site-specific background reading. The natural background exposure rate at the BONUS reactor facility ranges from 3 to 10 μR/h (Irizarry 1991) and averages 5 μR/h (DOE 1999a).

Post-decommissioning surveys have been conducted annually and have not indicated increases in radiation levels. Some of the observations have noted concerns from weathering on the outside of the structure, extensive overgrowth around the facility, the presence of friable asbestos, and flooding of the basement (which prevented sampling during one reporting period).

Another radiological survey was conducted in 1996 to evaluate levels of residual radioactivity in the facility (Auxier and Associates, Inc. 1997). Residue samples were collected from the facility to identify radionuclides of concern and their relative abundances. The primary radionuclide was cesium-137 (72 percent), but smaller quantities of nickel-63 (22 percent), strontium-90 (3 percent), and cobalt-60 (3 percent) were also present. Strontium-90 was not identified at all as a contributor to the radionuclide inventory in the decommissioning report, but was identified as a minor contributor in the Auxier and Associates, Inc. analysis.

Gamma exposure rate measurements inside the enclosed domed building indicated radiation levels ranging from 5 to 9 µR/h in the entrance building, 5 to 10 µR/h on the basement floor, 4 to 6 µR/h on the main operating floor, and 3 to 8 µR/h on the mezzanine and upper surfaces of the reactor. These results are similar to the natural background exposure rate range of 3 to 10 µR/h at this site. Elevated radiation levels were found on the basement and main operating floors in isolated locations, most of which were associated with liquid handling systems or larger reactor components. The maximum gamma exposure rate was measured at 500 µR/h on the north surface of the main operating floor entombment at a height of about 6 to 12 inches (15 to 30 cm) above the floor surface. Other components ranged from 15 to 30 µR/h on contact. Many of the plugged floor drains on the basement floor had elevated radiation levels on contact, but the levels decreased to the general area exposure rate range at approximately 3 feet (1 meter [m]) from the source.

The 1996 survey personnel also performed a general cleanup of the building and disposed of approximately 25 truckloads of materials from the facility, collected primarily from the former Health Physics Office, the former Chemistry Laboratory, and the former Shift Supervisor's Office (Figure 2−4). Removal of these materials was necessary to allow access to floor areas for the survey. It was estimated that these materials covered approximately 50 percent of the floor space and restricted access to the floor and lower wall surfaces for radiological characterization. Records related to BONUS facility operations and items or equipment of potential historical significance were segregated and retained. Visual inspection and radiological survey measurements were used to identify low-activity sources and contaminated materials that were not suitable for unrestricted release. Such items generally were relocated to the former Health Physics Office for further evaluation and disposition by PREPA. Items containing other (nonradioactive) potentially hazardous substances also were identified and generally relocated to the former Chemistry Laboratory for further evaluation and disposition by PREPA. No contamination was detected on the other materials surveyed. Of these materials, 25 batches of BONUS-related records were retained in the former Shift Supervisor's Office, and the remainder were disposed of at an off-site landfill as nonhazardous waste.

In 1997, Shonka Research Associates, Inc. (1997), under subcontract to the Jacobs EM Team, conducted a detailed characterization survey to assess the levels of radioactivity remaining at the BONUS facility. This survey evaluated 100 percent of accessible floor surfaces and the building walls to a minimum height of 1 m (3.3 feet) above the floor surface for fixed and removable beta-gamma contamination. A survey of external gamma exposure rates also was performed. Air

samples collected within the building had no detectable airborne activity (the minimum detectable level was 9.9×10^{-12} µCi/milliliter). Soil samples were collected from areas adjacent to the building, and ground water monitor wells were installed to sample shallow ground water. No radionuclides potentially attributable to BONUS operations were identified in the soil or ground water samples. The relative abundance of radionuclides in a sample of dust collected from the basement floor was estimated at 88.66 percent cesium-137, 9.14 percent nickel-63, 1.36 percent cobalt-60, and 0.84 percent strontium-90. A summary of the surface contamination data is presented in Table 2−4.

Table 2–4. 1997 BONUS Enclosed Domed Building Radiological Measurements

BONUS Enclosed Domed Building Location	Surface Count Rate (dpm/100 cm^2)	Surface Activity (picocuries/m^2)			
		Cesium-137	Nickel-63	Cobalt-60	Strontium-90
Main Reactor Ring	1.98E+04	7.96E+05	8.21E+04	1.22E+04	7.54E+03
Reactor Top and Mezzanine	1.51E+05	6.09E+06	6.28E+05	9.32E+04	5.76E+04
Main Rooms	9.25E+03	3.73E+05	3.84E+04	5.71E+03	3.53E+03
Center	1.74E+06	7.01E+07	7.23E+06	1.07E+06	6.64E+05
Basement	1.25E+05	5.02E+06	5.17E+05	7.68E+04	4.75E+04
Main Floor Visitor Area	1.32E+04	5.31E+05	5.48E+04	8.13E+03	5.03E+03
Reactor Floor	1.62E+05	6.55E+06	6.75E+05	1.00E+05	6.20E+04

Source: Shonka Research Associates, Inc. (1997).

This surface contamination survey was conducted in a manner that ensured a detection limit of 1,000 dpm/100 cm^2 averaged over 1 m^2. The survey was designed to identify localized areas of contamination (hot spots) with more than three times the average detection limit (or 3,000 dpm/100 cm^2). The detection of such hot spots was difficult, however, because of elevated and highly variable background radiation fields. Hence, some of the localized areas of elevated contamination reported in the survey at levels above 3,000 dpm/100 cm^2 may actually be below the criterion. Where possible, survey personnel used a surface contamination monitor (SCM) device, which employs an array of computerized radiation detectors, including a position-sensitive proportional counter, to scan entire surface areas. Areas of elevated contamination exceeding release limits included portions of the basement, particularly the southwest quadrant of the basement, and localized areas of the main floor and mezzanine. Survey results included the following:

Auditorium: The auditorium was measured for fixed radioactivity in a single survey unit using the SCM. None of the 1-m^2 areas measured had average activity exceeding 1,000 dpm/100 cm^2, and only a single 100-cm^2 area had activity exceeding the 3,000 dpm/100 cm^2 criterion. This reading was believed to be a false positive attributed to variability in background. In a survey for removable radioactivity, none was detectable in the auditorium.

Enclosed Domed Building, Basement: The floors of the basement rooms and open areas were surveyed for fixed radioactivity in a series of 29 survey units. Surveys also were performed for the lower walls (0–1 m). Most survey areas in the basement had one or more 1-m^2 sections where activity exceeded 1,000 dpm/100 cm^2. The highest levels of contamination were found in the southwest quadrant of the basement around process equipment and appeared to be the result of a liquid spill.

Removable radioactivity was surveyed on the basement floors, walls (0–1 m), and reactor piping and equipment. Removable activity above the MDA was identified in several areas: along the southern side of the reactor, the Switch Area and Station Battery Area, the Condensate Resin Regeneration Room, the open area at the bottom of the southern stairwell, the Blower and Filter for Reactor Vessel Annulus Exhaust Room, and the 4,000-Gallon Retention Tank Room. Reactor equipment having removable radioactivity included the tanks in the 4,000-Gallon Retention Tank Room, Condensate Pumps, the platform in the Reactor Purification and Reheat Room, a sample sink, and a basin beneath Shield Cooling Pump No. 2. The *Summary Report for the Radiological Survey of the Boiling Nuclear Superheat (BONUS) Research Reactor, Rincón, Puerto Rico* (Jacob Environmental Management Team 1998) provides a detailed summary of these results.

Enclosed Domed Building, Main Floor: The main floor was surveyed for fixed radioactivity using 42 survey units. Results indicated that 16 percent of the surveyed area exceeded the 1,000 dpm/100 cm^2 guideline for activity averaged over 1 m^2, and 19 percent exceeded the 3,000 dpm/100 cm^2 guideline. One area of radioactivity was found near the north face of the reactor under a pipe coupling. The highest reading in a 100-cm^2 area was over 12 million dpm/100 cm^2. This same area had the highest waist-high gamma exposure rate of 50 µR/h (this location corresponds to the same area where Auxier and Associates, Inc. [1997] measured 500 µR/h). Some of the radioactivity was removable, and the areas were decontaminated to levels lower than 200 dpm/100 cm^2. The area of highest fixed radioactivity was covered with lead bricks to provide further exposure protection. The lower walls (0–1 m) were surveyed throughout the main floor; radioactivity above guidelines was found only along the north face of the concrete monolith.

As in the basement, there were various items on the main level that had levels of fixed radioactivity in excess of the guidelines. Some of these items had removable radioactivity but were decontaminated during the survey to levels below the most restrictive guideline. Fixed radioactivity on these items ranged from 1,082 to 296,960 dpm/100 cm^2. One notable area was a sink near the main air lock. The *Summary Report for the Radiological Survey of the Boiling Nuclear Superheat (BONUS) Research Reactor, Rincón, Puerto Rico* (Jacob Environmental Management Team 1998) provides details of these results.

Concrete Monolith Top and Mezzanine: The concrete monolith top and mezzanine were surveyed for fixed radioactivity in a series of four units. Results indicated that 13 percent of the surveyed area exceeded the 1,000 dpm/100 cm^2 guideline, and 12 percent exceeded the 3,000 dpm/100 cm^2 guideline. The highest levels were found in a groove in the monolith top where the wheels of the crane move. Localized radioactivity of approximately 150,000 dpm/ 100 cm^2 was found. No fixed radioactivity was detected above guidelines on the walls. No removable radioactivity above the MDA was detected on this level. The *Summary Report for the Radiological Survey of the Boiling Nuclear Superheat (BONUS) Research Reactor, Rincón, Puerto Rico* (Jacob Environmental Management Team 1998) provides details of these results.

Outside the enclosed domed building, the natural background gamma exposure rate was estimated at approximately 5 µR/h at the site perimeter. All areas of the site had gamma exposure rates similar to this rate with the exception of two areas: a location near the north emergency air lock, which had readings of 10 µR/h at 1 m, and a location near the reactor air exhaust stack, which had readings of 320 µR/h at contact with the ground surface and 17 µR/h at

1 m. The high readings at this second location were from two contaminated bolts. Readings returned to background levels after these bolts were removed.

Based on the results of this survey, the following recommendations were made to reduce the potential for exposure to radioactive material:

- Cover[4] the higher level of radioactivity measured on the floor near the north reactor face under the pipe coupling with a minimum of 10 inches (25.4 cm) of concrete to reduce the 1-m exposure rate to facility background levels.

- Sweep and mop the basement floor to collect loose radioactivity.

- Prohibit public access to the basement or ensure by some means (e.g., placing a security guard or raising the height of the plexiglass wall) that the public cannot climb over the plexiglass wall. Public access should also be prohibited from other areas of the basement, including the 4,000-gallon Retention Tank Room, Condensate Pump Room, Reactor Purification and Reheat Room, Reactor Feedwater Room, Condensate Resin Regeneration Room, and the Vapor Sphere Room; these rooms should be secured with a locking door or similar barrier to prevent public access.

- Paint or otherwise cover (e.g., tile) floors in all areas that will be accessible to the public, to ensure that any residual radioactivity will remain fixed and does not become removable in the future. If paint is used, two coats of different colors should be applied so that it will be evident when the surface coat becomes worn.

PREPA completed all of these recommended actions in 1999. Additionally, in 2004, PREPA fixed removable contamination in the basement (URS Ltd. report pending).

Results of the most current radiological surveys of the facility are in the annual Sampling and Inspection Reports for the BONUS facility site (Webb 2001b and 2002). Radiological conditions on the basement level of the enclosed domed building are expected to change after removable contamination is cleaned up by the DOE Office of Environmental Management in the near future and DOE places concrete on the basement floor (DOE 2003c).

2.6 Geology

The BONUS site is located in a coastal lowland area on the western coast, near Rincón. Thirty-one core-holes were drilled to determine subsoil conditions during the design and construction of the enclosed domed building foundation slab. These cores indicated that the top stratum typically consisted of silty sand and cemented sand as sandstone in different degrees of strength and varying in thickness from 7 to 17 feet (2 to 5.3 m). Some sandstone required boring with a diamond drill. Underlying this upper stratum was a heterogeneous mass of sandy clay and silt

[4] In cases where residual radioactivity cannot be readily removed to achieve criteria, these areas may be covered to reduce potential radiation exposures. Cover materials may include paint, floor tiles, concrete, etc. The purpose of such materials is both to provide additional shielding, which will reduce external gamma exposure rates, and also to help ensure that the residual radioactivity remains fixed to building surfaces and does not become readily removable.

with pieces of limestone rock and silty clay or sand. Most of the borings terminated in a gray and brown silty clay stratum about 100 feet (30 m) deep (DOE 2002).

2.7 Seismicity

Puerto Rico is located in an active seismic region (Zone 2 category). Numerous earthquakes have been recorded in this area, dating from 1615 to the present. The strongest earthquakes affecting Puerto Rico occurred in 1670, 1787, 1867, and 1918, resulting in numerous fatalities and severe economic damage. During 2000, 735 seismic events were detected in this region by the Puerto Rico Seismic Network (Puerto Rico Seismic Network 2001, cited in DOE 2003a). The month of greatest seismic activity was May, with 51 events. Of these, only 2.3 percent were reported as felt. The largest earthquake during 2000, recorded at a magnitude of 4.9 (Richter Scale) and an intensity of IV (Modified Mercalli Scale), occurred on December 11. Within the island of Puerto Rico, the most active region is south of an imaginary line that extends from Rincón to Guayama.

No evidence of damage (e.g., cracks, corrosion, wear, or deflections of concrete or metal components) to the BONUS facility as a result of seismic events has been identified to date. Because the 7-foot-diameter, 3-inch-thick steel reactor vessel and all associated piping and facilities have been filled with grout or concrete and encased in a reinforced concrete shell 10 feet wide, and because no liquid or gaseous materials are present that might be susceptible to release, the physical characteristics of the concrete monolith would not be susceptible to release of hazardous materials even in the event of structural damage from a severe earthquake or hurricane.

2.8 Surface Water

No surface water features are present at the BONUS site. The site is located approximately 300 feet (100 m) inland from the Atlantic Ocean.

2.9 Ground Water

In the immediate area of the BONUS site, shallow ground water occurs in a weathered limestone unit. Three monitor wells installed at the site in 1997 intersected the water table at depths of approximately 23 to 40 feet (7 to 12 m) below ground surface (Jacobs Environmental Management Team 1998a and 1998b). The DOE Office of Environmental Management is scheduled to close these wells in the near future (DOE 2002 and 2003c).

2.10 Threatened or Endangered Species

The BONUS site that surrounds the facility lies within the range of the endangered hawksbill sea turtle (*Eretmochelys imbricata*), the leatherback sea turtle (*Dermochelys coriacaea*), and the endangered plant *Buxus vahlii*. The beaches adjacent to the site provide potential nesting habitat for the two species of sea turtle. A population of *Buxus vahlii* is present on this property (owned by PREPA adjacent to the BONUS facility). This plant species is known to exist only on Puerto Rico and St. Croix. The population adjacent to the facility is one of the five known locations of the plant on the island of Puerto Rico, and it is one of the largest.

3.0 Requirements of the Memorandum of Understanding

Under the terms of the *Memorandum of Understanding between the U.S. Department of Energy Office of Legacy Management and the Puerto Rico Electric Power Authority for the Use, Maintenance, and Control of the Boiling Nuclear Superheater Reactor Facility in Rincón, Puerto Rico* (Appendix A), both PREPA and DOE accept specific responsibilities and duties.

PREPA responsibilities include:

- Granting DOE right of entry to the PREPA property and improvements thereon for inspections, monitoring, consultation, access to records, remedial investigations and activities, and other purposes. This right shall remain in effect for as long as radioactive materials at the BONUS facility exceed limits for unrestricted release, unlimited exposure, and unrestricted recycling or disposal.

- Implementing and maintaining a radiation protection program. PREPA shall conduct radiological protection activities in accordance with the RPP Plan (DOE 1999a), BONUS Radiological Control Manual (DOE 1998), BONUS Sampling and Analysis Plan (SAP) (DOE 1999b), and PREPA's Standard Operating Procedures (PREPA 1998).

- Complying with the reporting requirements specified for the radiation protection program for the BONUS facility, including requirements for submitting duplicate records to DOE to be incorporated into the site collection.

- Supplying all equipment, supplies, and labor needed to perform the annual surveillance and maintenance duties identified in this LTS&M Plan and being responsible for the maintenance, calibration, and safety of such equipment in accordance with the BONUS Radiological Control Manual (DOE 1998).

- Notifying DOE if radiological measurements indicate that standards or limits identified in the RPP Plan (including ALARA limits) are exceeded or if radiological survey results indicate a significant change in conditions and controlling dispersion of materials and access to and exposure from the affected areas until DOE management has responded to the notification.

- Conducting quarterly visual inspections of the facility and submitting quarterly inspection reports to the DOE Project Manager.

- Maintaining custody of records generated during routine or annual monitoring, surveillance, inspections, and nonroutine sampling and monitoring events and maintaining custody of historical records, including records documenting construction, operations, and decommissioning.

- Maintaining control of the entire BONUS facility, protecting employees and the public by maintaining appropriate restrictions and controls for areas with contaminant levels above acceptable criteria, and controlling access to areas with physical hazards.

- Maintaining the site in a safe and structurally sound condition for access by workers and the public. Maintenance includes, but is not limited to, ensuring the integrity of any

remaining asbestos encapsulation and preventing exposure to electrical and any other nonradiological hazards.

- Assuming all liability associated with use of the BONUS facility as a museum open to the public, including being responsible for any loss or destruction of, damage to, or redistribution of, DOE-owned property caused by the activities of PREPA.

DOE responsibilities include:

- Concurring (in writing) with plans and procedures, and in revisions to these documents, insofar as they pertain to maintaining the radiological safety of visitors, workers, and the public at the BONUS facility.

- Auditing PREPA adherence to the RPP Plan (DOE 1999a) and other applicable guidance, policy, laws, and regulations.

- Conducting periodic inspections of the BONUS facility in accordance with this LTS&M Plan and submitting a written record of inspection results to PREPA.

- Documenting inspections and other site-related activities for the LTS&M site records collection; maintaining site records, including pertinent historical records, annual reports of site physical and radiological conditions, releases, and emergency responses, as part of the DOE LTS&M site records collection.

- Approving all activities that result in accessing contaminated or regulated material.

- Disposing of radioactive waste generated as a result of maintenance or structural repairs at no cost to PREPA if DOE has approved in advance the activity resulting in waste generation.

4.0 Long-Term Surveillance and Maintenance Program

4.1 Radiological Surveys

PREPA will conduct quarterly and annual surveys to assess radiological conditions throughout the enclosed domed building in accordance with the procedures in the Standard Operating Procedures [SOP] (PREPA 1998), the BONUS SOP (DOE 1999b), and the SOP Addendum (Webb 2001a). Quarterly and annual sampling will be performed at the locations identified in the SOP, as modified by the Addendum. Both gamma exposure rate monitoring and contamination level monitoring will be conducted. PREPA will submit an annual report of survey results to the DOE Project Manager for review and comment within 60 days of conducting the last survey of a calendar year. The report will include the results of radiological surveys conducted since the previous annual report. Annual reports will be available to the public and other agencies.

At its discretion, DOE will conduct independent radiological surveys of the facility or will accompany PREPA personnel during a regular scheduled survey.

Gamma Exposure Rate Monitoring: Gamma exposure rate measurements will be obtained to determine the gross radiation level associated with the entombment structure and the external piping system. In addition, five random measurements will be collected in areas permitted for public access. Additional measurements will be collected if any of the following conditions exist:

- If the inspector observes excessive deterioration of the structures during visual inspection.
- If any of the readings from the normal data collection points indicate a gamma exposure rate in excess of 0.4 microroentgens per hour (400 μR/h).
- If the inspector observes any conditions that justify additional measurements.

Gamma exposure rate measurement data will be tabulated on data sheets indicating the sampling locations, instrument identification (i.e., model and serial number), date of calibration, time of daily check, date of inspection, and inspector. If additional gamma exposure rate measurements are collected, information such as (1) the reason for taking additional measurements, (2) the number and location of the measurements, and (3) observations and/or conclusions relative to the measurements, such as sampling conditions or procedures employed, will be recorded.

Contamination Level Monitoring: Direct beta-gamma measurements and smears will be taken in the same locations as the gamma exposure rate measurements. Collection of these measurements are designed to determine gross contamination levels associated with the entombment structure and the external piping system. In addition, random sampling will include five large area swipes in five locations in areas where public access is permitted. Additional total surface contamination smears will be taken if any of the following conditions exist:

- If the inspector observes excessive deterioration of the structures during visual inspection.
- If any of the measurements from the normal data collection points indicate a contamination level in excess of 1,000 dpm (beta/gamma)/100 cm^2 removable contamination and/or 5,000 dpm (beta/gamma)/100 cm^2 total surface contamination.
- If the inspector observes any conditions that justify additional measurements.

Contamination smear data will be tabulated on data sheets indicating the sampling locations, date of inspection, and inspector. If additional direct and smear measurements are taken, information such as (1) the reason for taking additional measurements, (2) the location of the contamination, and (3) observations and conclusions relative to taking the measurements, such as sampling conditions or procedures employed, will be recorded.

4.2 General Inspection of the Facility by PREPA

PREPA will conduct quarterly visual inspections of the facility to evaluate the structural adequacy of the building, the general condition of the containment of both the entombment and the external systems, and the condition of areas open to public access. Inspection results will be summarized in a letter or memorandum addressed to the DOE Project Manager within 30 days of the inspection. The inspection will consist of the following:

Concrete Monolith Exterior: PREPA will conduct a visual inspection of the exterior concrete surfaces of the entombment structure. Inspectors will look for evidence of cracking that could result in loss of structural or containment integrity or reduce the effectiveness of the concrete for shielding purposes. If PREPA inspectors observe cracking, PREPA will conduct gamma exposure rate monitoring. If levels of radiation are found above acceptable criteria, PREPA will immediately restrict access and report the condition to the DOE Project Manager. The DOE Project Manager will then inform PREPA of the course of action to follow.

Concrete Monolith Penetrations: PREPA will visually examine entombment penetrations for evidence of cracking at weld joints or spalling of concrete. If PREPA observes degradation of penetration sealing systems, PREPA will conduct gamma exposure rate monitoring. If levels of radiation are found above acceptable criteria, PREPA will immediately restrict access and report the condition to the DOE Project Manager. The DOE Project Manager will then inform PREPA of the course of action to follow.

External Piping Systems: PREPA will visually inspect external piping systems for corrosion, leaks, or integrity breaches. If PREPA finds visual indications of leakage or other failure, PREPA will conduct gamma exposure rate monitoring. If levels of radiation are found above acceptable criteria, PREPA will immediately restrict access and report the condition to the DOE Project Manager. The DOE Project Manager will then inform PREPA of the course of action to follow.

Basement: PREPA will inspect the basement to determine if water is accumulating. If water is present, PREPA will immediately inform the DOE Project Manager. PREPA and the DOE Project Manager will agree on the appropriate action, which will be in accordance with the RPP.

Main Floor: PREPA will inspect the main floor area to determine the condition and proper placement of access control barricades, ceramic floor tiles, and lead blocks.

Mezzanine: PREPA will inspect the condition and proper placement of access control barriers to the mezzanine level.

General Exterior Conditions: Inspectors should note changes within the 5-acre BONUS facility. Changes that might be significant include new development, changes in land use, and

stability of hill slopes around the facility. Changes in land use and conditions beyond the 5-acre site should be noted, as well.

Special inspections will be made immediately following any unusual and potentially destructive event such as extreme weather, earthquake, or tidal wave.

Inspectors should use photographs, as necessary, to support or supplement written observations. Photograph documentation should include noting the location of the photograph on a map and noting the azimuth of the photograph. Photographs may be electronic files, computer disc files, or prints and negatives.

4.3 General Inspection of the Facility by DOE

At its discretion, DOE will conduct independent inspections of the facility or will accompany PREPA personnel during a regularly scheduled inspection. DOE will contact PREPA and the Mayor of Rincón (for public participation purposes) to inform them of impending visits.

4.3.1 Inspection Checklist

If DOE conducts an inspection, BONUS site managers will brief inspectors and the inspection checklist will be reviewed before the inspection. A sample inspection checklist is provided in Appendix B. The checklist includes:

- Specific site surveillance features to be inspected.
- Routine observations to be made.
- Special issues or problems to be evaluated.

The checklist will be reviewed before and after the inspection and, if necessary, revised to reflect changes or new conditions at the site. The checklist will be accompanied by a copy of the *Office of Land and Site Management Project Safety Plan* (DOE 2004). This plan includes general and site-specific health and safety requirements for the inspection, including a list of local medical and emergency services.

4.3.2 Personnel

For a DOE inspection, typically a team of two or more inspectors will be assigned to conduct the inspection. Inspectors will be trained and experienced scientists, engineers, and/or radiological control technicians. The inspection team will be selected on the basis of skills and experience appropriate to the issues or concerns at the site. A radiological control technician must conduct the radiological surveys. If serious or unique conditions develop at the site, additional inspectors, specialized in specific fields, may be assigned to the inspection team.

4.3.3 Reporting

Inspectors shall report inspection results to key personnel from DOE and PREPA.

For DOE:
Project Manager
U.S. Department of Energy
Office of Legacy Management,
Office of Land and Site Management
(304) 285-4991
Attention: Ron Staubly (or successor)

For PREPA:
Acting Supervisor
Environmental Studies Department
Puerto Rico Electric Power Authority
Rincón, Puerto Rico
(787) 289-4989, -4988
Attention: Arsenio Reyes (or successor)

The above persons or their successors and staff shall be referred to collectively as the BONUS Facility Joint Management Team ("Joint Management Team").

4.4 Follow-Up Inspections

Follow-up inspections may be conducted in response to significantly new or changed conditions at the site. DOE and/or PREPA will conduct a follow-up inspection when:

- A condition is identified during a quarterly or annual inspection (or other site visit) that requires personnel, perhaps with special expertise, to return to the site to evaluate the condition.

- DOE or PREPA is notified by a citizen or outside agency that conditions at the site are substantially changed.

DOE or PREPA may request the assistance of local agencies to confirm the seriousness of a condition before conducting a follow-up inspection. Results of follow-up inspections will be described in a separate report that is submitted to the DOE Project Manager and PREPA supervisor within 30 days of the inspection.

4.5 Facility Maintenance

PREPA, as owner of the BONUS facility and its contents (except for the radioactive material) is responsible for maintaining the site in a safe and structurally sound condition for access by workers and the public and to maintain the integrity of the concrete monolith.

4.6 Emergency Response

A coordinated emergency response by the Joint Management Team may be required if unusual damage or disruption were to occur that could threaten or compromise site safety, security, or integrity. The information in Table 4−1 is a guide to the actions DOE and/or PREPA may take in response to a variety of potential problems.

Table 4–1. Criteria for Emergency Response

Priority	Event	Example	Response
1[a] (Urgent)	Extensive site damage	Earthquake or tidal wave causes damage to the enclosed domed building and flooding occurs	1. Notify Joint Management Team. 2. Conduct immediate follow-up inspection by DOE/PREPA emergency response team. 3. Determine level of radioactive release, if any. 4. Determine a course of action to repair facility.
2	Breach of site security with or without removal of radioactive materials	Willful human intrusion; significant vandalism	1. Notify Joint Management Team. 2. Assess damage. Perform risk assessment, if warranted. 3. Repair damage. 4. Evaluate current level of security. 5. Harden security, as necessary.
3	Erosion or instability of land surrounding the site	Erosion or deposition of sediments that affect the site, possibly after a hurricane or severe storm.	1. Assess damage. Perform risk assessment, if warranted. 2. Repair damage, if necessary. 3. Stabilize eroded area, if necessary.

[a]Priority highly dependent upon scale and on-site evaluation.

The table shows that the difference between various emergency responses is primarily one of risk or urgency. In the event of a Priority 1 or 2 event, an emergency response team will assess the damage and decide whether evaluation of the problem is required or if immediate intervention (corrective action) is essential. This decision will be based on the Joint Management Team's evaluation of the adequacy of the damaged feature to perform its intended function. To make this decision, the Joint Management Team will assess and evaluate the following. The evaluation may include risk analysis.

- Adequacy of the design specifications for the damaged feature to control or accommodate the observed problems.
- Extent of the damage, degradation, or departure from the design (or as-built condition) of the damaged feature.
- Ability of the feature, in its damaged condition, to withstand a design-basis event.

In the *Environmental Assessment for Authorizing the Puerto Rico Electric Power Authority (PREPA) to Allow Public Access to the Boiling Nuclear Superheat (BONUS) Reactor Building, Rincón, Puerto Rico* (DOE 2003), an accident analysis was conducted for the enclosed domed building. Results of this analysis indicated that no radioactive or hazardous materials at the facility would be available for release under plausible accident scenarios.

In 1969, a design-based accident analysis was generated by PRWRA and validated by the former AEC Division of Reactor Licensing for a severe earthquake and tidal wave scenario

(DOE 2002). The earthquake was assumed to crack the enclosed domed building, the steel entombment liner, the concrete wall around the pressure vessel, the shield tank, the grout between the shield tank and the pressure vessel, and finally, the bottom of the pressure vessel. The enclosed domed building foundation was assumed to remain watertight and to be flooded to the level of the highest adjacent ground, about 2 feet (0.6 m) above the bottom of the pressure vessel. It was also assumed that the pressure vessel internals had been corroding at a conservatively high rate and that the corrosion products would be released instantaneously into the flood water when the building was flooded. Ingestion and contact dose calculations indicated that the concentrations for nickel-63 did not exceed the maximum permissible body burden of 200 µCi for ingestion. On the basis of this information, the specifications for construction of the entombment system, and the most recent DOE inspection, the existing entombment would be capable of withstanding anticipated accidents.

A flood involving the basement area may occur during a major hurricane. Historical evidence indicates that the basement was flooded during Hurricane Georges in 1998 as a result of plugged storm water drains, defective door seals, and excessive runoff. Flood water was allowed to evaporate from the area, and repairs were made to prevent recurrence.

In the event that a person such as an errant visitor gains access to the basement, the exposure rate, assuming an 8-hour stay, would be much less than a typical worker dose of 54 millirem per year (mrem/year). In addition, this dose would be far less than the primary dose limit of 100 mrem/year specified by DOE Order 5400.5 for members of the public.

4.7 Records

The DOE Office of Legacy Management maintains active records for the BONUS facility at its office in Grand Junction, Colorado. Inactive records will be stored at a federal records center. Records contain information essential to the long-term care and custody of the site pursuant to applicable laws and regulations. Records include the BONUS facility decommissioning plan, radiological survey reports, environmental assessment, Finding of No Significant Impact, annual site inspection reports, and other site-specific documents. Records in the DOE site collection addressing BONUS design, construction, operation, and decommissioning are duplicates of records managed by PREPA.

These records are available for agency and public inspection. Selected documents are available online at http://www.gjo.doe.gov/programs/LTSM.

Records for the BONUS facility are maintained in compliance with DOE requirements:

- DOE Order 200.1, *Information Management Program*.
- 36 CFR Parts 1220−1236, “National Archives and Records Administration.”

4.8 Public Participation

DOE seeks to encourage public participation in the surveillance and maintenance process at the BONUS facility site. DOE will accomplish this by:

- Disseminating site information through its website at http://www.gjo.doe.gov/programs/LTSM, such as the LTS&M Plan and inspection results.
- Contacting the mayor of Rincón before making site visits.
- Responding to citizens' requests.

Through these activities, DOE hopes to ensure that the public and key community leaders are kept informed of site activities and status changes.

4.9 Quality Assurance

The long-term care of the BONUS facility and activities related to the annual surveillance, monitoring, and maintenance of the site comply with DOE Order 414.1A, *Quality Assurance*, and ANSI/ASQC E4-1994, *Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs* (American Society for Quality Control 1994). Project-specific quality assurance requirements are detailed in the *Quality Assurance Program Plan for the Long-Term Surveillance and Maintenance Program* (DOE 2003d).

Quality assurance requirements are transmitted to subcontractors through procurement documents when appropriate.

4.10 Health and Safety

LTS&M activities are conducted in accordance with health and safety procedures established for the LM−50 Program. These procedures are consistent with DOE orders, regulations, codes, and standards.

Health and safety concerns specific to DOE work at the BONUS facility are in the *Office of Land and Site Management Project Safety Plan* (DOE 2004). This plan contains a list of emergency telephone numbers and addresses for local fire, hospital, ambulance, and police or sheriff, as well as a map to the nearest emergency medical facility. Personnel are briefed on health and safety requirements during a pre-inspection meeting. DOE inspectors will carry a copy of this plan and will conduct and document a site safety briefing before conducting an inspection.

DOE maintenance subcontractors are advised of health and safety requirements through appropriate procurement documents. Subcontractors are required to have a health and safety program that complies with Occupational Safety and Health Administration standards. Work will be conducted under the requirements of the *Office of Land and Site Management Project Safety Plan*. A Job Safety Analysis will be developed by the contractor and subcontractor to address hazards and mitigation.

End of current text

5.0 References

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Appendix A

Memorandum of Understanding
Between the U.S. Department of Energy Office of Legacy Management and the Puerto Rico Electric Power Authority

The Memorandum of Understanding will be appended when finalized.

Appendix B

Inspection Checklist

Inspection Checklist
BONUS Decommissioned Reactor Facility, Rincón, Puerto Rico

Date of This Revision: _____

Last Inspection: _____

Inspectors: _____ and _____

Next Inspection (Planned): _____

No.	Item	Issue	Action
1	Specific site surveillance features	See attached table.	Inspect.
2	Enclosed domed building—entombed concrete monolith and monolith penetrations	Structural defects or degradation can result in loss of containment of radioactive materials.	Inspect for possible indications of structural problems, such as cracking, staining, and spalling.
3	Enclosed domed building—external piping systems	Systems were flushed during decommissioning. Incidental contamination remains, which may be released if systems corrode or otherwise fail.	Inspect for possible indications of deterioration, such as peeling and blistering paint, staining, and flaking.
4	Enclosed domed building—basement	Some areas contain radiological contamination in excess of DOE standards; the general public is not allowed access to contaminated areas.	Note condition of access control barricades.
5	Enclosed domed building—basement flooding	Water accumulating in basement may mobilize and redistribute surface contamination.	Inspect for gasket and storm water drains.
6	Enclosed domed building—main floor	Some areas contain radiological contamination in excess of DOE standards; the general public is not allowed access to contaminated areas.	Note condition of access control barricades, ceramic floor tile, and lead blocks; note general housekeeping.
7	Enclosed domed building—mezzanine	Some areas contain radiological contamination in excess of DOE standards; the general public is not allowed access to contaminated areas.	Note condition of access control to mezzazine; note general housekeeping.
8	Enclosed domed building—exterior	Building should appear well maintained	Visually inspect.
9	Surrounding land	New or changing features or activities adjacent to the site may affect site security.	Note changes within 0.25 mile (400 m) of site.
10	General site upkeep	Building should appear well maintained.	Observe and evaluate changes in site conditions.
11	Site security	Security guard should be stationed at site at all times.	Ensure security guard is present.
12	Erosion	Ensure that hill slopes and beach adjacent to site are not actively eroding in a way that could adversely affect the facility.	Evaluate erosional features on adjacent slopes and beach.

Checklist Of Site Specific Surveillance Features
BONUS Decommissioned Reactor Facility, Rincón, Puerto Rico

Feature	Comment
Access road and parking area	Asphalt
Entrance gate	Motor-operated
Access through security gate	Note security of site; sign-in required on log sheet
Security fence	Chain-link, topped with three strands of barbed wire
Enclosed domed building—monolith plaques	Visually inspect