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22 March 2005

Reference: BYR-2005-019

Mr. Daniel Hall, Section Chief
Solid Waste Management
Massachusetts Department of Environmental Protection
Western Regional Office
436 Dwight Street
Springfield, MA 01103



RE: Revised Beneficial Use Determination for Structures
Yankee Nuclear Power Station, Rowe, MA

Dear Mr. Hall:

Environmental Resources Management (ERM), on behalf of Yankee Atomic Electric Company (YAEC), is pleased to submit a revised Beneficial Use Determination (BUD) for Structures at the Yankee Nuclear Power Station (YNPS) in Rowe, Massachusetts. This submittal replaces the BUD for Structures application dated on 22 September 2004. The revised BUD application is intended to allow concrete slabs and foundations to remain in-place, to allow concrete and asphalt to be processed and used for site grading, and to allow inactive subsurface utility lines to remain in-place. As discussed with the Department, this submittal is being made with the same transmittal and application forms as the original submittal.

We appreciate your support of this project. Should you have questions or require additional information, please contact Mr. Kenneth W. Dow, Environmental Manager, at (413) 424-2245.

Sincerely,

John W. McTigue
FOR John W. McTigue, P.G., LSP
Principal-in-Charge

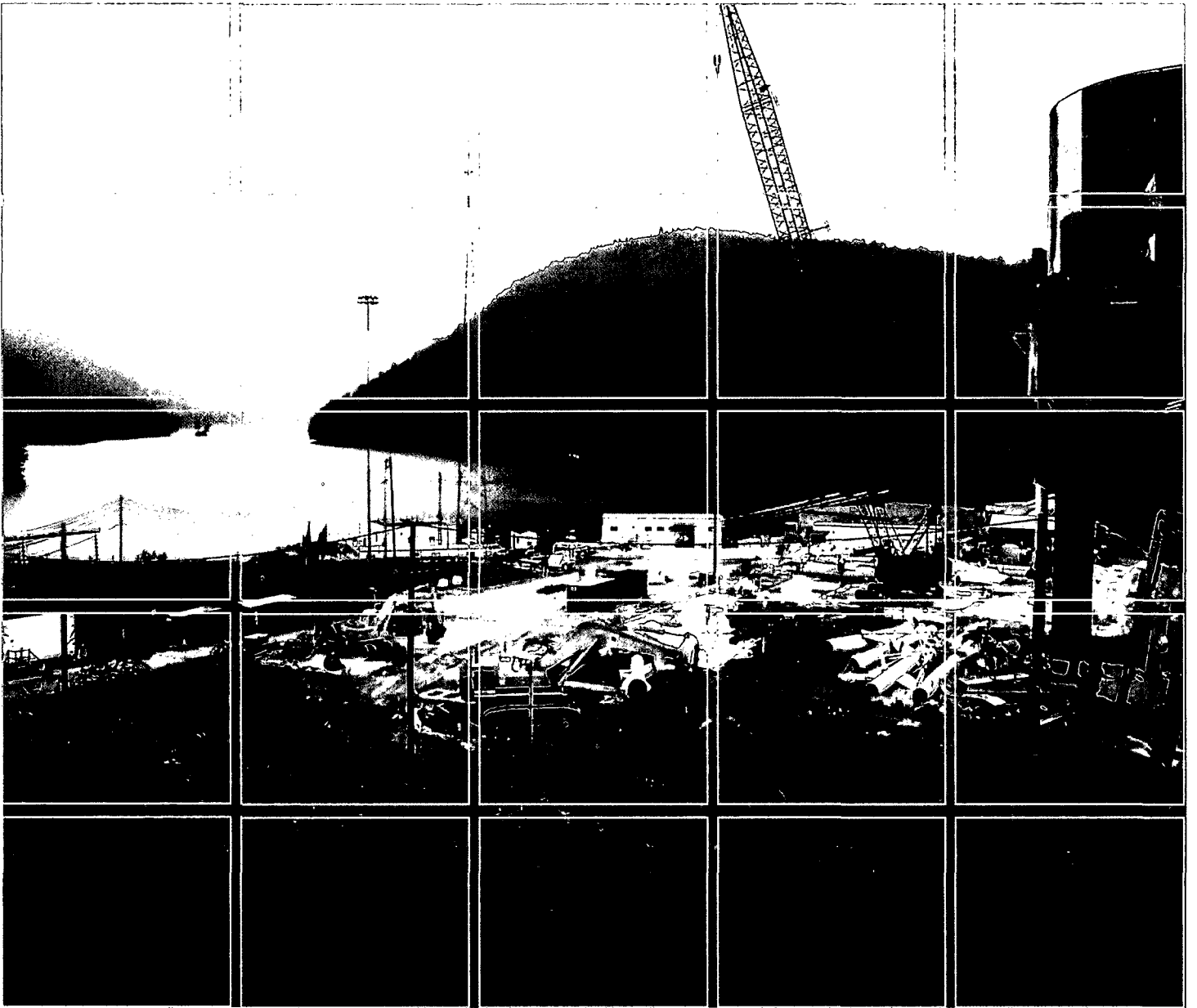
Gregg A. Demers
Gregg A. Demers, P.E., LSP
Project Manager

Enclosures: Revised Beneficial Use Determination Application (2 copies)

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Application for Beneficial Use Determination for Structures

Yankee Nuclear Power Station
Site Closure Project
Rowe, Massachusetts

22 March 2005

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1.0 INTRODUCTION

1.1 BACKGROUND

The Yankee Atomic Electric Company (YAEC) is in the process of decommissioning and closing the Yankee Nuclear Power Station (YNPS) located in Rowe, Massachusetts (see Figure 1). YNPS began operations in 1960 and operated safely and successfully for 31 years. In February 1992, the YAEC Board of Directors decided it was in the best economic interest of electric customers to cease operations permanently at YNPS and decommission the plant. YAEC intends to complete the majority of decommissioning and physical site closure activities at the site by mid-2005 and to restore the site to environmental quality standards that will enable future unrestricted use of the site, where feasible.

The site is located at 49 Yankee Road in the northwestern Massachusetts Town of Rowe, adjacent to the Vermont border (Figure 1). The site consists of an approximately 1,800-acre property owned by YAEC (see Figure 1) and portions of an adjacent property to the west owned by USGen New England, Inc. (USGen NE). The site abuts the eastern shore of the Deerfield River and Sherman Reservoir, adjacent to Sherman Dam, one of several dams along the Deerfield River used for hydroelectric power generation.

This revised application for a Beneficial Use Determination (BUD) – Major was developed by YAEC, with the assistance of Environmental Resources Management (ERM) and Gradient Corporation (Gradient), to support the site closure project. Copies were originally provided to the Massachusetts Department of Environmental Protection (DEP or Department) in September 2004. This revised application replaces the September 2004 version based on the Department's and the Massachusetts Department of Public Health's (DPH's) review and comment of the previous application and discussions with YAEC regarding planned demolition activities. The original Transmittal Forms (BWP SW 13, W050861) are included in Appendix A.

1.2 PURPOSE AND SCOPE

The purpose of the BUD application is to provide the Department, DPH and other regulatory and non-regulatory stakeholders with

documentation necessary to review and approve the proposed rationale, plans and procedures to beneficially reuse processed concrete and asphalt and to leave building slabs, foundations and utility lines in-place. This application was prepared consistent with available Department guidance for a BUD application and includes a description of the solid waste material to be beneficially used, estimated quantities, physical and chemical properties and proposed handling methods to ensure that beneficial reuse of materials on site poses no significant adverse effects to public health, safety, or the environment (MA DEP, 2004). This application also relies on the restoration of site topography by re-grading with at least 36 inches of soil over any non-native materials that are left on site under the BUD.

This BUD application does not address the management of soil in the Southeast Construction Fill Area (SCFA). A separate BUD application, along with a Corrective Action Design, both dated 4 November 2004, were submitted to address the removal of the SCFA and the reuse of soils from the SCFA for site regrading. A BUD approval for the SCFA was issued by the Department on 23 December 2004.

2.0 GENERAL INFORMATION

2.1 GENERAL DESCRIPTION

2.1.1 *Planned Re-Use of Structures*

Unless otherwise noted below, all building structures at the site will be demolished and the debris removed from the site, including floor slabs and foundations. A summary of those structures intended to remain at the site is provided in Table 1. Figure 2 shows what structures will remain in-place. A building-by-building is provided below (note that underground utilities are addressed in Section 2.1.2):

- Office Building – This building will remain intact and is not subject to the BUD.
- Gatehouse – These buildings will remain intact and is not subject to the BUD.
- Interim Spent Fuel Storage Installation (ISFSI) – This radiological waste storage pad will remain intact and is not subject to the BUD..
- Meteorological Tower – This tower will remain intact and is not subject to the BUD.
- Turbine Building and Auxiliary Building - The majority of the slab will remain in place with the exception of portions that will be removed to facilitate final site grading. Foundations will remain in place. The removed concrete will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: 1,400 cubic yards.
- Office attached to Turbine Building - This slab will be removed to facilitate final site grading. The removed concrete will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: included with Turbine Building estimate.
- Service Building - The majority of this slab will remain in place with the exception of those areas that will be removed to access subsurface radiological piping and those portions removed to facilitate final site grading. Foundations will remain in-place. The removed concrete will be processed and monitored for reuse as beneficial fill in accordance

with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: 550 cubic yards.

- Service Building Annex - The majority of the slab will remain in place with the exception of those areas that will be removed to access subsurface radiological piping and those portions removed to facilitate final site grading. Foundations will remain in-place. The removed concrete will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: included with Service Building estimate.
- North Decon Room - All remaining portions of the slab and foundations will remain in place. Material to remain on-site: included with Service Building
- Stores Warehouse - The majority of the slab will remain in place with the exception of portions that will be removed to facilitate final site grading. Foundations will remain in-place. The removed concrete will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: 350 cubic yards.
- Tank Farm Moat & Gas Drum Decay Area - All remaining portions of the structures will remain in place. Material to remain on-site: 400 cubic yards.
- Ion Exchange Pit (IX Pit) - Will be removed in its entirety with the exception of the south wall, which will remain to support final site grading. All removed concrete will be shipped off site for disposal. Material to remain on-site: 200 cubic yards.
- Safety Injection/Diesel Generator (SI/DG) Building - All remaining portions of the slabs and foundations will remain in place. Material to remain on-site: 60 cubic yards.
- New Fuel Vault - Will be removed in its entirety. All removed concrete will be shipped off site for disposal. Material to remain on-site: none
- Spent Fuel Pit - Will be removed in its entirety. All removed concrete will be shipped off site for disposal. Material to remain on-site: none.
- New and Old SI Tank Base - All remaining portions of the slabs and foundations will remain in place. Material to remain on-site: 30 cubic yards.

- Tank 39 Base Primary Water Tank - All remaining portions of the slabs and foundations will remain in place. Material to remain on-site: 40 cubic yards.
- Demin Water Tank Slab - All remaining portions of the structures will remain in place. Material to remain on-site: 15 cubic yards.
- Fuel Transfer Enclosure (South Decon Room) - Will be removed in its entirety. All removed concrete will be shipped off site for disposal. Material to remain on-site: none.
- Vapor Container/Reactor Support Structure (VC/RSS) - The RSS is a massive concrete structure. Following extensive characterization and abatement, demolition has begun on the RSS. Much of the original above grade structure will be stockpiled for reuse on-site. All remaining portions of the structural foundations will remain in place. The stockpiled concrete from the RSS will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: 1,700 from the in-place materials plus 7,000 cubic yards of processed concrete.
- Compactor Building - All remaining portions of the slabs and foundations will remain in place. Material to remain on-site: 85 cubic yards.
- Waste Disposal Building - All remaining portions of the slabs and foundations will remain in place. Material to remain on-site: 135 cubic yards.
- Potentially Contaminated Area (PCA) Warehouse - The majority of the slab and foundations will remain in place with the exception of those areas that will be removed to access subsurface radiological concerns. The removed concrete will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: 610 cubic yards.
- PCA #1 (Old PCA) - The majority of the slab and foundation will remain in place with the exception of those areas that will be removed to access subsurface radiological piping and those portions removed to facilitate final site grading. The removed concrete will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: included with PCA Warehouse estimate.
- PCA #2 (New PCA) - All remaining portions of the slab and foundation will remain in place. Material to remain on-site: included with PCA Warehouse estimate.

- Fire Water Tank Slab - All remaining portions of the structure's slab will remain in place. Material to remain on-site: 60 cubic yards.
- Fire Water Pump House - All remaining portions of the slab and foundation will remain in place. Material to remain on-site: 65 cubic yards.
- Safe Shutdown Building - All remaining portions of the slab and foundation will remain in place. Material to remain on-site: 200 cubic yards.
- Circulating Water Discharge Structure (Seal Pit) - Following demolition activities to meet current local, state and federal permits for the Seal Pit, all remaining portions of the slabs and foundations will remain in place. Material to remain on-site: 300 cubic yards.
- Circulating Water Intake (Screenwell House) - Following demolition activities to meet current local, state and federal permits for the Screenwell House, all remaining portions of the slabs and foundations will remain in place. Material to remain on-site: 1,350 cubic yards.
- Primary Auxiliary Building (PAB) - The majority of the lower slab and foundations will remain in place with the exception of those areas that will be removed to access subsurface radiological piping and those portions removed to facilitate final site grading. The lower level south foundation wall will remain to assist in final site grading. In addition, following extensive characterization and abatement, much of the original above grade structure has been demolished and is being stored in a stockpile on-site. The stockpiled and other removed concrete will be processed and monitored for reuse as beneficial fill in accordance with the Materials Reuse Protocol described in Section 3.1.2. Material to remain on-site: 700 cubic yards from the in-place materials plus 1,200 cubic yards from the above grade stockpile.
- Rad Lab Sump Pit - Will be removed in its entirety. All removed concrete will be shipped off site for disposal. Material to remain on-site: none.
- Fuel Oil Transfer Pump House - Will be removed in its entirety. All removed concrete will be shipped off site for disposal. Material to remain on-site: none.
- Fuel Transfer Chute - Will be removed in its entirety. All removed concrete will be shipped off site for disposal. Material to remain on-site: none.
- Elevator Shaft - Will be removed in its entirety. All removed concrete will be shipped off site for disposal. Material to remain on-site: none.

- Yard Crane Supports - All remaining portions will remain in place. Material to remain on-site: 40 cubic yards.

The building foundations proposed to remain on-site consist primarily of concrete reinforced with steel and concrete masonry units (i.e., cinder blocks). Subsurface concrete structures proposed to remain (e.g., slabs and sumps) will be perforated as necessary to allow infiltration of storm water and/or flow of groundwater through the foundations/structures.

Building surfaces were characterized for paint containing polychlorinated biphenyls (PCBs) and other hazardous constituents prior to demolition. On-going abatement of PCB-containing paint at concentrations of 50 mg/kg or greater of PCBs has been conducted under specific United States Environmental Protection Agency (US EPA) approved work plans developed in accordance with the Alternative Method of Disposal Authorization (AMDA), issued by the US EPA under Section 6(e)(1) under the Toxic Substance Control Act (TSCA) and the PCB regulations (40 CFR 761).

The concrete foundations remaining in the subsurface are undergoing visual inspection, where accessible, to determine if any coatings are present. Any paint remaining on subsurface materials proposed to be left in-place (except spray paint incidental to demolition) will be tested to confirm that PCBs are not present in the paint. Any paint found to contain PCBs will be removed from the surface of the concrete prior to reuse under the BUD. Any non-PCB paint to remain on concrete will also be tested for RCRA 8 metals. Any non-PCB paint containing RCRA-8 metals at concentrations exceeding applicable BUD re-use criteria will be removed prior to reuse.

Mastic coatings are present on some subsurface foundations that will remain in-place. Where accessible, the mastic coatings have been tested for asbestos. Discussions have been held with the Department regarding the feasibility of removal of mastic from these structures. YAEC proposes that mastic coatings on foundations remain in-place for the following reasons:

- Mastic coatings containing asbestos are non-friable. These coatings were designed to be used in the subsurface, and as such, pose a low potential for adverse impact to human health and/or the environment if they remain on the structures, are not disturbed or rendered friable.

- Removal of mastic coatings would require extensive excavation and removal of the upper surface of the concrete containing the coating. Disturbance of these materials during removal could pose a significant short-term risk to worker health and safety and the environment due to the potential for asbestos fibers to become friable and be released to the environment. Containment and monitoring would minimize the potential risks associated with asbestos removal, but not eliminate short-term risks associated with waste generation, management, off-site transportation and disposal.
- Leaving mastic coatings on subsurface structures would eliminate the short-term risk to human health and the environment posed by removal and waste management. Placement of restrictions on the deed to the property that prohibit subsurface excavation or disturbance of subsurface structures containing mastic coatings and/or require appropriate oversight of excavations and management of wastes encountered, as necessary, would eliminate the potential for future adverse exposure to human health and the environment posed by mastic coatings.

Therefore, YAEC proposes to leave mastic coatings on subsurface structures and file a deed restriction prohibiting future work that could result in the disturbance of these materials, unless the work is conducted by a qualified professional. This approach will eliminate the short-term risks to human health and the environment posed by mastic removal and ensure continued protection of human health and the environment into the foreseeable future.

2.1.2 *Utility Lines to Remain In-Place*

An extensive evaluation has been performed of all subsurface utilities and associated structures based on-site drawings. A utility matrix was developed to aid in evaluating whether a utility component should be removed or decommissioned in-place. This evaluation is based on ongoing discussions with the Department, including a meeting held at the Yankee site on February 2, 2005.

YAEC is proposing to leave selected inactive utility lines in-place that are problematic to remove due to obstacles such as their location beneath building slabs, their encasement in concrete ducts, the presence of asbestos-containing material (ACM) as a pipe component or around the pipes and difficulties associated with ACM abatement or the location/depth of the utility line. Reasonable measures will be taken to

remove the contents of the utility lines (i.e., water, wires, etc) as part of the decommissioning process; however, wires/cables may remain in-place in inaccessible locations (including some wires that could be coated with ACM). Lines proposed to remain in-place will be permanently capped at each end with grout where accessible.

Site underground utilities have been separated into the following categories to facilitate the Department's review of this application and to document the rationale for the leaving proposed utilities in-place. These include the following:

- Under Building Slab (pipes) – Pipes located beneath or immediately adjacent to the foundation of a building slab are proposed to be left in-place. Removal of these lines would require a significant effort that is not justified since the slabs are proposed to remain in-place. If the pipe is greater than eight inches in diameter, it will be filled with flow-fill. Pipes less than eight inches in diameter will not be filled, but contents removed and ends capped with grout, as feasible.
- Concrete Encased Duct Bank – Many of the site electric conduits were installed within concrete structures (duct banks) and encased within concrete within the structure to protect them from the elements. Much of this pipe is identified as 'fiber' pipe and limited testing has revealed it not to be ACM. Asbestos wrap around cables within utility manholes entering these pipes has been identified as ACM. This asbestos material will be removed within the manhole prior to pulling cables, however, should the cable not be fully removed, ACM may remain. Once cables have been pulled, YAEC proposes to grout the ends of accessible conduits and leave duct banks and filled manholes in-place following demolition. Removal of these structures would require abatement of ACM that is currently isolated and encased in concrete. The ACM as either wrap, a component of the cable, or conduit does not pose a significant adverse risk to human health or the environment under current or proposed future conditions. Therefore, YAEC proposes to leave ACM within subsurface structures and file a deed restriction prohibiting future work that could result in the disturbance of these materials, unless the work is conducted by a qualified professional. This approach will eliminate the short-term risks to human health and the environment posed by ACM removal and ensure continued protection of human health and the environment into the foreseeable future.

- Creosote Timbers over Concrete Duct Bank – Site drawings have identified the presence of 2-inch thick creosote wooden timbers placed as markers to prevent excavation and accidentally penetrating electrical lines within the duct banks. YAEC proposes to leave these timbers in-place so that they can continue to serve as markers to prevent accidental damage of the conduits within the duct banks. The presence of these timbers as markers will be noted in the deed restriction to be placed on that portion of the property subject to the BUD to facilitate their future use as markers in the event that future activities require controlled subsurface excavation and/or management of subsurface ACM. Creosote timbers associated with rail lines will be removed.

- Concrete and Steel Pipes – Pipes have been identified that are predominantly made of concrete or steel, which are similar to the concrete duct banks and inert materials. Many of the pipes are located in close proximity to the Sherman Dam and removal would have a potential adverse effects on the structural integrity of the dam. YAEC proposes to remove pipes where the majority of the line is located at a depth of less than five feet. YAEC proposes to leave the pipes in-place where the majority of the line is located at a depth of greater than five feet and fill the pipes with flow-fill. Pipes with a diameter of eight inches or less would not be filled, but the contents (wires, etc.) removed to the extent practical and the ends of the pipe capped with grout. Pipes encountered during site excavation activities will be removed if encountered. As an example, the Circulating and Service Water Lines that provided cooling water from Sherman Reservoir through the Screenwell House to the Turbine Building and then back through the Discharge Structure to Sherman Reservoir are proposed to be left in-place including:
 - One 100-foot long, 10-foot diameter buried corrugated steel intake pipe between Sherman Reservoir and Screenwell House
 - One 7-foot diameter concrete intake pipe between Screenwell House and Turbine Building
 - Two 1-foot diameter steel water service lines between Screenwell House and Turbine Building
 - Four 5-foot diameter steel pipes below Turbine Building
 - One 3-foot diameter corrugated steel pipe between Screenwell House and Discharge Structure

- One 7-foot diameter discharge pipe between Turbine Building and Discharge Structure (a portion of the pipe is concrete lined with steel and a portion of the pipe is all steel)
- Three 4-foot diameter steel capped pipes near Discharge Structure branching off from the 7-foot diameter steel pipe

Yankee intends to leave each of the above lines in-place and fill them with a flow-fill.

- Storm Water Distribution System – An evaluation has been performed of the East and West storm water collection systems to determine whether site radiological release criteria have been met. The systems are comprised of storm water catch basins and lateral lines that direct storm water through two outfalls managed under a National Discharge and Elimination System (NPDES) permit issued jointly by EPA and the Department. YAEC propose to leave the majority of these systems in-place and fill the voids with flow-fill. Exceptions include those segments of both systems that will be removed due to excavations to remove the deep foundations (Spent Fuel Pool / Ion Exchange Pit), the Sherman Dam extension base development, and shoreline components that will be removed to accommodate the final site grading.
- Individual Electrical Conduits / Utility Lines – Subsurface site electrical conduits, other small utility lines and pipes are made of inert materials that do not pose an adverse risk of harm to human health and/or the environment. YAEC proposes to remove conduits and utility lines where the majority of the line is shallower than five feet below existing grades. YAEC proposes to evaluate the feasibility of removal of utility lines where the majority of the line is at a depth of greater than five feet below existing grade. Where removal is feasible based on depth and/or other planned site excavation activities, those lines would be removed. Where removal is judged to be infeasible due to the location, depth and/or structure of the line (e.g., found to contain ACM), these lines are proposed to remain in-place.
- Electrical Grounding Grid – Due to the former use of the site as a power station, an extensive grounding grid was established during plant construction (1950s) that tied into each structure and subsurface amenity to ensure all aspects of operation were properly protected. Composed of bare copper cable, YAEC intends to remove those portions of the grid that are encountered during

ongoing excavation and/or demolition activities. YAEC proposes to leave the remainder of the grounding grid in-place.

- Fire Water Protection System – A fire water protection system consists of a looped header that connected to numerous hydrant stations throughout the site. The depth of this system is at least seven feet below existing grades. YAEC intends to leave that portion of this system that is decommissioned in-place unless encountered through other excavation. Hydrants will be removed to a depth of five feet below grade.
- Sanitary System- Sanitary sewer lines are considered outside the scope of this BUD application since the closure of septic systems will be addressed under the requirements of the State Environmental Code Title 5 regulations (310 CMR 15.000). However, portions of the sanitary line, primarily within the footprint of the Sherman Dam extension, will be removed.

2.1.3 *Processed Concrete and Asphalt*

YAEC proposes to beneficially reuse processed concrete block, reinforced concrete and asphalt from paved areas at the site. The locations where processed concrete and asphalt will be reused to grade the site are shown in Figure 3. All processed concrete will meet the Materials Reuse Protocol that is under development between YAEC, the Department, and DPH with regards to a potential radiological constituents (Section 3.1.2). All paint containing PCBs will be removed from the concrete prior to reuse. Non-PCB paints that remain on concrete will be evaluated to ensure the metals concentrations comply with BUD risk criteria. Processed concrete and asphalt used on site will be placed in horizontal lifts and compacted to reduce void space and create a stable fill material.

2.1.4 *End-State*

Following the completion of demolition activities aboveground structures that will remain at the site will include the ISFSI, the Gatehouse, an office building, and a potable water well. The post-decommissioning grading and planting plans (Kleinschmidt, August 2004) have been approved by the Department as part of the Integrated Permit Package submitted to the Division of Waterways and Wetlands. YAEC intends to extend the east embankment of the Sherman Dam to permanently replace the temporary flood control measures that had been part of YNPS. The site will be regraded and planted following the completion of demolition activities.

The regrading plan will provide a minimum of 36 inches of soil cover above any foundations or utility lines that are left in-place.

A deed restriction will be placed on that portion of the YAEC property where material will remain in the subsurface that was approved for beneficial reuse under the BUD. The deed restriction will meet the Department's requirements and conditions imposed under BUD approval and will be separate and distinct from any Notice of Activity and Use Limitation (AUL) that may be placed on the property to prevent adverse exposure to residual levels of radioactivity, oil and/or hazardous materials that may remain in the subsurface on site.

2.2 *SOURCE*

The Yankee Nuclear Power Station in Rowe, Massachusetts is the source of the solid waste that will remain on-site. The name and address of the generator are:

Yankee Atomic Electric Company
49 Yankee Road
Rowe, MA 01367

2.3 *INDUSTRIAL PROCESSES*

The solid waste that will remain in-place is derived from the decommissioning of YNPS. The items were constructed using traditional construction methods and include concrete, steel reinforced concrete, asphalt, steel pipes, fiber pipes, concrete pipes, and copper wire.

2.4 *QUANTITY*

The volumes of concrete materials to be used on site are described by structure in Section 2.1.1, and total 16,490 cubic yards plus approximately 1,000 cubic yards of flow fill. In addition, approximately 1,500 cubic yards of asphalt are also anticipated to be re-used. Concrete, flow fill, and asphalt combine to approximately 18,990 cubic yards of material.

The volume estimates of materials to be reused on-site under the BUD are based on the current site closure plans and reasonable knowledge of the dimensions/construction of features to remain on-site. Based on the ability of processed concrete to meet the Materials Reuse Protocol, this

quantity may vary. The actual volumes used and these final site conditions will be documented on as-built drawings showing fill areas and buried features. In the event that additional structures/foundations are deemed eligible for on-site use, YAEC will ensure that these items meet all of the criteria that have been specified in this submittal.

3.0 *CHEMICAL, PHYSICAL, AND BIOLOGICAL PROPERTIES*

3.1 *CHEMICAL PROPERTIES*

3.1.1 *Overview*

The solid waste to be beneficially reused primarily consists of concrete blocks, reinforced concrete and asphalt. Concrete is produced by mixing cement and water with inert materials such as sand and gravel. A chemical reaction known as hydration occurs between the cement and water that creates a hard, rock-like product. Steel reinforcing bar (rebar) is imbedded in poured concrete. Asphalt pavement typically contains approximately 95 percent aggregate, consisting of stone, sand, or gravel and five percent asphalt cement as a binder.

Due to the inert nature of the concrete and asphalt, reactivity, leachability, metals content and volatile organic compound concentrations are not a potential concern. The pH of groundwater at the site, which currently ranges from 5 to 8, is not expected to be impacted by leaving the reinforced concrete in-place.

3.1.2 *Radiological Characterization*

The following Materials Reuse Protocols are under development by YAEC in coordination with the Massachusetts DPH. The Materials Reuse Protocols are being utilized for determination of above and below grade processed concrete debris that would qualify for purposes of reuse as backfill (including grading material). Note that these protocols apply only to above and below grade processed concrete debris for use as fill and do not apply to existing subsurface slabs/structures and asphalt. The Materials Reuse Protocols are being finalized and currently include:

1. Performance of bulk monitoring of all potentially radioactive bulk-reuse materials utilizing gamma sensitive instrumentation capable of detecting a volumetric concentration that would not contribute more than 1 millirem per year (mrem/yr) Total Effective Dose Equivalent (TEDE) above background after burial to any individual. Materials above this requirement would not be considered acceptable for re-use as backfill.

2. Included in the above 1 mrem/yr requirement are evaluations of the presence of the hard-to-detect radionuclides (e.g., Iron-55, Nickel-63, Carbon-14, Hydrogen-3).
3. The concrete is to contain no detectable plant related transuranics.
4. The exposure modeling and parameters to be used will be coordinated with the DPH and Nuclear Regulatory Commission (NRC) and implemented with DPH concurrence.

Existing subsurface structures to be reused under the BUD, including below grade concrete structures, concrete slabs (fractured and/or perforated) and asphalt will meet release criteria determined by meeting 10 mrem/yr Derived Concentration Guideline Levels (DCGLs). In addition, excavated soils to be used as backfill within the BUD area will also meet the 10 mrem/yr DCGL criteria. The YNPS License Termination Plan (LTP) includes the applicable DCGLs that are being applied to the site. It should be noted that the DPH site release criteria (10 mrem/yr) is more conservative than the NRC criteria (25 mrem/yr) and as such, the DCGLs found in the LTP will be adjusted to reflect the DPH criteria.

3.1.3 *Non-Radiological Characterization*

As described in Section 2.1, paint containing PCBs will be removed from concrete and asphalt to be used for site grading. YAEC has collected core samples of the concrete to verify that PCB concentrations are less than two (2) milligrams per kilogram (mg/kg) following the removal of paint. In the event that non-PCB paint remains on concrete, core samples will be collected to verify that that metals concentrations do not pose a risk (see Section 4.2 for risk criteria).

A mastic coating will remain on some foundation walls at the site. The mastic coating is inert. As described in Section 2.1, some of the mastic may contain non-friable asbestos.

3.2 *PHYSICAL PROPERTIES*

3.2.1 *Size*

The concrete foundations and walls are generally up to 1 foot thick, except where two walls abut. Concrete to be used for site grading and asphalt from paved areas will be processed as necessary to provide a suitable base for the three feet of soil that will be placed over the non-native materials.

3.2.2 *Density*

The concrete will contain rebar and typically has a density of 150 pounds per cubic foot. Certain structures, such as the Fuel Transfer Chute (most of which has been shipped off-site), were constructed with concrete that had a density of at least 225 pounds per cubic foot. The density of asphalt is estimated to be approximately 140 pounds per cubic foot.

3.2.3 *Percent Solids*

The solid waste to be beneficially used is reinforced concrete and asphalt that is 100 percent solid.

3.2.4 *Liquid Content*

The concrete is free of liquids. Water that may be present in some subsurface utility lines (e.g., water and sewer lines) will be removed prior to decommissioning the lines.

3.3 *BIOLOGICAL PROPERTIES*

Due to the nature of the concrete and asphalt, there is no biological activity or pathogens associated with the foundations or utility lines.

4.0 PROPOSED HANDLING METHODS AND UTILIZATION

4.1 PROPOSED HANDLING

The foundations, concrete and asphalt and utility lines remaining at the site will be managed on site. Voids within utility lines greater than eight inches in diameter will be filled. Utility lines less than eight inches in diameter will be abandoned in-place. Three feet of soil will cover any non-native materials left in-place.

The concrete structures (buildings, slabs and support columns) will be demolished using standard construction practices and heavy machinery. Large structures such as the Reactor Support Structure will be minimized by mechanical means. Smaller structures will be demolished with various hydraulic claws and shears, as appropriate. Once the buildings are brought to grade elevation, structural steel beams and metal will be segregated into piles for sorting, packaging and disposal. Rebar that is exposed will be cut off as close as possible for disposal and rebar that is contained within concrete will remain on-site. Concrete will be crushed using heavy equipment to accommodate stockpiling, prior to being loaded into containers for radiation surveying on-site in accordance with the Materials Reuse Protocol. Material surveyed for re-use on site will be either placed directly into building voids or stockpiled until used for site grading.

4.2 PROPOSED UTILIZATION

4.2.1 *General Description*

The remaining foundations and buried utility lines will be incorporated in the final site re-grading.

4.2.2 *Locations Where Material is to be Used*

Figure 2 shows the locations of foundations that will remain. Figure 3 shows where processed concrete and asphalt will be used.

Health and Environmental Impacts

The material to be reused under the BUD primarily consists of inert construction materials comprised of concrete and asphalt. Potential residual impacts on the concrete include paint, as well as radiological constituents (below DCGLs) for remaining structures (with the exception of the ISFSI facility) including foundations, slabs, subsurface asphalt and soil.

The BUD guidance document states that the applicant must demonstrate that Critical Contaminants of Concern (CCCs), such as PCBs as defined in the guidance document, are consistent with background. Based on discussions with DEP at a pre-application meeting held on 1 July 2004, it is our understanding that this requirement of the BUD guidance may not be applicable for a Category 3 BUD and that this issue will undergo further review by DEP.

Confirmation sampling of the concrete is being performed to ensure that the maximum residual PCB concentration will be no more than 2 mg/kg in the concrete debris. This maximum threshold is essentially equivalent to the proposed default BUD S-2 and S-3 standard of 1.6 mg/kg for PCBs. The S-2 and S-3 BUD values represent an average concentration (this is inherent to the risk assessment process). Although concrete will be confirmed to contain no more than 2 mg/kg as a sample-specific maximum concentration, the actual average PCB concentration in concrete will be well below the S-2 and S-3 BUD standards for PCBs. Because PCBs in concrete will meet the BUD S-2 and S-3 standards, no further assessment for PCBs is required.

In the event that non-PCB paint is left on concrete surfaces, the coated concrete will be tested for RCRA 8 metals. The sampling results will be evaluated to ensure that the average concentrations are below the S-2 and S-3 BUD values. If the average concentrations are higher, then the paint will be abated or the concrete will be disposed off-site.

No standards exist in the draft BUD guidance for radionuclides. However, due to the operation of the power plant, the concrete may contain radiological constituents at concentration less than or equal to the DCGL. The use of the Materials Reuse Protocol is consistent with a Category 3 Beneficial Use of Secondary Materials in Restricted Applications because the management of the concrete beneath 3-foot of soil overburden meets the DEP BUD guidance risk management criteria (overall cancer risk less than or equal to 5 in 10,000; or 0.5×10^{-5}). A Human Health Risk Assessment was prepared by Gradient Corporation

(Appendix B) to evaluate potential risks associated with the on-site reuse of concrete.

The risk assessment guidelines for the BUD, which adopt those defined under the MCP with a more conservative risk threshold, define health protection on the basis of cancer risk, rather than radiation dose. MADEP does not have guidelines for the evaluation of cancer risk for radionuclides. Consequently, the U.S. EPA guidelines, published in the *Soil Screening Guidance for Radionuclides* (USEPA, 2000a,b) were used for the Human Health Risk Assessment.

The final site grading and re-vegetation plan will ensure that the concrete will reside beneath 3-feet of soil. A deed restriction will require a Health & Safety Plan and Soil Management Plan for subsurface excavation activities. Thus, the deed restriction will prevent "direct contact" pathways such as incidental ingestion and dermal contact with subsurface materials. Thus, the primary pathway of possible concern for exposure to radionuclides in the subsurface concrete is from external radiation (*e.g.*, ionizing radiation emitted as the result of radioactive decay).

The health assessment presented here indicates that soil grading plan and use of concrete debris as fill, satisfies the interim draft BUD guidance for Category 3 use of Secondary Materials in Restricted Applications. As such, compliance with the Materials Reuse Protocol under development with the Massachusetts DPH would provide an even greater level of protection to human health and the environment.

5.0 REFERENCES

U.S. Environmental Protection Agency (USEPA). 2000a. Soil Screening Guidance for Radionuclides: Technical Background Document. EPA/540-R-00-006. Office of Radiation and Indoor Air; Office of Solid Waste and Emergency Response. Washington, DC.

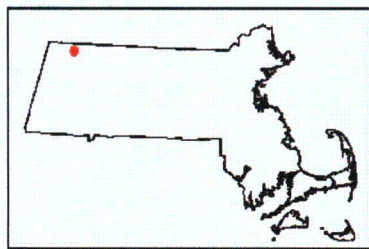
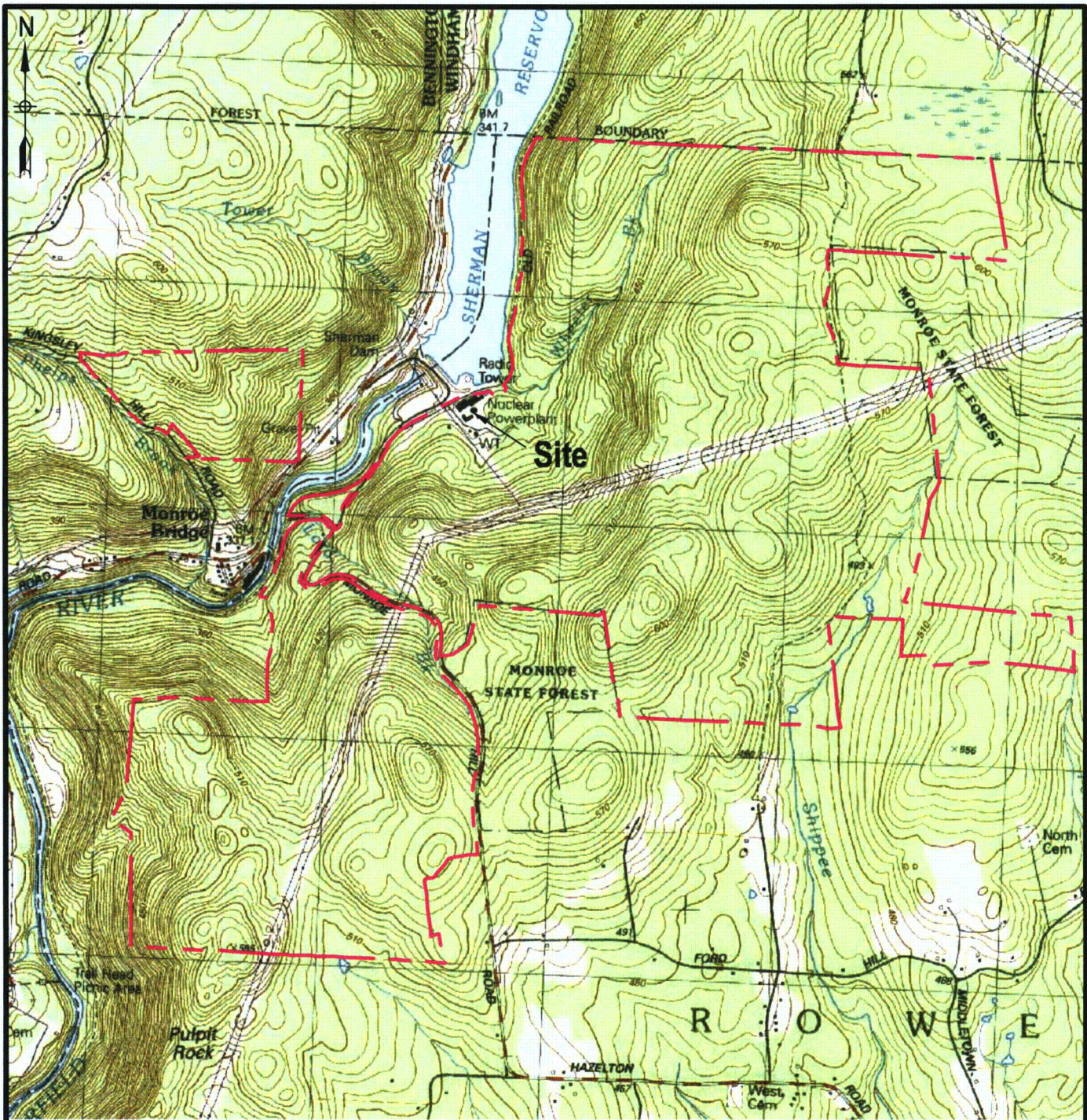
U.S. Environmental Protection Agency (USEPA). 2000b. Soil Screening Guidance for Radionuclides: User's Guide. EPA/540-R-00-007. Office of Radiation and Indoor Air; Office of Solid Waste and Emergency Response. Washington, DC.

Massachusetts Department of Environmental Protection, Bureau of Waste Prevention, "Draft Interim Guidance Document for Beneficial Use Determination Regulations 310 CMR 19.060", March 18, 2004.

Table 1
Summary of Structures to be Reused
Yankee Nuclear Power Station, Rowe, MA

Structure Name	Approximate Volume of Concrete to Remain In-Place (cubic yards)	Approximate Volume of Concrete to be Processed (cubic yards)
Turbine Building	1,400	
Service Building	550	
Stores Warehouse	350	
Tank Farm Moat & Gas Drum Decay Area	400	
Ion Exchange Pit (south wall)	200	
Safety Injection/Diesel Generator Building	60	
New/Old SI Tank Base	30	
Tank 39 Base Primary Water Tank	40	
Demin Water Tank Slab	15	
Vapor Container/Reactor Support Structure	1,700	7,000
Compactor Building	85	
Waste Disposal Building	135	
PCA Warehouse	610	
Fire Water Tank Slab	60	
Fire Water Pump House	65	
Safe Shutdown Building	200	
Circulating Water Discharge Structure	300	
Circulating Water Intake Structure	1,350	
Primary Auxiliary Building	700	1,200
Yard Crane Supports	40	
Subtotal	8,290	8,200
Total	16,490	

Note: Table does not include a summary of utilities or asphalt to be reused under the BUD.



--- YAEC Property Boundary

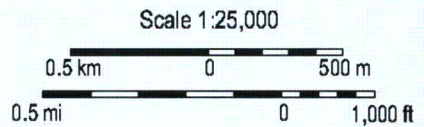
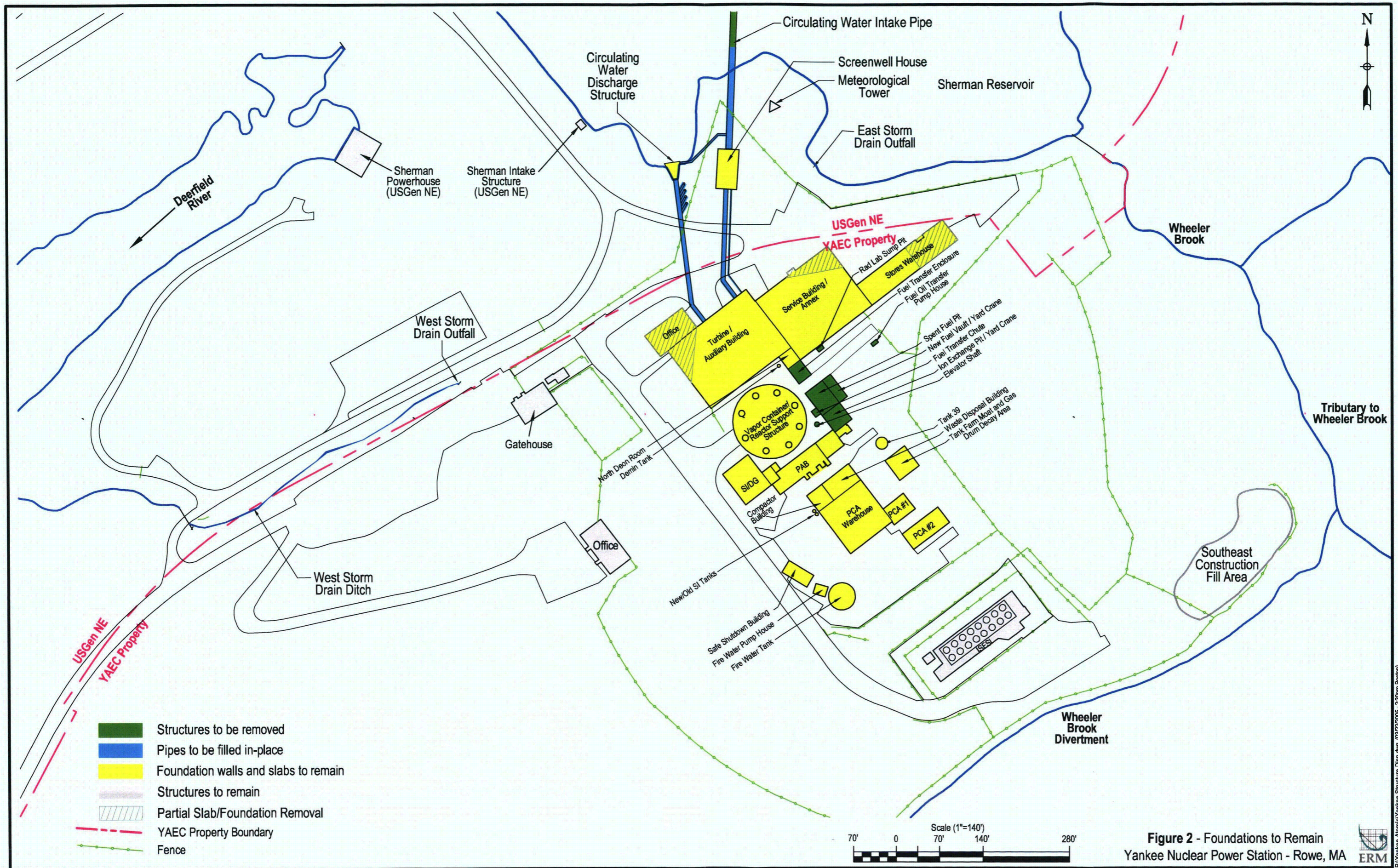


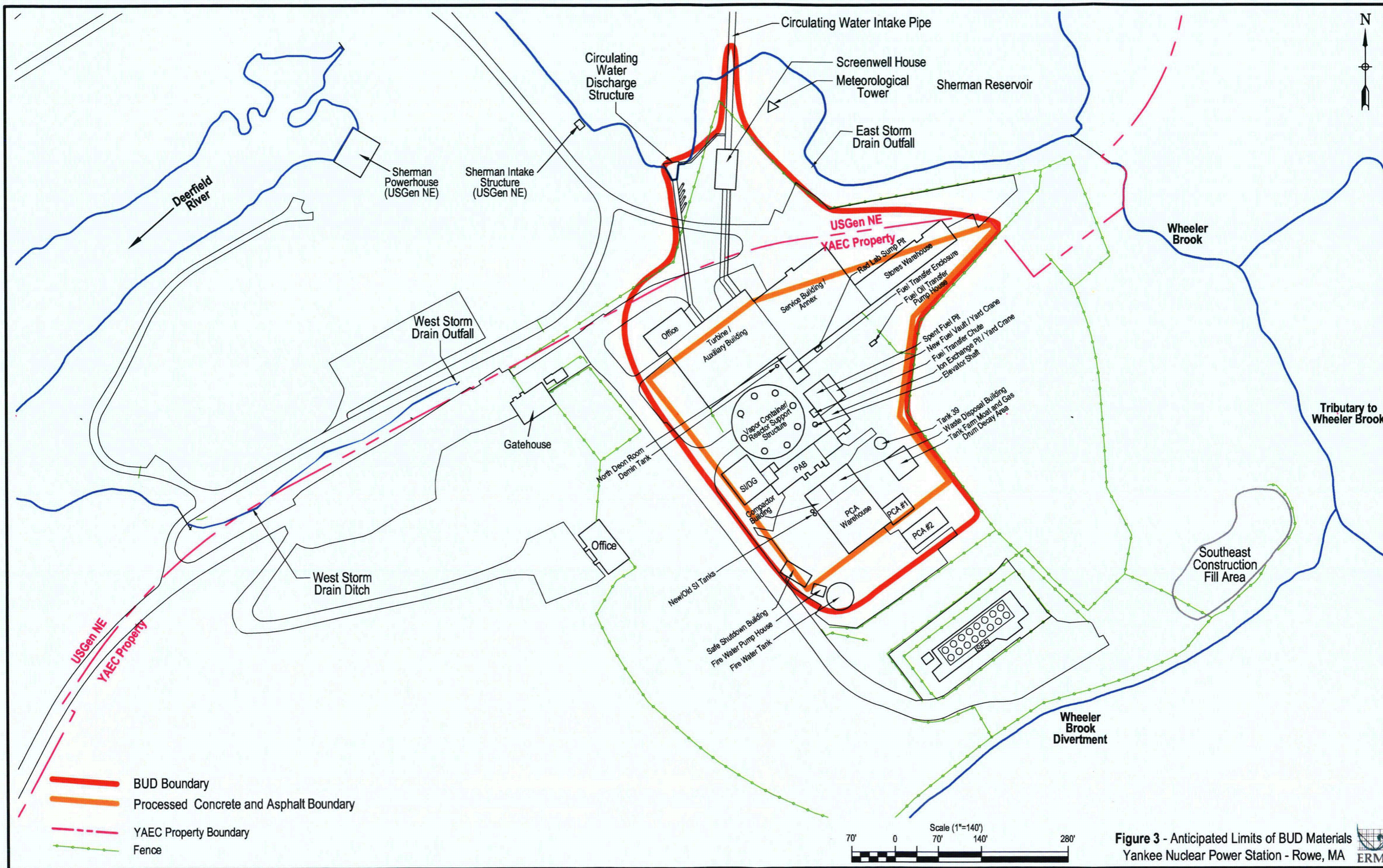
Figure 1 - Locus Map
 Yankee Nuclear Power Station - Rowe, MA





R:\Yankee Atomic\Yankee Structure Disp.dwg (03/22/2005 - 2:30pm Becton)





R:\Yankee Atomic\Yankee Structure Disp.dwg (03/22/2005 - 2:22pm Boston) ERM

Appendix A
Transmittal and Application
Forms



Enter your transmittal number

W050861

Transmittal Number

Your unique Transmittal Number can be accessed online: <http://www.state.ma.us/scripts/dep/trasmfrm.stm> or call DEP's InfoLine at 617-338-2255 or 800-462-0444 (from 508, 781, and 978 area codes).

Massachusetts Department of Environmental Protection Transmittal Form for Permit Application and Payment

1. Please type or print. A separate Transmittal Form must be completed for each permit application.

2. Make your check payable to the Commonwealth of Massachusetts and mail it with a copy of this form to: DEP, P.O. Box 4062, Boston, MA 02211.

3. Three copies of this form will be needed.

Copy 1 - the original must accompany your permit application. Copy 2 must accompany your fee payment. Copy 3 should be retained for your records

4. Both fee-paying and exempt applicants must mail a copy of this transmittal form to:

DEP
P.O. Box 4062
Boston, MA
02211

* Note:
For BWSC Permits,
enter the LSP.

A. Permit Information

BWPSW013 Beneficial Use Determination - Major
1. Permit Code: 7 or 8 character code from permit instructions 2. Name of Permit Category
Beneficial use of concrete foundations and utility lines
3. Type of Project or Activity

B. Applicant Information – Firm or Individual

Yankee Atomic Electric Company
1. Name of Firm - Or, if party needing this approval is an individual enter name below:
2. Last Name of Individual 49 Yankee Road 3. First Name of Individual _____ 4. MI _____
5. Street Address _____
Rowe MA 01367 413-424-5261
6. City/Town 7. State 8. Zip Code 9. Telephone # 10. Ext. #
Kenneth Dow dow@yankee.com
11. Contact Person 12. e-mail address (optional)

C. Facility, Site or Individual Requiring Approval

Yankee Atomic Electric Company
1. Name of Facility, Site Or Individual
49 Yankee Road
2. Street Address _____
Rowe MA 01367 413-424-5261
3. City/Town 4. State 5. Zip Code 6. Telephone # 7. Ext. #
8. DEP Facility Number (if Known) 9. Federal I.D. Number (if Known) 10. BWSC Tracking # (if Known)

D. Application Prepared by (if different from Section B)*

Environmental Resources Management
1. Name of Firm Or Individual
399 Boylston St. 6th Floor
2. Address _____
Boston MA 02116 617-646-7842
3. City/Town 4. State 5. Zip Code 6. Telephone # 7. Ext. #
John McTigue
8. Contact Person 9. LSP Number (BWSC Permits only)

E. Permit - Project Coordination

1. Is this project subject to MEPA review? yes no
If yes, enter the project's EOE file number - assigned when an Environmental Notification Form is submitted to the MEPA unit: 13247
EOEA File Number

F. Amount Due

Special Provisions:

- 1. Fee Exempt (city, town or municipal housing authority)(state agency if fee is \$100 or less).
There are no fee exemptions for BWSC permits, regardless of applicant status.
- 2. Hardship Request - payment extensions according to 310 CMR 4.04(3)(c).
- 3. Alternative Schedule Project (according to 310 CMR 4.05 and 4.10).
- 4. Homeowner (according to 310 CMR 4.02).

DEP Use Only

Permit No:

Rec'd Date:

Reviewer:

Fee addressed under MOU \$1,580.00
between Yankee and DEP Dollar Amount Date



Massachusetts Department of Environmental Protection
Bureau of – Waste Prevention – Solid Waste Management
BWP SW 13 Beneficial Use Determination – Major
BWP SW 30 Beneficial Use Determination - Minor
Application for Beneficial Use Determination

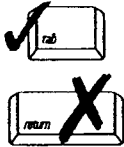
W050861

Transmittal Number #

Facility ID (if known)

A. Project Information

Important:
When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.



DIRECTIONS:
1. Specify the page numbers in which the following information is located.

2. Enter NA if information requested is not applicable.

1. Which permit category are you applying for? BWP SW 13 BWP SW 30

2. **General Information about the Solid Waste**

Page #

DEP USE ONLY

a. General description of the waste

3

b. Source of the waste

7

(1) Name of the generator

7

(2) Address of the generator

c. Description of the industrial process which produces the waste

7

d. Quantity (volume and/or tonnage)

7

3. **Chemical, Physical and Biological Properties of the Waste**

a. Chemical properties of the waste

(1) pH

8

(2) reactivity

8

(3) leachability (TCLP test)

8

(4) total metals

8

(5) VOCs

8

(6) other appropriate constituents

8

b. Physical properties of the waste

(1) size

9

(2) density

9

(3) percent solids

10

(4) liquid content of the waste

10

c. Biological properties of the waste, if applicable



Massachusetts Department of Environmental Protection
 Bureau of – Waste Prevention – Solid Waste Management
BWP SW 13 Beneficial Use Determination – Major
BWP SW 30 Beneficial Use Determination - Minor
Application for Beneficial Use Determination


W050861
 Transmittal Number #
 Facility ID (if known)

A. Project Information (cont.)

	Page #	DEP USE ONLY
(1) pathogens	10	
4. Proposed Handling Methods and Utilization	11	
a. Proposed handling methods		
(1) transportation	11	
(2) storage	11	
(3) processing	11	
b. Proposed utilization		
(1) general description	11	
(2) location(s) where material is to be used	11	
(3) health and environmental impacts	11	

B. Certification: 310 CMR 19.011

Any person, required by these regulations or any order issued by the Department, to submit papers shall identify themselves by name, profession, and relationship to the applicant and legal interest in the facility, and make the following certification: "I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate and complete. I am aware that there are significant penalties both civil and criminal for submitting false information including possible fines and imprisonment.

Frank Helin
 Print Name

 Authorized Signature
 Decommissioning Director
 Position/Title
 9/22/2004
 Date



Massachusetts Department of Environmental Protection
 Bureau of – Waste Prevention – Solid Waste Management
BWP SW 13 Beneficial Use Determination – Major
BWP SW 30 Beneficial Use Determination - Minor
Application for Beneficial Use Determination

W050861
 Transmittal Number #
 Facility ID (if known)

A. Project Information (cont.)

	Page #	DEF USE ONLY
(1) pathogens	10	
4. Proposed Handling Methods and Utilization	11	
a. Proposed handling methods		
(1) transportation	11	
(2) storage	11	
(3) processing	11	
b. Proposed utilization		
(1) general description	11	
(2) location(s) where material is to be used	11	
(3) health and environmental impacts	11	

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Michael G. Kline
 Print Name
 Michael G. Kline
 Authorized Signature
 General Manager
 Position/Title
 9/21/04
 Date

Appendix B
Human Health Risk Assessment
BUD for Concrete

**Human Health Risk Assessment
Beneficial Use Determination (BUD) for Concrete
Yankee Nuclear Power Station
Rowe, Massachusetts**

Prepared for
Yankee Atomic Electric Company
49 Yankee Road
Rowe, Massachusetts 01367

Prepared by
Gradient Corporation
20 University Road
Cambridge, MA 02138

September 22, 2004

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2	Hazard Identification.....	2
3	Dose-Response Assessment.....	2
4	Exposure Assessment.....	3
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Table 2	Summary of External Radiation Risk Calculations for BUD
Table 3	External Radiation Risk Calculations – No Overburden Conditions
Table 4	Screening Comparison of Radionuclide Leaching to Groundwater Compared to Drinking Water Guidelines

1 Introduction and BUD Goals

This document presents a human health risk assessment to support the Category 3 Beneficial Use Determination (BUD) for Secondary Materials in Restricted Applications for concrete debris. This BUD is a component of the environmental site closure underway at the Yankee Nuclear Power Station (YNPS). Yankee Atomic Electric Company (YAEC) owns YNPS and surrounding lands, which comprise approximately 1,800 acres, of which approximately 12 acres is occupied by the nuclear plant itself.

Since 1992, the plant has been in the process of being dismantled and YAEC is terminating the YNPS federal license with the Nuclear Regulatory Commission (NRC). In order to terminate its nuclear operating license, YAEC must complete a process of radiological cleanup defined by the NRC and set forth in YAEC's License Termination Plan (LTP). In addition, YAEC will comply with the Massachusetts Department of Public Health (MADPH) requirements for meeting radiological dose guidelines. Both the NRC and MADPH require compliance with radiological "dose-based" requirements for the protection of human health.

In parallel with the license termination and cleanup to meet the NRC and MADPH radiological dose requirements, YAEC is conducting a comprehensive environmental closure that will ensure that the property poses no adverse human or environmental risks once YAEC transfers title of the property. The environmental site closure is being performed as a voluntary action that will adhere to guidelines established by the Massachusetts Department of Environmental Protection (MADEP) as well as guidelines established by the U.S. Environmental Protection Agency (USEPA) -- in addition to the requirements noted above established by NRC and MADPH.

This human health risk assessment was performed to support a Category 3 BUD as outlined in the March 18, 2004 Draft Interim Guidance Document for Beneficial Use Determination Regulations, 310CMR19.060 (MADEP, 2004). The risk management guidelines defined in the draft BUD guidance require demonstration of meeting 0.5×10^{-6} cancer risk for an individual constituent, and 0.5×10^{-5} overall cancer risk summed over all constituents. No cleanup standards for radionuclides are available in the Draft BUD Guidance. This risk assessment develops risk-based support for residual levels of radionuclides in concrete debris, and is consistent with an MCP Method 2 approach.

The BUD risk assessment methods follow those defined under the MCP (MADEP, 1995). However, MADEP does not have any published radiological risk assessment guidance. Thus, the

assessment of radiological risks to support the BUD relied upon the most recent guidance set forth in the USEPA (2000a) Soil Screening Guidance for Radionuclides: Technical Background Document.

2 Hazard Identification

Constituents of potential concern (COPCs) for the BUD include residual PCBs and radionuclides in concrete debris. Confirmation sampling of the concrete will ensure that the maximum residual PCB concentration will be no more than 2 mg/kg in the concrete debris. This maximum threshold is essentially equivalent to the default BUD S-2 and S-3 standard of 1.6 mg/kg for PCBs. The BUD S-2 and S-3 defaults represent a risk-based acceptable average concentration (this is inherent to the risk assessment process). Although all concrete will be confirmed to contain no more than 2 mg/kg, the actual average PCB concentration in concrete will be below the S-2 and S-3 BUD standards for PCBs. Thus, no further risk assessment is required for PCBs in concrete to meet the BUD Category 3 guidelines.

No standards exist in the draft BUD guidance for radionuclides. Thus, the COPCs for the BUD risk assessment are the radionuclides listed in the YNPS LTP. The radionuclide COPCs are listed in Table 1.

The Dose Concentration Guideline Levels (DCGLs) developed in the LTP ensure that the radiation dose from exposure to residual radionuclides is no more than 25 mrem/yr to meet NRC requirements. These DCGLs for the concrete debris were developed using the RESRAD multipathway risk assessment and radionuclide fate modeling system developed by the U.S. Department of Energy (ANL, 2001). The concrete debris that is proposed to be used as fill, covered by 3-feet of soil overburden, will have residual radionuclide concentrations that are less than or equal to the DCGL concentrations. Thus, for this risk evaluation, we conservatively assumed that the concrete debris had concentrations equal to the DCGLs, even though the actual average concentration will by definition be less than the DCGLs.

3 Dose-Response Assessment

USEPA classifies all radionuclides as carcinogens, based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of radiologically induced cancers in humans. For radiological constituents, cancer slope factors have been published in the

USEPA (2000a) Soil Screening Guidance for Radionuclides: Technical Background Document. This document was used as the bases of the dose-response (toxicity) factors used for the BUD risk assessment.

4 Exposure Assessment

Although the ultimate use for the Site has not been determined, it will likely include open space for recreational activities. Furthermore, an Activity Use Limitation (AUL) will be enforced over that portion of the site that constituted the former industrial area, and this is the area applicable to the BUD for concrete. The AUL will ensure that the 3-foot overburden in the former industrial area is maintained.

The AUL will preclude excavation, without a DEP-approved soil management plan and would occur only under the oversight of a Licensed Site Professional (LSP). Thus, the AUL will prevent "direct contact" pathways such as incidental ingestion and dermal contact with subsurface materials. Furthermore, indirect pathways such as intake from vegetables that might conceivably be grown on the graded area, would not lead to the uptake of radionuclides as they would lie beneath the 3-foot of graded material. Thus, the remaining pathway of possible concern for exposure to radionuclides in the subsurface concrete, is from external radiation (*e.g.*, ionizing radiation emitted as the result of radioactive decay).

In order to evaluate the attenuation provided by the 3-feet of overburden, we used the U.S. Department of Energy RESRAD multipathway risk assessment model (ANL, 2001). We first calculated the external radiation dose assuming no overburden, then performed a parallel calculation for a scenario that included 3-foot of soil overburden. For both scenarios, a unit concentration (*e.g.*, 1 pCi/g) was used for each radionuclide (the dose and risks scale directly as a function of the source concentration).

As summarized in Table 1, the dose reduction provided by the 3-foot of overburden is quite large, ranging from over 10,000-fold at a minimum, and for some radionuclides diminishing the external radiation dose by well over a million-fold.

Although the AUL may not necessarily preclude installation of a well for drinking water from a regulatory perspective, as a practical matter installation of a drinking water well would be implausible with the AUL in place. Nevertheless, we examined the leaching to groundwater pathway for the radionuclides in concrete, as discussed in the next section.

5 Radiological Risk Characterization

Although the AUL will preclude direct contact with subsurface concrete debris, radionuclides can have a deleterious effect on humans without being taken into or brought in contact with the body. This is because high-energy beta particles and photons from radionuclides can exert their energy directly in human tissue. Such "external radiation" exposures can result from exposure to residual radionuclides at the site. Gamma and x-rays are the most penetrating of the emitted radiation and comprise the primary contribution to the radiation dose from external exposures. Radionuclide intake is expressed in units of radiation activity (*i.e.*, picocurie or pCi) rather than mass.

5.1 External Radiation

Cancer risk associated with external radiation exposures was calculated using the following equation, which accounts for external radiation exposure while indoors and outdoors (USEPA, 2000b):¹

$$\text{Risk} = \bar{C} \times \left(\frac{\text{EF}}{365 \text{ days/yr}} \right) \times \text{ED} \times \text{ACF} \times [\text{ET}_o + (\text{ET}_i \times \text{GSF})] \times \text{CSF}_{\text{ext}} \quad (5-1)$$

where:

\bar{C}	=	Average exposure point concentration (pCi/g)
EF	=	Exposure frequency (days/yr)
ED	=	Exposure duration (<i>e.g.</i> , 30 years)
ACF	=	Area correction factor (default = 0.9; USEPA, 2000a)
ET_o	=	Exposure time fraction outdoors (default = 0.073; USEPA, 2000a)
ET_i	=	Exposure time fraction indoors (default = 0.683; USEPA, 2000a)
GSF	=	Gamma shielding factor (default = 0.4; USEPA, 2000a)
CSF_{ext}	=	Cancer slope factor for external radiation (risk/yr per pCi/g)

Values for the radionuclide cancer slope factors are given in USEPA's Soil Screening Guidance for Radionuclides (USEPA, 2000a) as well as the RESRAD User's Manual (ANL, 2001).

¹ Note that the equation in the USEPA Technical Background Document contains a typographical error, the correct equation is found in Equation 4, page 2-22, of the USEPA User's Guide. Note further that the USEPA SSLs are written in terms of a "risk based concentration" (*e.g.*, the SSL term is the radionuclide concentration (C) term); the risk equation here simply rearranges the USEPA equation to express it as a function of risk.

Adjustment of Concentration for Radioactive Decay

The concentration of radionuclides in the environment declines according to radionuclide-specific decay rates. Thus, the radionuclide concentration (C) is not a constant, but rather declines as a function of time according to the following exponential equation:

$$C(t) = C_0 e^{-\lambda t} \tag{5-2}$$

where

- C(t) = concentration at time "t" in years (pCi/g)
- C₀ = initial concentration at time t=0 (pCi/g)
- λ = $\frac{\ln(2)}{t_{1/2}}$ is the decay constant (per year)
- t_{1/2} = half-life (years)

The average concentration (\bar{C}) over a particular time period (T) is given by integrating the declining concentration over the time period:

$$\begin{aligned} \bar{C} &= \frac{1}{T} \int_0^T C_0 e^{-\lambda t} dt \\ &= C_0 \frac{(1 - e^{-\lambda T})}{T\lambda} \end{aligned} \tag{5-3}$$

where C₀ is the exposure point concentration at the beginning (time t=0) of the exposure period. In this analysis, we adopted the standard "default" assumption of a 30-year exposure duration (i.e., T = 30 years, where T and ED are synonymous).

For radionuclides with short half-lives (e.g., shorter than the typical exposure duration of interest), the time-averaged concentration can be appreciably less than the initial concentration. Conversely, for long-lived radionuclides, the adjustment for radioactive decay is insignificant.

A summary of the external radiation cancer risks for the BUD is provided in Table 2. The risks calculated for the 3-foot overburden are given by calculating the risks using Equation 5-1 with the average concentration given by Equation 5-3 as though no overburden existed (see Table 3), and then

adjusting these risks by accounting for dose reduction provided by the 3-foot overburden. The risk assessment results meet the dual BUD risk-based criteria:

- All individual radionuclide risks fall below 0.5×10^{-6}
- The total risk of 1×10^{-8} (rounded from 9.8×10^{-9}) is well below the BUD risk guideline of 0.5×10^{-5} .

This evaluation demonstrates that the Category 3 BUD for concrete meets the risk management guidelines in the Draft BUD Guidance document (MADEP, 2004).

Relationship Between Radiation Dose (mrem/yr) and Cancer Risk

As noted in Section 2, the DCLGs in the LTP are established on the basis of limiting the possible radiation dose to 25 mrem/yr. Cancer risk can be related to radiation dose through the following equation:

$$\text{Risk}_{\text{ext}} = \text{Dose}_{\text{ext}} \times \text{ED} \times \frac{(1 - e^{-\lambda T})}{\lambda} \times \left(\frac{\text{CSF}_{\text{ext}}}{\text{DCF}_{\text{ext}}} \right) \tag{5-4a}$$

For radionuclides with long half-lives, this reduces to:

$$\text{Risk}_{\text{ext}} = \text{Dose}_{\text{ext}} \times \text{ED} \times \left(\frac{\text{CSF}_{\text{ext}}}{\text{DCF}_{\text{ext}}} \right) \tag{5-4b}$$

where

- Dose_{ext} = External radiation dose (mrem/yr)
- CSF_{ext} = External radiation cancer slope factor (risk per pCi/g)
- DCF_{ext} = External radiation dose conversion factor (mrem/yr per pCi/g)

The relationship between "risk" and "dose" is provided here for completeness. For the BUD, the dose calculations are not needed to ensure compliance with the BUD risk management guidelines. However, as shown in Table 2, the dose for due to subsurface concrete materials would be approximately 10,000-fold below the Massachusetts Department of Public Health dose guideline of 10 mrem/year.

5.2 Leaching to Groundwater

Using methods consistent with the MCP and MADEP Guidelines (MADEP 1994, 1995), and also defined in U.S. EPA's (2000a,b) Soil Screening Guide for Radionuclides, we examined possible leaching to groundwater for the radionuclides in concrete. For this evaluation we performed the following stepwise screening evaluation:

1. Calculate an equilibrium concentration of radionuclide in pore water using standard equilibrium partitioning equations:
2. Applied a "dilution attenuation factor" (DAF) to the pore water values as a screening estimate of the concentration at a hypothetical well.
3. Compared the resulting concentrations in "groundwater" to drinking water standards for radionuclides.

The equations used for step 1 and 2 are outlined below:

Step 1:

$$C_w = C_s \times \left(\frac{\rho_b}{\phi + \rho_b K_d} \right) \times 10^3 \text{ (g/kg)} \quad (5-5)$$

Step 2:

$$C_{gw} = \frac{C_w}{DAF} \quad (5-6)$$

where

C_w	=	concentration in pore water (pCi/L)
C_s	=	concentration in soil (pCi/g)
C_{gw}	=	concentration in groundwater (pCi/L)
K_d	=	soil-water partition coefficient (L/kg)
ϕ	=	porosity or water content (cm^3/cm^3)
ρ_b	=	soil bulk density (g/cm^3)
DAF	=	dilution attenuation factor (unitless)

The radionuclide soil-water partition coefficients, which are based on values published in the RESRAD User's Manual, are also summarized in the LTP (Appendix 6N).

There are no DAF values for radionuclides in the MADEP (1994, 1995) guidance. However, the MADEP has derived DAF values for a range of organic compounds with varying soil-water K_d parameters, as summarized below:

Parameter	K_{oc} (L/kg)	K_d (L/kg)	DAF
benzene	83	0.083	56.5
ethylbenzene	575	0.575	121.1
toluene	270	0.27	80.6
o-xylene	302	0.302	83.3
TCE	124	0.124	76.3
PCE	468	0.468	86.2
1,1,1-TCA	157	0.157	169.2
naphthalene	1288	1.288	222.2

Notes:

$$K_d = K_{oc} \times f_{oc} \text{ (} f_{oc} = 0.001, \text{ i.e., 0.1\% organic carbon)}$$

Source: MADEP (1994)

Based on these modeled DAF values, MADEP (1994) developed a regression equation for DAF values for non-modeled compounds as a function of chemical partition coefficient.

As summarized in Table 4, the soil-water partition coefficients for radionuclides are greater than (e.g., less soluble in water) than all of the compounds modeled by MADEP. Rather than extrapolate beyond the range of the MADEP modeled results, we adopted a DAF value of 222 (e.g., the value for naphthalene with a K_d value of 1.3), as this was the compound with the largest K_d value modeled. This DAF value is likely to underestimate the dilution for the radionuclides, with typical K_d values ranging from approximately 10 L/kg to over 1,000 L/kg (see Table 4).²

The calculated radionuclide concentrations in groundwater (C_{gw}) calculated in this manner, were compared to the drinking water standards, as summarized in Table 4. Note that for this calculation, the average concentration in concrete debris over a 30-year period, taking into account radioactive decay (Equation 5-3), was used for the value of C_s in Equation 5-5. As the results in Table 4 indicate, the placement of subsurface concrete debris under the BUD with radionuclide concentrations equal to the DCGLs would not lead to groundwater contamination above drinking water standards.

² Tritium (Hydrogen-3 in Table 4) is the notable exception, as it does not "partition" to soil.

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Tables

**Table 1
Radiation Dose Reduction Due to 3-Foot Soil Overburden**

Radionuclide	Radiation Dose at Year 1		
	External Radiation Dose (mrem/yr)		Dose Reduction
	No Overburden	3-Foot of Soil	
Cobalt (Co-60)	7.5E+00	1.6E-04	4.6E+04
Cesium (Cs-137)	1.8E+00	4.1E-06	4.5E+05
Silver (Ag-108m)	1.7E+00	2.9E-06	5.9E+05
Tritium (H-3)	n/a	n/a	n/a
Carbon (C-14)	3.1E-08	5.4E-24	5.8E+15
Iron (Fe-55)	n/a	n/a	n/a
Nickel (Ni-63)	n/a	n/a	n/a
Strontium (Sr-90)	1.3E-02	9.4E-10	1.4E+07
Niobium (Nb-94)	1.7E+00	6.7E-06	2.6E+05
Technetium (Tc-99)	2.3E-05	5.4E-18	4.3E+12
Antimony (Sb-125)	3.1E-01	3.0E-07	1.0E+06
Cesium (Cs-134)	3.2E+00	9.4E-06	3.4E+05
Europium (Eu-152)	3.7E+00	3.6E-05	1.0E+05
Europium (Eu-154)	3.9E+00	4.9E-05	7.9E+04
Europium (Eu-155)	8.5E-02	3.3E-13	2.6E+11
Plutonium (Pu-238)	8.9E-05	5.9E-17	1.5E+12
Plutonium (Pu-239)	1.7E-04	1.3E-12	1.3E+08
Plutonium (Pu-241)	1.0E-05	3.9E-15	2.6E+09
Americium (Am-241)	2.5E-02	5.3E-21	4.8E+18
Curium (Cm-243)	3.2E-01	2.9E-09	1.1E+08

Notes:

All doses calculated using RESRAD 6.22 for a unit concentration (1 pCi/g) in soil and default parameters from RESRAD. Doses and dose reduction are for external radiation pathways (all other pathways turned off).

gamma shielding factor = 0.7

fraction of time outdoors = 0.5

fraction of time indoors = 0.25

n/a = not applicable, not a cancer risk for external radiation (USEPA, 2000).

Table 2
Summary of External Radiation Risk Calculations for BUD

Radionuclide	Concrete Debris DCGL [1] (pCi/g)	External Radiation Cancer Risk Without 3-Foot Overburden [2] (pCi/g)	Dose/Risk Reduction 3-Foot Overburden [3] (at Year 1)	External Risk With 3-Foot Overburden [4]	External Dose With 3-Foot Overburden [5] (mrem/yr)
Co-60	4.3	1.2E-04	4.6E+04	2.6E-09	4.5E-04
Cs-137 + D	6.7	1.1E-04	4.5E+05	2.5E-10	1.5E-05
Silver - 108m + D	7.0	4.2E-04	5.9E+05	7.0E-10	3.4E-05
Hydrogen-3	280.0	n/a	n/a	n/a	n/a
Carbon-14	7.2	5.0E-10	5.8E+15	8.6E-26	4.9E-21
Iron-55	140.0	n/a	n/a	n/a	n/a
Nickel-63	100.0	n/a	n/a	n/a	n/a
Strontium-90+D	0.8	9.5E-08	1.4E+07	6.7E-15	3.9E-10
Niobium-94	7.0	4.6E-04	2.6E+05	1.8E-09	7.8E-05
Technetium-99m	61.0	4.5E-08	4.3E+12	1.0E-20	5.3E-16
Antimony-125+D	31.0	7.2E-05	1.0E+06	7.0E-11	2.2E-05
Cesium-134m	4.7	2.9E-05	3.4E+05	8.4E-11	3.9E-05
Europium-152	9.5	2.3E-04	1.0E+05	2.2E-09	1.9E-04
Europium-154	9.1	1.7E-04	7.9E+04	2.1E-09	2.6E-04
Europium-155	380.0	1.0E-04	2.6E+11	3.9E-16	8.0E-11
Plutonium-238	9.5	5.5E-09	1.5E+12	3.6E-21	2.8E-16
Plutonium-239	8.8	1.6E-08	1.3E+08	1.2E-16	6.1E-12
Plutonium-241	140.0	2.7E-09	2.6E+09	1.0E-18	3.0E-13
Americium-241	4.1	9.9E-07	4.8E+18	2.1E-25	1.1E-20
Curium-243	4.7	1.2E-05	1.1E+08	1.1E-13	7.4E-09
Totals				9.8E-09	1.1E-03
Regulatory Guideline				5.0E-06	10

Notes:

[1] Dose concentration guideline levels for concrete debris in LTP (radionuclide concentration in concrete will be less than or equal to these values).

[2] External radiation risk for no overburden calculated using EPA (2000) default parameters and cancer slope factors.

[3] Dose reduction for 3-foot soil cover calculated using RESRAD 6.22 for a unit concentration (1 pCi/g) in soil and default parameters from RESRAD.

[4] Cancer risk for BUD based on 3-foot overburden (Column [2] divided by column [3].)

[5] External radiation dose at year-1 Cancer risk for BUD based on 3-foot overburden (Dose with no cover from Table 3, divided by column [3])

n/a - radionuclide not a cancer risk for external radiation (EPA, 2000).

**Table 3
External Radiation Risk and External Dose Calculations -- No Overburden Conditions**

Radionuclides Evaluated	Concentration (C ₀) (pCi/g)	Half-Life (t _{1/2}) (yrs)	Ave. Conc. (C _{ave}) (pCi/g)	Slope Factor (CSF) (Risk/yr- pCi/g)	DCF (mrem/yr - pCi/g)	Cancer Risk (C _{ave} × IF × CSF)	Dose - 1 yr (C × IF × DCF) (mrem/yr)
Co-60	4.3	5.3	1.07	1.24E-05	1.62E+01	1.19E-04	2.1E+01
Cs-137 + D	6.7	30.0	4.83	2.55E-06	3.41E+00	1.10E-04	6.8E+00
Silver - 108m + D	7.0	127.0	6.46	7.19E-06	9.65E+00	4.2E-04	2.0E+01
Hydrogen-3	280.0	12.0	133.02				
Carbon-14	7.2	5730.0	7.19	7.83E-12	1.34E-05	5.0E-10	2.9E-05
Iron-55	140.0	3.0	20.18				
Nickel-63	100.0	100.0	90.29				
Strontium-90+D	0.8	29.0	0.54	1.96E-08	2.46E-02	9.5E-08	5.6E-03
Niobium-94	7.0	20000.0	7.00	7.29E-06	9.68E+00	4.6E-04	2.0E+01
Technetium-99m	61.0	210000.0	61.00	8.14E-11	1.26E-04	4.5E-08	2.3E-03
Antimony-125+D	31.0	3.0	4.47	1.81E-06	2.45E+00	7.2E-05	2.3E+01
Cesium-134m	4.7	2.0	0.45	7.10E-06	9.47E+00	2.9E-05	1.3E+01
Europium-152	9.5	13.0	4.74	5.30E-06	7.01E+00	2.3E-04	2.0E+01
Europium-154	9.1	8.0	3.24	5.83E-06	7.68E+00	1.7E-04	2.1E+01
Europium-155	380.0	5.0	89.94	1.24E-07	1.82E-01	1.0E-04	2.1E+01
Plutonium-238	9.5	88.0	8.46	7.22E-11	1.51E-04	5.5E-09	4.3E-04
Plutonium-239	8.8	24000.0	8.80	2.00E-10	2.95E-04	1.6E-08	7.8E-04
Plutonium-241	140.0	14.0	72.91	4.11E-12	1.89E-05	2.7E-09	7.9E-04
Americium-241	4.1	432.0	4.00	2.76E-08	4.37E-02	9.9E-07	5.4E-02
Curium-243	4.7	28.0	3.32	4.19E-07	5.83E-01	1.2E-05	8.2E-01
Total:						2.3E-04	2.8E+01

IF _{risk}	(EF/365) × ED × ACF × (ET _{out} + (ET _{in} × GSF))	8.96E+00
IF _{dose}	(EF/365) × ACF × (ET _{out} + (ET _{in} × GSF))	2.99E-01

where:

EF	=	Exposure Frequency (d/yr)	350	(EPA, 2000)
ED	=	Adult + Child Exposure Duration(yr)	30	(EPA, 2000)
ACF	=	Area Correction Factor	0.9	0.5 acre (EPA, 2000)
Etout	=	Exposure time outside (fraction)	0.073	(EPA, 2000)
Etin	=	Exposure time inside (fraction)	0.683	(EPA, 2000)
GSF	=	gamma shielding factor	0.40	(EPA, 2000)
		ACF × (Etout + (Etin × GSF)) =	3.12E-01	
		Exposure time at site (hr/day)	18.1	
		Away from site (hr/day)	5.9	

Table 4
Screening Comparison of Radionuclide Leaching to Groundwater Compared to Drinking Water Guidelines

Radionuclide	Half-life (yr)	Initial Conc. (DCGL) [1] (pCi/g)	Average Conc. 30-years [2] (pCi/g)	Partition Coeff. Kd [3] (L/kg)	Concentration in Pore Water [4] (pCi/L)	Concentration DAF = 100 [4] (pCi/L)	Drinking Water Guidelines [5] (pCi/L)
Co-60	5.27	4.3	1.1	282.0	3.8	0.02	100
Cs-137 + D	30	6.7	4.8	137.0	35.2	0.16	200
Silver - 108m + D	127	7.0	6.5	6500.0	1.0	0.00	5.8 (RBL)
Hydrogen-3	12	280	133.0	0.00	731,598.7	3,295	20,000
Carbon-14	5,730	7.2	7.2	70.70	101.4	0.46	2,000
Iron-55	3	140	20.2	12.5	1,591.1	7.17	2,000
Nickel-63	100	100	90.3	35.5	2,530.4	11.4	50
Strontium-90+D	29	0.76	0.5	10.50	50.8	0.23	8
Niobium-94	2.00E+04	7.0	7.0	316.0	22.1	0.10	6.1 (RBL)
Technetium-99m	2.10E+05	61	61.0	14	4,458.3	20.08	900
Antimony-125+D	3	31	4.5	1,550	2.9	0.01	300
Cesium-134m	2	4.7	0.5	137.0	3.3	0.01	80
Europium-152	13	9.5	4.7	1,000.0	4.7	0.02	200
Europium-154	8	9.1	3.2	1000.0	3.2	0.01	60
Europium-155	5	380	89.9	1,000	89.9	0.41	600
Plutonium-238	88	9.5	8.5	888.0 [a]	9.5	0.04	15
Plutonium-239	2.40E+04	8.8	8.8	888.0 [a]	9.9	0.04	15
Plutonium-241	14	140	72.9	888.0 [a]	82.1	0.37	27 (RBL)
Americium-241	432	4	4.0	447 [a]	9.0	0.04	15
Curium-243	28	4.7	3.3	400.0 [a]	8.3	0.04	15

Notes:

- [1] Values reported in License Termination Plan.
- [2] Calculated average concentration in subsurface concrete over 30 year time period based on radioactive decay (see text).
- [3] Median Kd values reported in LTP (from RESRAD). Values noted [a] are 25th percentiles from LTP Appendix 6N.
- [4] Equilibrium concentration between concrete/soil and groundwater assuming no dilution (see text).
- [5] Drinking water guidelines are MCLs from USEPA (2000) Soil Screening Guidance for Radionuclides. RBL = Risk Based Limit (no MCL)

Parameters for [2], [3] and [4]:

Averaging Period (yrs):	30
bulk density (g/cc):	1.54
porosity (cc/cc):	0.28
Dilution Attenuation Factor (DAF)	222