Entergy

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10 CFR 50.82

November 16, 2018

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Post Shutdown Decommissioning Activities Report
Pilgrim Nuclear Power Station

Docket No. 50-293
License No. DPR-35

REFERENCES: 1. Letter, Entergy Nuclear Operations, Inc. to USNRC, "Notification of Permanent Cessation of Power Operations," 2.15.080, dated November 10, 2015 (ML15328A053)

LETTER NUMBER: 2.18.070

Dear Sir or Madam:

Pursuant to 10 CFR 50.82(a)(4), Entergy Nuclear Operations, Inc. (ENO), on behalf of itself and Entergy Nuclear Generation Company (ENGC), is submitting a Post Shutdown Decommissioning Activities Report (PSDAR) for the Pilgrim Nuclear Power Station (PNPS). By letter dated November 10, 2015, ENO notified the NRC of its intent to permanently cease power operations at PNPS no later than June 1, 2019 (Reference 1).

The enclosed PSDAR has been developed consistent with Regulatory Guide 1.185, Revision 1, "Standard Format and Content for Post-Shutdown Decommissioning Activities Report." The PSDAR includes a description of the planned decommissioning activities, a schedule for their accomplishment, a site-specific decommissioning cost estimate, and a discussion that provides the basis for concluding that the environmental impacts associated with site-specific decommissioning activities will be bounded by appropriate, previously issued, environmental impact statements. The PSDAR also includes a discussion of the schedule and projected costs associated with spent fuel management and site restoration activities. Funding for spent fuel management activities is being addressed in a separate submittal as an update to the PNPS Spent Fuel Management Plan, pursuant to 10 CFR 50.54(bb).

In accordance with 10 CFR 50.82(a)(4)(i), a copy of the PNPS PSDAR is being provided to the Commonwealth of Massachusetts by transmitting a copy of this letter and its Enclosure to the designated State Officials.

There are no new regulatory commitments contained in this letter.

Should you have any questions concerning this submittal or require additional information, please contact Mr. Peter J. Miner at (508) 830-7127.

Sincerely,

Mandy K. Halter

MKH/shr

Enclosure: Pilgrim Nuclear Power Station Post-Shutdown Decommissioning Activities Report

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NRC Resident Inspector
Pilgrim Nuclear Power Station

Pilgrim Nuclear Power Station

Post-Shutdown Decommissioning Activities Report

Prepared on Behalf of Entergy Nuclear Generation Company
by TLG Services, Inc.

November 2018

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TABLES

ATTACHMENTS

Acronyms

AIF	Atomic Industrial Forum
ALARA	As Low As Reasonably Achievable
BMP	Best Management Practices
BWR	Boiling Water Reactor
CFR	Code of Federal Regulations
DCE	Decommissioning Cost Estimate
DOE	Department of Energy
DSEIS	Draft Supplemental Environmental Impact Statement (NUREG-1437)
ENGC	Entergy Nuclear Generation Company
ENOI	Entergy Nuclear Operations, Inc.
ENTERGY	Entergy Corporation
EPA	Environmental Protection Agency
FSAR	Final Safety Analysis Report
FSS	Final Status Survey
GEIS	Generic Environmental Impact Statement (NUREG-0586)
GTCC	Greater than Class C
GW	Groundwater
ISFSI	Independent Spent Fuel Storage Installation
LLRW	Low-Level Radioactive Waste
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MassDEP	Massachusetts Department of Environmental Protection
MWth	Megawatt-thermal
NEI	Nuclear Energy Institute
NESP	National Environmental Studies Project
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
PNPS	Pilgrim Nuclear Power Station
PSDAR	Post-Shutdown Decommissioning Activities Report
SEIS	Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437), Supplement 29 "Regarding Pilgrim Nuclear Power Station"
SFP	Spent Fuel Pool
SSCs	Structures, Systems and Components
UFSAR	Updated Final Safety Analysis Report

1.0 INTRODUCTION AND SUMMARY

1.1 Introduction

In accordance with the requirements of Title 10 of the Code of Federal Regulations (CFR) 50.82, "Termination of license," paragraph (a)(4)(i), this report constitutes the Post-Shutdown Decommissioning Activities Report (PSDAR) for the Pilgrim Nuclear Power Station (PNPS). This PSDAR contains the following:

1. A description of the planned decommissioning activities along with a schedule for their accomplishment.
2. A discussion that provides the reasons for concluding that the environmental impacts associated with site-specific decommissioning activities will be bounded by appropriate previously issued environmental impact statements.
3. A site-specific decommissioning cost estimate (DCE), including the projected cost of managing irradiated fuel and the post-decommissioning site restoration cost.

The PSDAR has been developed consistent with Regulatory Guide 1.185, "Standard Format and Content for Post-Shutdown Decommissioning Activities Report," (Reference 1). This report is based on currently available information and the plans discussed herein may be modified as additional information becomes available or conditions change. As required by 10 CFR 50.82(a)(7), ENOI will notify the Nuclear Regulatory Commission (NRC) in writing, with copies sent to the affected State(s), before performing any decommissioning activity inconsistent with, or making any significant schedule change from, those actions and schedules described in the PSDAR, including changes that significantly increase the decommissioning cost.

1.2 Background

The PNPS site is located on the rocky western shore of Cape Cod Bay in the Town of Plymouth, Plymouth County, Massachusetts. The nearest large cities are Boston, Massachusetts, approximately 38 miles to the northwest and Providence, Rhode Island, approximately 44 miles to the west. The PNPS facility occupies approximately 140 acres. ENGC also owns approximately 1,500 acres of forestland adjacent to the plant site, which falls under Massachusetts General Law Chapter 61 and holds a documented forest management plan.

PNPS employs a General Electric boiling water reactor nuclear steam supply system licensed to generate 2,028 megawatts - thermal (MWth). PNPS was purchased by Entergy Nuclear Generation Company (ENGC) in July 1999, and is operated by Entergy Nuclear Operations, Inc. (ENOI) on behalf of ENGC. The current facility operating license for PNPS expires at midnight, June 8, 2032. PNPS employs a General Electric boiling water reactor nuclear steam supply system licensed to generate 2,028 megawatts - thermal (MWth) The principal structures of PNPS are the reactor and turbine buildings, off-gas retention building, radwaste building, diesel generator building, intake structure, switchyard, main stack, trash compaction facility, and administration buildings.

PNPS structures are primarily located within the fenced owner-controlled area (OCA), with the exception of the wastewater treatment facility and the main stack.

A brief overview of the major milestones related to PNPS construction and operational history is as follows:

• Construction Permit Issued:	August 26, 1968
• Operating License Issued:	June 8, 1972
• Commercial Operation:	December 1, 1972
• Initial Operating License Expiration:	June 8, 2012
• Renewed Operating License Expiration:	June 8, 2032

By letter dated November 10, 2015 (Reference 2), ENOI notified the NRC that it intended to permanently cease power operations of PNPS no later than June 1, 2019. ENOI will submit a supplement to this letter certifying the date on which operations have ceased, or will cease, in accordance with 10 CFR 50.82(a)(1)(i) and 10 CFR 50.4(b)(8). Upon docketing of the certifications required by 10 CFR 50.82(a)(1)(i) and 10 CFR 50.82(a)(1)(ii), pursuant to 10 CFR 50.82(a)(2), the 10 CFR Part 50 license for PNPS will no longer authorize operation of the reactor or emplacement or retention of fuel in the reactor vessel.

Pursuant to 10 CFR 50.51(b), "Continuation of license," the license for a facility that has permanently ceased operations continues in effect beyond the expiration date to authorize ownership and possession of the utilization facility until the Commission notifies the licensee in writing that the license has been terminated.

During the period that the license remains in effect, 10 CFR 50.51(b) requires that ENGC:

1. Take actions necessary to decommission and decontaminate the facility and continue to maintain the facility including storage, control, and maintenance of the spent fuel in a safe condition.
2. Conduct activities in accordance with all other restrictions applicable to the facility in accordance with NRC regulations and the 10 CFR 50 facility license.

10 CFR 50.82(a)(9) states that power reactor licensees must submit an application for termination of the license at least two years prior to the license termination date and that the application must be accompanied or preceded by a license termination plan to be submitted for NRC approval.

1.3 Summary of Decommissioning Alternatives

The NRC has evaluated the environmental impacts of three general methods for decommissioning power reactor facilities in NUREG-0586, "Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors," (GEIS) (Reference 3). The three general methods evaluated are summarized as follows:

- DECON: The equipment, structures and portions of the facility and site that contain radioactive contaminants are promptly removed or decontaminated to a level that permits termination of the license shortly after cessation of operations.
- SAFSTOR: After the plant is shut down and defueled, the facility is placed in a safe, stable condition and maintained in that state (safe storage). The facility is decontaminated and dismantled at the end of the storage period to levels that permit license termination. During SAFSTOR, a facility is left intact or may be partially dismantled, but the fuel is removed from the reactor vessel and radioactive liquids are drained from systems and components and then processed. Radioactive decay occurs during the SAFSTOR period, thereby reducing the quantity of contamination and radioactivity that must be disposed of during decontamination and dismantlement.
- ENTOMB: Radioactive structures, systems and components (SSCs) are encased in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

The decommissioning approach that has been selected by ENGC for PNPS is the SAFSTOR method. The primary objectives of the PNPS decommissioning project are to remove the facility from service, reduce residual radioactivity to levels permitting unrestricted release, restore the site, perform this work safely, and complete the work in a cost effective manner. The selection of a preferred decommissioning alternative is influenced by a number of factors at the time of plant shutdown. These factors include the cost of each decommissioning alternative, minimization of occupational radiation exposure, availability of low-level waste disposal facilities, availability of a high-level waste (spent fuel) repository or a Department of Energy (DOE) interim storage facility, regulatory requirements, and public concerns. In addition, 10 CFR 50.82(a)(3) requires decommissioning to be completed within 60 years of permanent cessation of operations.

Under the SAFSTOR methodology, the facility is placed in a safe and stable condition and maintained in that state allowing levels of radioactivity to decrease through radioactive decay, followed by decontamination and dismantlement. After the safe storage period, the facility will be decontaminated and dismantled to levels that permit license termination. In accordance with 10 CFR 50.82(a)(9), a license termination plan will be developed and submitted for NRC approval at least two years prior to termination of the license.

The decommissioning approach for PNPS is described in the following sections.

- Section 2.0 describes the planned decommissioning activities and the general timing of their implementation.
- Section 3.0 describes the overall decommissioning schedule, including the spent fuel management activities.
- Section 4.0 provides an analysis of expected decommissioning costs, including the costs associated with spent fuel management and site restoration.

- Section 5.0 describes the basis for concluding that the environmental impacts associated with decommissioning PNPS are bounded by the NRC generic environmental impact statement related to decommissioning.
- Section 6.0 is a list of references.

2.0 DESCRIPTION OF PLANNED DECOMMISSIONING ACTIVITIES

ENGC is currently planning to decommission PNPS using a SAFSTOR method. SAFSTOR is broadly defined in Section 1.3 of this report. Use of the SAFSTOR method will require the management of spent fuel because of the DOE's failure to perform its spent fuel removal obligations under its contract with ENGC. To explain the basis for projecting the cost of managing SNF, a discussion of spent fuel management activities for the site is included herein.

The initial decommissioning activities to be performed after plant shutdown will entail preparing the plant for a period of safe-storage (also referred to as dormancy). This will entail de-fueling the reactor and transferring the fuel into the spent fuel pool, draining of fluids and de-energizing non-essential systems, and reconfiguring the electrical distribution, ventilation, heating, and fire protection systems. Systems temporarily needed for continued operation of the spent fuel pool will be reconfigured for operational efficiency. Additional ISFSI storage capacity will be developed to allow for dry storage of all spent fuel assemblies and GTCC waste generated during the plant operations.

During dormancy the PNPS will be staffed with personnel who will monitor, maintain and provide security for the ISFSI and plant facilities. Staffing and configuration requirements are expected to change during the period of dormancy, principally dependent upon the status of the spent fuel being stored on-site. This can be characterized as one of three spent fuel conditions, as follows:

- Wet and dry storage of spent fuel
- On-site dry storage of all spent fuel
- All spent fuel removed from the site

Spent fuel will remain in the spent fuel pool (SFP) until it meets the criteria for transfer to the ISFSI. After all fuel has been transferred to the ISFSI, the pool and supporting systems will be in a drained and de-energized condition for the remainder of the dormancy period. The spent fuel will be stored in the ISFSI until transfer to the Department of Energy (DOE).

After the final spent fuel transfer to the ISFSI, the plant will remain in dormancy until the start of dismantling and decontamination (D&D) activities. D&D activities will be scheduled to enable the license to be terminated within 60 years after permanent cessation of operations. Following completion of the D&D activities and termination of the NRC license, site restoration will be performed.

For the purposes of the current site-specific decommissioning cost estimate, it is assumed that remaining structures are to be demolished to three-feet below grade and the excavations backfilled. Decommissioning activities will be performed in accordance with written, reviewed and approved site procedures. There are no identified or anticipated decommissioning activities that are unique to the PNPS site outside the bounds considered in the GEIS.

Radiological and environmental programs will be maintained throughout the decommissioning process to ensure occupational, public health and safety, and environmental compliance.

Radiological programs will be conducted in accordance with the facility's revised Technical Specifications, Operating License, Updated Final Safety Analysis Report (UFSAR), Radiological Environmental Monitoring Program, and the Offsite Dose Calculation Manual. Non-radiological Environmental Programs will be conducted in accordance with applicable requirements and permits.

Tables 2.1 and 2.2 provide summaries of the schedule / plant status and costs for decommissioning PNPS. The major decommissioning activities and the general sequence of activities are discussed in more detail in the sections that follow.

TABLE 2.1
Decommissioning Schedule and Plant Status Summary

Decommissioning Activities / Plant Status	Start	End	Approximate Duration (years)
Pre-Shutdown Planning	2018	May 2019	1.0
Transition from Operations			
Plant Shutdown	May 31, 2019	--------	--------
Preparations for SAFSTOR Dormancy	May 31, 2019	March 2020	0.84
SAFSTOR Dormancy			
Dormancy w/Wet Fuel Storage	March 2020	2022	2.8
Dormancy w/Dry Fuel Storage	2022	2062	40.0
Dormancy w/No Fuel Storage	2062	2073	10.4
Preparations for Dismantling & Decontamination (D&D)			
Preparations for D&D	2073	2074	1.5
Dismantling & Decontamination (D&D)[3]			
Large Component Removal	2074	2076	1.4
Plant Systems Removal and Building Decontamination	2076	2078	2.3
License Termination	2078	2079	0.7
Site Restoration			
Site Restoration	2079	2080	1.5
Total from Shutdown to Completion of License Termination	---------	--------	60

TABLE 2.2
Decommissioning Cost Summary
(Thousands of 2018 dollars)

Decommissioning Periods	License Termination	Spent Fuel Management	Site Restoration	Totals
Planning and Preparations	144,683	93,869	0	238,552
Dormancy w/Wet Fuel Storage	125,888	134,770	0	260,658
Dormancy w/Dry Fuel Storage	245,489	191,611	0	437,100
Dormancy w/No Fuel Storage	49,031	0	0	49,031
Site Reactivation	46,701	0	571	47,272
Decommissioning Preparation	35,482	0	451	35,933
Large Component Removal	225,394	0	369	225,763
Plant Systems Removal and Building Remediation	281,263	0	881	282,143
License Termination	33,840	0	0	33,840
Site Restoration	225	0	50,743	50,968
Total [a]	1,187,994	420,250	53,014	1,661,258

[a] Columns may not add due to rounding

2.1 Discussion of Decommissioning Activities

The following narrative describes the basic activities associated with decommissioning the PNPS. The site specific DCE (detailed in Attachment 1) is divided into phases or periods based upon major milestones within the project or significant changes in the annual projected expenditures. The following sub-sections correspond to the five major decommissioning periods within the estimate.

2.1.1 Preparations for Dormancy

The NRC defines SAFSTOR as, "A method of decommissioning in which a nuclear facility is placed and maintained in a condition that allows the facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use." The facility is left intact (during the dormancy period), with structures maintained in a stable condition. Systems that are not required to support the spent fuel, HVAC, Emergency Plan or site security are drained, de-energized, and secured. Minimal cleaning/removal of loose contamination and/or fixation and sealing of remaining contamination is performed. Access to contaminated areas is maintained secure to provide controlled access for inspection and maintenance.

The process of placing the plant in safe-storage will include, but is not limited to, the following activities:

- Creation of an organizational structure to support the decommissioning plan and evolving emergency planning and site security requirements.
- Revision of technical specifications, plans and operating procedures appropriate to the operating conditions and requirements.
- Characterization of the facility and major components as may be necessary to plan and prepare for the dormancy phase.
- Isolation of the spent fuel pool and reconfiguring fuel pool support systems so that draining and de-energizing may commence in other areas of the plant.
- Design and construction of additional ISFSI capacity.
- Deactivation (de-energizing and /or draining) of systems that are no longer required during the dormancy period.
- Processing and disposal of water and water filter and treatment media not required to support dormancy operation.
- Disposition of incidental waste that may be present prior to the start of the dormancy period, such as excess tools and equipment and waste produced while deactivating systems and preparing the facility for dormancy.
- Reconfiguration of power, lighting, heating, ventilation, fire protection, and any other services needed to support long-term storage and periodic plant surveillance and maintenance.
- Stabilization by fixing or removing loose incidental surface contamination to facilitate future building access and plant maintenance. Decontamination of high-dose areas is not anticipated.
- Performance of interim radiation surveys of the plant, posting caution signs and establishing access requirements, where appropriate.
- Maintenance of appropriate barriers for contaminated and radiation areas.
- Reconfiguration of security boundaries and surveillance systems, as required.

The following is a general discussion of the planned reconfiguration expected after plant shutdown.

Electrical Systems

The electrical system will undergo a series of reconfigurations between shutdown and the time all spent fuel has been transferred to dry storage. The reconfigurations will be performed to improve system flexibility and operational control, reduce operating and maintenance expenses, and to provide diverse means of aligning the power sources to the station loads particularly for Spent Fuel Pool-related systems and critical security equipment. The ISFSI facility will require installation of a new electrical distribution system independent of the existing station service and will also include a new diesel generator and uninterruptable power supply system.

Mechanical Systems

Following shutdown, as applicable, fluid filled systems will be drained and abandoned, and resins removed based on an evaluation of system category, functionality, and plant configuration. System categories include: 1) Balance of Plant (BOP), 2) Emergency Core Cooling System (ECCS), 3) Nuclear Steam Safety System (NSSS), 4) Spent Fuel Pool Cooling (SFPC), and 5) Dry Fuel Storage (DFS). Plant configurations include: 1) Post-shutdown (fuel in the reactor), 2) Post-defuel (no fuel in the reactor); 3) Post-gates in (no fuel in reactor, spent fuel pool is physically isolated from the reactor); 4) Reactor vessel drained; 5) Reduced risk of zirconium fire; and 6) Post-dry fuel storage (all spent fuel in dry fuel storage). The plant configuration and functionality of each system within the plant configuration as it evolves will determine when a system can be drained and abandoned.

Ventilation and Heating Systems

Ventilation will be reconfigured for the Turbine Building (TB) and Reactor Building (RB) to support remaining systems and habitability. Fluid filled systems in the TB will either be drained or freeze protection installed, and the heating steam secured. The RB ventilation system will be reconfigured to maintain building temperature to support habitability and the functioning of Fuel Pool Cooling systems, Fire Protection systems, and systems required for Dry Fuel Storage loading.

Fire Protection Systems

Active and passive features of the Fire Protection (FP) systems will be revised based on a fire hazards analysis. The fire hazards analysis provides a comprehensive evaluation of the facility's fire hazards, the fire protection capability relative to the identified hazards, and the ability to protect spent fuel and other radioactive materials from potential fire-induced releases. The fire hazards analysis will be reevaluated and revised as necessary to reflect the unique or different fire protection issues and strategies associated with decommissioning. It is expected that as the plant's systems are drained and de-energized, the combustible loading footprint shrinks, and the hazards are removed, the FP systems, features and requirements will be reduced or eliminated.

Maintenance of Systems Critical to Decommissioning

There are no currently identified mechanical systems that will be critical to the final decommissioning process. As such, mechanical systems will be abandoned after all spent fuel has been transferred to Dry Fuel Storage, with the exception of systems required to maintain habitability during dormancy. The site power distribution system will be abandoned with the possible exception of Motor Control Centers that are required to support ventilation and lighting. The organization responsible for the final dismantlement will be expected to establish necessary temporary services, including electrical and cranes.

2.1.2 Dormancy

Activities required during the early dormancy period while spent fuel is stored in the fuel pool will be substantially different than those activities required during dry fuel or no fuel storage.

Early activities include operating and maintaining the spent fuel pool and its associated systems, relocating the ISFSI, and transferring spent fuel from the pool to the ISFSI. Assuming the timely receipt of the required regulatory approvals, the construction of the consolidated ISFSI is estimated to be completed in 2020. Spent fuel transfer is expected to be complete by mid-year 2022. After the fuel transfer is completed, the pool and systems will be drained and de-energized for long-term storage.

Dormancy activities will include a 24-hour security force, an evolving risk-based emergency response program, preventive and corrective maintenance on security systems, area lighting, general building maintenance, freeze protection heating, ventilation of buildings for periodic habitability, routine radiological inspections of contaminated structures, maintenance of structural integrity, and a site environmental and radiation monitoring program. A fire protection program will be maintained.

Security during the dormancy period will be conducted primarily to safeguard the spent fuel on site and prevent unauthorized entry. A security barrier, sensors, alarms, and other surveillance equipment will be maintained as required to provide security.

An environmental surveillance program will be carried out during the dormancy period to monitor for radioactive material in the environment. Appropriate procedures will be established and initiated for potential releases that exceed prescribed limits. The environmental surveillance program will consist of a version of the program in effect during normal plant operations that will be modified to reflect the plant's conditions and risks at the time.

Late in dormancy, activities will include transferring the spent fuel from the ISFSI to the DOE. For planning purposes, ENGC's current spent fuel management plan for the PNPS spent fuel is based, in general, upon the following projections: 1) a 2030 start date for the DOE initiating transfer of commercial spent fuel to a federal facility, 2) a corresponding 2030 date for beginning to remove spent fuel from PNPS, and 3) a 2062 completion date for removal of all PNPS spent fuel. Transfer could occur earlier if the DOE is successful in implementing its current strategy for the management and acceptance of spent fuel.[1] The ISFSI pad and facilities will be decommissioned at the time of plant decommissioning or after DOE has removed all spent fuel from the site.

2.1.3 Preparations for Decommissioning

Prior to the commencement of decommissioning operations, preparations will be undertaken to reactivate site services and prepare for decommissioning. Preparations include engineering and planning, a site characterization, and the assembly of a decommissioning management organization. This will include the development of work plans, specifications and procedures.

2.1.4 Decommissioning (Dismantling and Decontamination)

Following the preparations for decommissioning, physical decommissioning activities will take place. This includes the removal and disposal of contaminated and activated components and structures, leading to the termination of the 10 CFR 50 operating license. Although much of the radioactivity will decrease during the dormancy period due to decay of ^{60}Co and other short-lived radionuclides, the internal components of the reactor vessel will still exhibit radiation dose rates that will likely require remote sectioning under water due to the presence of long-lived radionuclides such as ^{94}Nb, ^{59}Ni, and ^{63}Ni. Portions of the sacrificial shield and primary containment walls may also be radioactive due to the presence of activated trace elements with longer half-lives (such as ^{152}Eu and ^{154}Eu). It is assumed that radioactive contamination on structures, systems, and component surfaces will not have decayed to levels that will permit unrestricted release. These surfaces will be surveyed and items dispositioned in accordance with the existing radioactive release criteria.

Significant decommissioning activities in this phase include:

- Reconfiguration and modification of site structures and facilities, as needed, to support decommissioning operations. Modifications may also be required to the reactor or other buildings to facilitate movement of equipment and materials, support the segmentation of the reactor vessel and reactor vessel internals, and for large component removal.
- Design and fabrication of temporary and longer-term shielding to support removal and transportation activities, construction of contamination control envelopes, and the procurement of specialty tooling.
- Procurement or leasing of shipping cask, cask liners, and industrial packages for the disposition of low-level radioactive waste (LLRW).

[1] DOE's repository program assumes that spent fuel is accepted for disposal from the nation's commercial nuclear plants in the order ("queue") in which it was removed from service ("oldest fuel first"). The contracts that U.S. generators have with the DOE provide mechanisms for altering the oldest fuel first allocation scheme, including emergency deliveries, exchanges of allocations amongst generators, and the option of providing priority acceptance from permanently shutdown nuclear reactors. Given DOE's failure to accept fuel under its contracts, it is unclear how these mechanisms will operate once DOE begins accepting spent fuel from commercial reactors. Accordingly, this PSDAR assumes that DOE will accept spent fuel in an oldest fuel first order.

- Decontamination of components and piping systems, as required, to control (minimize) worker exposure.
- Disposition of the turbine, condenser, main steam piping, and associated equipment; with appropriate dispositioning based upon radiological surveys.
- Disposition of systems and components.
- Removal of the recirculation pumps and associated piping for controlled disposal.
- Contaminated material will be characterized and segregated for additional offsite processing (disassembly, chemical cleaning, volume reduction, and waste treatment), and/or packaged for controlled disposal at a low-level radioactive waste disposal facility.
- Disposition of control rod blades.
- Disassembly and segmentation of the reactor vessel internals. This will likely involve use of remotely operated equipment within the reactor cavity, covered with a contamination control envelope. The cavity water level will likely need to be maintained just below the cut to maintain the working area dose rates ALARA. Some of this material may exceed Class C (GTTC) disposal requirements. This GTTC material will be packaged for transfer to the DOE.
- Segmentation of the reactor vessel. Similar to the internals some of this work may involve the use of remotely operated equipment.
- Removal of the steel liners from the drywell, torus, refueling pool and spent fuel pool, disposing of the activated and/or contaminated sections as radioactive waste.
- Disposition of the activated and contaminated portions of the concrete sacrificial shield and primary containment walls and contaminated concrete surfaces that exceed the material release criteria.
- Material likely to be free of contamination may be surveyed and released for unrestricted disposition, e.g., as scrap, recycle, or general disposal, or sent to an off-site NRC / Agreement State licensed processor for radiological evaluation and appropriate disposition.
- Remediation of contaminated surface soil or sub-surface media will be performed as necessary to meet the unrestricted use criteria in 10 CFR 20.1402.
- Underground piping (or similar items) and associated soil will be removed as necessary to meet license termination criteria.

At least two years prior to the anticipated date of license termination, a License Termination Plan (LTP) will be submitted to the NRC. That plan will include: a site characterization, description of the remaining dismantling / removal activities, plans for remediation of remaining radioactive materials, developed site-specific Derived Concentration Guideline Levels (DCGLs), plans for the final status (radiation) survey (FSS), designation of the end use of the site, an updated cost estimate to complete the decommissioning, and associated environmental concerns.

The FSS plan will identify the radiological surveys to be performed once the decontamination activities are completed and will be developed using the guidance provided in the "Multi-Agency

Radiation Survey and Site Investigation Manual (MARSSIM)" (reference 14). This document incorporates statistical approaches to survey design and data evaluation. It also identifies state-of-the-art, commercially available instrumentation and procedures for conducting radiological surveys. Use of this guidance ensures that the surveys are conducted in a manner that provides a high degree of confidence that applicable NRC criteria are satisfied. Once the FSS is complete, the results will be submitted to the NRC, along with a request for termination of the NRC license.

2.1.5 Site Restoration

After the NRC terminates the license, site restoration activities will be performed. ENGC currently assumes that remaining clean structures will be removed to a nominal depth of three feet below the surrounding grade level. Affected area(s) would then be backfilled with suitable fill materials, graded, and appropriate erosion controls established. The unused portion of non-contaminated concrete rubble produced by the demolition activities will be transported to an offsite area for appropriate disposal as construction debris.

2.2 General Decommissioning Considerations

2.2.1 Major Decommissioning Activities

As defined in 10 CFR 50.2, "definitions," a "major decommissioning activity" is "any activity that results in permanent removal of major radioactive components, permanently modifies the structure of the containment, or results in dismantling components for shipment containing greater than class C waste in accordance with § 61.55." The following discussion provides a summary of the major decommissioning activities currently planned for PNPS. These activities are envisioned to occur in the Dismantling and Decontamination Period. The schedule may be modified as conditions dictate.

Prior to starting a major decommissioning activity, the affected components will be surveyed and decontaminated, as required, in order to minimize worker exposure, and a plan will be developed for the activity. Shipping casks and other equipment necessary to conduct major decommissioning activities will be procured.

The initial major decommissioning activity inside the reactor building will be the removal, packaging, and disposal of systems and components attached to the reactor.

Following reactor vessel and cavity re-flood, the reactor vessel internals will be removed from the reactor vessel and segmented, if necessary, for packaging, transport and disposal, or to separate greater than Class C (GTCC) waste. Internals classified as GTCC waste will be segmented and packaged into containers similar to spent fuel canisters for transfer to the DOE. Removal of the reactor vessel follows the removal of the reactor internals. While industry experience indicates that there may be several options available for the removal and disposal of the reactor vessel (i.e., segmentation or disposal as an intact package) intact removal may not be a viable option due to transportation size and weight restrictions. If segmented it is likely that the work would be performed remotely in-air, using a contamination control envelope.

Other major decommissioning activities that would be conducted include the removal and disposal of the turbine, condenser, recirculation pumps, main steam piping, feed water piping, pumps and heaters, liners (from the spent fuel pool, drywell and reactor cavity), the torus, spent fuel storage racks and neutron activated / contaminated concrete materials. The disposition of the drywell structure would be undertaken as part of the reactor building demolition.

2.2.2 Other Decommissioning Activities

In addition to the reactor and large components discussed above, all other plant components will be removed from the reactor, turbine and associated buildings, radiologically surveyed and dispositioned appropriately.

2.2.3 Decontamination and Dismantlement Activities

The overall objective of D&D is to ensure that radioactively contaminated or activated materials will be removed from the site to allow the site to be released for unrestricted use. This is achieved by radioactive decay during the SAFSTOR period which will significantly reduce the quantity of contamination and radioactivity that must be disposed of during decontamination and dismantlement. The disposition of remaining radioactive materials will be accomplished by the decontamination and/or dismantlement of contaminated structures. This may be accomplished by decontamination in place, off-site processing of the materials, or direct disposal of the materials as radioactive waste. A combination of these methods may be utilized. The methods chosen will be those deemed most appropriate for the particular circumstances.

Low-level radioactive waste (LLRW) will be managed in accordance with approved procedures and commercial disposal facility requirements. This includes characterizing contaminated materials, packaging, transporting and disposal at a licensed LLRW disposal facility.

2.2.4 Radioactive Waste Management

A major component of the decommissioning work scope for PNPS is the packaging, transportation and disposing of primarily contaminated / activated equipment, piping, concrete, and soil. A waste management plan will be developed to incorporate the most cost effective disposal strategy, consistent with regulatory requirements and disposal / processing options for each waste type at the time of the D&D activities. Because it is located in Massachusetts, PNPS is not affiliated with a waste compact agreement. As such, PNPS wastes may be disposed of at any available licensed LLRW facilities that engage in an agreement with PNPS. LLRW from PNPS will be transported by licensed transporters. The waste management plan will be based on the evaluation of available methods and strategies for processing, packaging, and transporting radioactive waste in conjunction with the available disposal facility options and associated waste acceptance criteria.

2.2.5 Removal of Mixed Wastes

If mixed wastes are generated they will be managed in accordance with applicable Federal and State regulations.

Mixed wastes from PNPS will be transported by authorized and licensed transporters and shipped to authorized and licensed facilities. If technology, resources, and approved processes are available, the processes will be evaluated to render the mixed waste non-hazardous.

2.2.6 Site Characterization

During the decommissioning process, site characterization will be performed in which radiological, regulated, and hazardous wastes will be identified, categorized, and quantified. Surveys will be conducted to establish the contamination and radiation levels throughout the plant. This information will be used in developing procedures to ensure that hazardous, regulated, and radiologically contaminated areas are remediated and to ensure that worker exposure is controlled. As decontamination and dismantlement work proceeds, surveys will be conducted to maintain a current site characterization and to ensure that decommissioning activities are adjusted accordingly.

As part of the site characterization process, a neutron activation analysis calculation study of the reactor internals, the reactor vessel, and the biological shield wall was performed. Using the results of this analysis (along with benchmarking surveys), neutron irradiated components will be classified (projected for the future D&D time-frame) in accordance with 10 CFR 61, “Licensing requirements for land disposal of radioactive waste.” The results of the analysis will form the basis of the plans for removal, segmentation, packaging and disposal.

2.2.7 Groundwater Protection and Radiological Decommissioning Records Program

A groundwater (GW) protection program currently exists at PNPS in accordance with the Nuclear Energy Institute (NEI) Technical Report 07-07, “Industry Groundwater Protection Initiative - Final Guidance Document.” A site hydrology study was completed as part of this initiative. Twenty-five (25) groundwater monitoring wells were installed around the plant to identify any leakage and transport of radiological contaminants. Twenty-three (23) of these wells are currently operational (one was abandoned due to location, and one was replaced due to poor functionality). This program is directed by procedures and will continue during decommissioning.

ENOI will also continue to maintain the existing radiological decommissioning records program required by 10 CFR 50.75(g). The program is directed by procedures.

Neither the monitoring results of the groundwater protection program nor events noted in 10 CFR 50.75(g) indicate the presence of long-lived radionuclides in sufficient concentrations following remediation as needed to preclude unrestricted release under 10 CFR 20.1402, "Radiological criteria for unrestricted use."

2.2.8 Changes to Management and Staffing

Throughout the decommissioning process, plant management and staffing levels will be adjusted to reflect the ongoing transition of the site organization. Staffing levels and qualifications of personnel used to monitor and maintain the plant during the various periods after plant shutdown will be subject to appropriate Quality, Technical Specification, Security and Emergency Plan requirements. The future worker dynamic will be comprised of both in-house and contract employees. The duties of this combined workforce include fuel movements, plant modifications in preparation for SAFSTOR, and D&D / license termination / site restoration work. Contractors may also be used to provide general services, staff augmentation or replace permanent staff. The monitoring and maintenance staff will be comprised of radiation protection, REMP, plant engineering and craft workers as appropriate for the anticipated work activities.

3.0 SCHEDULE OF PLANNED DECOMMISSIONING ACTIVITIES

ENGC intends to pursue the decommissioning of PNPS utilizing a SAFSTOR methodology. The SAFSTOR method involves removal of radioactively contaminated or activated material from the site following an extended period of dormancy. Work activities associated with the planning and preparation period began before the plant was permanently shut down and will continue through mid-2019. The schedule of spent fuel management and major decommissioning activities is provided in Table 2-1. Additional detail is provided in Attachment 1, the DCE.

The schedule accounts for spent fuel being stored in the ISFSI until the assumed date of transfer to the DOE.

4.0 ESTIMATE OF EXPECTED DECOMMISSIONING AND SPENT FUEL MANAGEMENT COSTS

10 CFR 50.82(a)(4)(i) requires the submission of a PSDAR either before or not later than two years after permanent cessation of operations. TLG Services, Inc. has prepared a site-specific decommissioning cost analysis for PNPS, which also provides projected costs of managing spent fuel, as well as non-radiological decommissioning and site restoration costs, accounted for separately. The site-specific DCE is provided in Attachment 1 and fulfills the requirements of 10 CFR 50.82(a)(4)(i) and 10 CFR 50.82(a)(8)(iii). A summary of the site-specific DCE, including the projected cost of managing spent fuel is provided in Table 2-2. The site-specific DCE, from which this table was derived, is provided as Attachment 1.

The methodology used by TLG Services, Inc. to develop the site-specific DCE follows the basic approach originally advanced by the Atomic Industrial Forum (AIF) in its program to develop a standardized model for decommissioning cost estimates. The results of this program were published as AIF/NESP-036, “A Guideline for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates,” (Reference 4). The AIF document presents a unit cost factor method for estimating direct activity costs, simplifying the estimating process. The unit cost factors used in the study reflect the latest available data, at the time of the study, concerning worker productivity during decommissioning.

Under NRC regulations (10 CFR § 50.82(a)(8)), a licensee must provide reasonable assurance that funds will be available (or “financial assurance”) for decommissioning (i.e., license termination) costs. The regulations also describe the acceptable methods a licensee can use to demonstrate financial assurance. Most licensees do this by funding a nuclear decommissioning trust (NDT). The NRC methodology limits the projected growth rate of the funds in the NDT to 2% per year (real, not nominal). ENGC uses an NDT for this purpose. The trust was transferred with the decommissioning liability as part of the sale transaction when Entergy acquired the plant. The trustee is The Bank of New York Mellon. The trust had a balance of $1,051,722,466 at of the end of October 2018.

10 CFR 50.82(a)(6)(iii) states that, “Licensees shall not perform any decommissioning activities,” as defined in 10 CFR 50.2 that, “Result in there no longer being reasonable assurance that adequate funds will be available for decommissioning.” ENGC does not intend to perform any decommissioning activities that result in there no longer being reasonable assurance that adequate funds will be available for decommissioning.

10 CFR 50.82(a)(8)(iv) states that, “For decommissioning activities that delay completion of decommissioning by including a period of storage or surveillance, the licensee shall provide a means of adjusting cost estimates and associated funding levels over the storage or surveillance period.”

4.1 Means of Adjusting Cost Estimates

The PNPS SAFSTOR schedule and the associated site-specific cost estimate summarized in Tables 2.1 and 2.2 and detailed in the DCE (Attachment 1) is reported in 2018 dollars using up-to-date 2018 pricing. ENOI will update the PNPS DCE as required by procedure and regulation. In calculating projected earnings, ENGC will apply a compounded 2% real rate of return on the trust fund per 10 CFR 50.75 (e). In accordance with 10 CFR 50.82(a)(8)(v)-(vii), ENOI will provide annual reports projecting the cost to complete decommissioning and spent fuel management costs.

4.2 Means of Adjusting Associated Funding Levels

During the SAFSTOR period, the site-specific DCE will be periodically updated in compliance with ENOI procedures and applicable regulatory requirements. In accordance with 10 CFR 50.82(a)(8)(v), decommissioning funding assurance will be reviewed and reported to the NRC annually during the SAFSTOR period. The latest site-specific DCE adjusted for inflation, in accordance with applicable regulatory requirements, will be used to demonstrate funding assurance. In addition, actual radiological and spent fuel management expenses will be included in the annual report in accordance with the applicable regulatory requirements.

If the funding assurance demonstration shows the DTF is not sufficient, then an alternate funding mechanism allowed by 10 CFR 50.75(e) and the guidance provided in Regulatory Guide 1.159 (Reference 5) will be put in place.

5.0 ENVIRONMENTAL IMPACTS

ENGC has concluded that the environmental impacts associated with planned PNPS site-specific decommissioning activities are less than and bounded by the impacts addressed by previously issued environmental impact statements. 10 CFR 50.82(a)(4)(i) requires that the PSDAR include, "...a discussion that provides the reasons for concluding that the environmental impacts associated with site-specific decommissioning activities will be bounded by appropriate previously issued environmental impact statements." The following discussion provides the reasons for reaching this conclusion and is based on two previously issued environmental impact statements:

1. NUREG-0586, Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors (Reference 3) (Referred to as the GEIS).
2. NUREG-1496, Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities (Reference 6).

In evaluating whether the impacts in these previously issued environmental impact statements are bounding, information from NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 29, Regarding Pilgrim Nuclear Power Station (Reference 7) was also considered.

5.1 Environmental Impact of PNPS Decommissioning

The following is a summary of the reasons for reaching the conclusion that the environmental impacts of decommissioning Pilgrim Nuclear Power Station (PNPS) are bounded by the GEIS. Each environmental impact standard in the GEIS is listed along with an explanation as to why ENGC concludes the GEIS analysis bounds the impacts of PNPS decommissioning on that standard. As a general matter, PNPS is smaller than the reference boiling water reactor used in the GEIS to evaluate the environmental impacts of decommissioning, and is therefore bounded by those assessments. Further, no unique site-specific features or unique aspects of the planned decommissioning have been identified.

5.1.1 Onsite/Offsite Land Use

Section 4.3.1 of the GEIS concluded that the impacts on land use are not detectable or small for facilities having only onsite land use changes as a result of large component removal, structure dismantlement, and low-level waste packaging and storage. PNPS has sufficient area onsite that has been previously disturbed (due to construction or operations activities) upon which to conduct all of these decommissioning activities. Any construction activities that would disturb one acre or greater of soil would require a construction storm water permit per the current EPA regulations

(EPA-2017). The storm water permit would contain best management practices (BMPs) to control sediment and erosion effect on water courses and wetlands.

Based on the GEIS, the experience of plants that are being decommissioned has not included any needs for additional land offsite. Consistent with this determination, ENGC does not anticipate any changes in land use beyond the site boundary during decommissioning. Therefore, ENGC concludes that the impacts of PNPS decommissioning on onsite/offsite land use are bounded by the GEIS.

5.1.2 Water Use

After plant shutdown, the operational demand for cooling water and makeup water will dramatically decrease. Additionally, after the plant is shut down and defueled, the amount of water used by the service water system will be much less than during normal operation of the plant. The need for cooling water will continue to decrease as the heat load of spent fuel in the spent fuel pool declines due to radioactive decay and as spent fuel is relocated from the spent fuel pool to the ISFSI. During plant shutdown, the use of potable water will decrease commensurate with the expected decrease in plant staffing levels. For these reasons, Section 4.3.2 of the GEIS concluded that water use at decommissioning nuclear reactor facilities is significantly smaller than water use during operation.

The GEIS also concluded that water use during the decontamination and dismantlement phase will be greater than that during the storage phase. However, there are no unique aspects associated with the decommissioning of PNPS and water use for such activities as flushing piping, high pressure water washing, dust abatement, etc. Consequently, PNPS water use impacts were addressed by the evaluation of the reference facility in the GEIS.

Therefore, ENGC concludes that the impacts of PNPS decommissioning on water use are bounded by the GEIS.

5.1.3 Water Quality

This section considers water quality impacts of nonradioactive material for both surface and groundwater during the decommissioning process. Table E-3 of the GEIS identifies decommissioning activities that may affect water quality. These activities include system deactivation activities (draining, flushing, and liquid processing) as well as facility decontamination and dismantlement activities (water spraying for dust suppression). The GEIS also emphasizes the need to minimize water infiltration during the SAFSTOR period.

ENGC has chosen to decommission PNPS using the SAFSTOR method. During the SAFSTOR planning and actual storage periods, storm water runoff and drainage paths will be maintained in their current configuration. Regulatory mandated programs and processes designed to minimize, detect, and contain spills will be maintained throughout the decommissioning process. Federal, state and local regulations and permits pertaining to water quality will remain in effect and no significant changes to water supply reliability are expected. The National Pollutant Discharge Elimination System (NPDES) permit, which regulates surface water discharges from the site (Reference 8) will remain in place as will the Groundwater Discharge Permit for the PNPS Wastewater Treatment Facility (Reference 9). ENOI concludes that the impacts of PNPS decommissioning on water quality are bounded by the GEIS.

5.1.4 Air Quality

There are many types of decommissioning activities listed in Section 4.3.4 of the GEIS that have the potential to affect air quality. NRC considered the potential for adverse impacts from these activities, the greatest of which would be fugitive dust, for the range of decommissioning plants and generically determined air quality impacts to be small. For those activities applicable to the SAFSTOR option, ENGC does not anticipate any activities beyond those listed in the GEIS that could potentially affect air quality. Also, reasonable and appropriate control measures such as wetting down unpaved areas, wetting of soil piles, covering loads and staging areas, and seeding of bare areas would be implemented to minimize fugitive dust. In addition, federal, state and local regulations pertaining to air quality will remain in effect to regulate emissions associated with criteria air pollutants, hazardous air pollutants, ozone-depleting gases and fugitive dust. Therefore, ENGC concludes that the impacts of PNPS decommissioning on air quality are bounded by the GEIS.

5.1.5 Aquatic Ecology

Aquatic ecology encompasses the plants and animals in the Atlantic Coastal Area near Cape Cod Bay and other wetlands near PNPS. Aquatic ecology also includes the interaction of those organisms with each other and the environment. Section 4.3.5 of the GEIS evaluates both the direct and indirect impacts from decommissioning on aquatic ecology.

Direct impacts can result from activities such as the removal of shoreline structures or the active dredging of canals. PNPS's shoreline structures are similar to the plants listed in Table E-2 of the GEIS, and there are no apparent discriminators based on the salient characteristics (size and location) listed in Table E-5 of the GEIS. Removal of the intake and discharge structures as well as other shoreline structures will be conducted in accordance with BMPs outlined in permits issued by the Massachusetts Department of Environmental Protection and if necessary, the U. S. Army Corps of Engineers. The intake canal dredging should no longer be required due to the diminished residual heat removal requirements, and the eventual relocation of the spent fuel to the ISFSI.

As previously discussed in Section 5.1.2, the amount of cooling water withdrawn from the Atlantic Ocean will significantly decrease thus reducing the potential impacts from impingement and entrainment of aquatic species. Additionally, any significant potential for sediment runoff or erosion on disturbed areas will be controlled in accordance with BMPs outlined in the storm water permit. ENOI does not anticipate disturbance of lands beyond the current operational areas of the plant, so there should not be any new impacts to aquatic ecology from runoff associated with land disturbance activities.

Therefore, ENOI concludes that the impacts of PNPS decommissioning on aquatic ecology are bounded by the GEIS.

5.1.6 Terrestrial Ecology

Terrestrial ecology considers the plants and animals in the vicinity of PNPS as well as the interaction of those organisms with each other and the environment. Evaluations of impacts to terrestrial ecology are usually directed at important habitats and species, including plant and animals that are important to industry, recreational activities, the area ecosystems, and those protected by endangered species regulations and legislation. Section 4.3.6 of the GEIS evaluates the potential impacts from both direct and indirect disturbance of terrestrial ecology.

Direct impacts can result from activities such as clearing native vegetation or filling a wetland. ENGC does not anticipate that any decommissioning activities, including ISFSI construction, will disturb habitat beyond the industrial area of the plant. All dismantlement, demolition, and waste staging activities are expected to be conducted within this industrial area of the site. Also the EPA controls significant impacts to the environment through regulation of construction activities.

Indirect impacts may result from effects such as erosional runoff, dust or noise. Any construction activities that would disturb one acre or greater of soil would require a permit from the EPA prior to proceeding with the activity. The storm water permit would contain BMPs to control sediment and the effects of erosion associated with the construction activity. Fugitive dust emissions would be controlled through the judicious use of water spraying. The basis for concluding that the environmental impacts of noise are bounded by the GEIS is discussed in Section 5.1.16 below.

5.1.7 Threatened and Endangered Species

As previously discussed in Section 5.0, the PNPS facility occupies approximately 140 acres. ENGC also owns an additional 1,500 acres adjacent to the plant site that is in a forest management plan. However, these 1,500 acres are not considered part of the PNPS industrial area. Therefore, evaluation of decommissioning impacts is limited to the 140 acres occupied by the PNPS facility.

Protected Terrestrial Species

There are five federally and/or state-listed terrestrial species within Plymouth County, including three birds, one reptile and one mammal as shown in Table 5.1-1 below.

TABLE 5.1
Protected Terrestrial Species, Plymouth County

Species	Scientific Name	Federal Status	State Status
Birds			
Piping Plover	*Charadrius melodus*	Threatened	Threatened
Red Knot	*Calidris canutus*	Threatened	Not listed
Roseate Tern	*Sterna dougallii*	Endangered	Endangered
Reptile			
Northern Red-bellied Cooter	*Pseudemys rubriventris*	Endangered	Endangered
Mammal			
Northern Long-eared Bat	*Myotis septentrionalis*	Threatened	Endangered

(USFWS 2017a; MESA 2017)

Of the species listed above, two birds (piping plover and roseate tern), and one reptile (northern red-bellied cotter) were identified in Supplement 29 to the GEIS regarding PNPS (PNPS SEIS) as occurring within the vicinity of the facility (Reference 7, Section 2.2.6.3). Although the piping plover and roseate tern occur in the vicinity of the facility, they are not dependent on habitats within the facility (Reference 7, Section 4.6.2), and are unlikely to be affected by decommissioning activities. The northern red-bellied cooter inhabits freshwater ponds that have abundant aquatic vegetation. Sandy soil with an open canopy on land surrounding the ponds is required for successful nesting. (Reference 7, Section 2.2.6.3) No such habitat exists on the PNPS property; therefore, this species will not be affected by decommissioning activities.

The red knot prefers coastal beaches and rocky shores, sand and mud flats. However, this bird species is migratory only, scattered along the coast in small numbers. (USWS 2016) The northern long-eared bat prefers mines and caves during the winter, and forested habitats during the summer. Since suitable habitat for the red knot and northern long-eared bat does not exist on the PNPS operational area, they are unlikely to be affected by decommissioning activities.

Based on the PNPS SEIS, there were approximately 73 additional species within the Town of Plymouth that are State-listed as endangered, threatened, or of special concern in Massachusetts. Approximately 22 of the State-listed species potentially could utilize habitats available on the PNPS site or the transmission line ROW based on their preferred habitat characteristics; however, their presence has not been confirmed. (Reference 7, Section 2.2.6.3 and Table 2.5)

Decommissioning activities with the greatest potential for affecting terrestrial plant and animal communities are those scheduled for late phases, when major reactor structures are to be removed, and the cooling water intake and discharge structures are to be demolished. The discharge canal itself and the breakwater wall will remain in place. As discussed in Section 5.1.1, land within the operational area is sufficient to provide space for laydown yards, equipment or materials storage, temporary offices, and other decommissioning support areas or structures. Current parking facilities have been adequate to support refueling and maintenance outages over the years, and are assumed to be adequate to support decommissioning.

Because there is ample open space to support PNPS decommissioning operations, there would be no reason to clear any land outside of the site operational area. Therefore, there would be no impacts to wildlife, such as destruction or degradation of existing habitat.

All decommissioning activities at PNPS will take place within the site operational area; therefore, impacts to terrestrial ecological resources, including threatened and endangered species, are expected to be small. State and federal resource agency staff would be consulted at the appropriate time to rule out the presence of previously undiscovered/unreported threatened or endangered species, and, if present, to ascertain if any mitigation measures are warranted.

Section 5.1.6 contains a more detailed discussion of potential impacts of decommissioning activities on (non-protected) terrestrial resources, and also concludes impacts would be bounded by the Decommissioning GEIS's finding of small impacts.

Protected Aquatic Species

Eleven federally and/or state-listed anadromous and marine species could occur in Cape Cod Bay in the vicinity of PNPS, including four sea turtles, five whales, and two fishes as shown in Table 5.2 below.

TABLE 5.2
Protected Aquatic Species

Species	Scientific Name	Federal Status	State Status
Turtles			
Loggerhead Turtle	*Caretta caretta*	Threatened	Threatened
Green Turtle	*Chelonia mydas*	Threatened	Threatened
Leatherback Turtle	*Dermochelys coriacea*	Endangered	Endangered
Kemp's Ridley Turtle	*Lepidochelys kempii*	Endangered	Endangered
Whales			
Sei Whale	*Balaenoptera borealis*	Endangered	Endangered
Fin Whale	*Balaenoptera physalus*	Endangered	Endangered
Blue Whale	*Balaenoptera musculus*	Endangered	Endangered
North Atlantic Right Whale	*Eubalaena glacialis*	Endangered	Endangered
Sperm Whale(a)	*Physeter catadon*	Endangered	Endangered
Fish			
Shortnose Sturgeon	*Acipenser brevirostrum*	Endangered	Endangered
Atlantic Sturgeon	*Acipenser oxyrinchus oxyrinchus*	Threatened	Endangered

(Reference 7, Table 2-4; MESA 2017; USFWS 2017b; USFWS 2017c; USFWS 2017d)

(a) The sperm whale has two accepted scientific names: *Physeter catadon* and *P. microcephalus.*

The endangered North Atlantic Right Whale and Sei Whale have recently been sighted in the shallow waters of Cape Cod Bay. PNPS has adopted procedures for reporting whale sightings in response to this development in cooperation with the U.S. Army Corps of Engineers. A live loggerhead turtle sighting was also reported in the bay approximately 4 miles offshore from the Pilgrim Plant in August 2018. Considering these new developments and in keeping with our commitment to environment and endangered species, PNPS acknowledges that it is possible for any of the listed species to occasionally appear in the vicinity of the Pilgrim Station. PNPS does not intend to disturb the canal and breakwater structures. The Massachusetts Department of Environmental Protection and/or the U. S. Army Corps of Engineers will evaluate and issue the permit(s) outlining BMP(s) for the removal of the intake and discharge systems in the later phases of decommissioning.

Conclusion

Section 4.3.7 of the GEIS also suggests that care be exercised in conducting decommissioning activities after an extended SAFSTOR period because there is a greater potential for rare species to colonize the disturbed portion of the site. However as previously discussed, procedural administrative controls and federal and state regulations that will remain in effect would ensure that mitigation measures are implemented as appropriate to protect wildlife.

NRC has determined that potential impacts of decommissioning on threatened and endangered species must be evaluated on a site-specific basis. ENGC has determined that none of the planned decommissioning activities at PNPS would encroach on the habitat of any state or federally listed species. Any indirect (disturbance-related) impacts from construction noise and human activity would be localized, of short duration, and ecologically insignificant. Birds and mammals that are intolerant of noise and human activity are expected to simply avoid (or move away from) noisy construction sites. ENGC therefore concludes that adverse impacts to threatened and endangered species from PNPS decommissioning activities would be small. However, as decommissioning plans mature, ENOI will update the PSDAR in accordance with applicable NRC regulations if relevant threatened and endangered species listings and critical habitat designations are revised.

Based on the above, the planned decommissioning of PNPS will not result in a direct mortality or otherwise jeopardize the local population of any threatened or endangered species.

5.1.8 Radiological

The GEIS considered radiological doses to workers and members of the public when evaluating the potential consequences of decommissioning activities.

Occupational Dose

The occupational radiation exposure to PNPS plant personnel will be maintained As Low As Reasonably Achievable (ALARA) and below the occupational dose limits in 10 CFR Part 20 during decommissioning. The need for plant personnel to routinely enter radiological areas to conduct maintenance, calibration, inspection, and other activities associated with an operating plant will be reduced, thus it is expected that the occupational dose to plant personnel will significantly decrease after the plant is shut down and defueled. The station ALARA program will be maintained during dormancy and the D&D periods to ensure that occupational dose is maintained ALARA and well within 10 CFR Part 20 limits.

ENGC has elected to decommission PNPS using the SAFSTOR alternative. It is expected that the occupational dose required to complete the decommissioning activities at PNPS would be reduced significantly by radioactive decay during the SAFSTOR period. ENGC estimates that the occupation radiation exposure would be 823, 111, and 80 person-rem, after SAFSTOR dormancy periods of 10, 30 and 50 years respectively. This estimate is based on an analysis of area by area decommissioning worker occupancy, current radiation levels and projected radionuclide decay.

The estimates for dormancy periods greater than 10 years are within the range of SAFSTOR dose estimates (326-834 person-rem) provided in Table 4-1 of the Decommissioning GEIS.

Public Dose

Section 4.3.8 of the GEIS considered doses from liquid and gaseous effluents when evaluating the potential impacts of decommissioning activities on the public. Table G-15 of the GEIS compared effluent releases between operating facilities and decommissioning facilities and concluded that decommissioning releases are lower. The GEIS also concluded that the collective dose and the dose to the maximally exposed individual from decommissioning activities are expected to be well within the regulatory standards in 10 CFR Part 20 and Part 50.

The expected radiation dose to the public from PNPS decommissioning activities will be maintained within regulatory limits and below comparable levels when the plant was operating through the continued application of radiation protection and contamination controls combined with the reduced source term available in the facility. Also Section 7.1 of the SEIS (Reference 7) concluded that there were no site-specific radiological dose aspects associated with decommissioning of PNPS. Therefore, ENGC concludes that the impacts of PNPS decommissioning on public dose are small and are bounded by the GEIS.

5.1.9 Radiological Accidents

The likelihood of a large offsite radiological release that impacts public health and safety after PNPS is shut down and defueled is considerably lower than the already very low likelihood of a release from the plant during power operation. This is because the majority of the potential releases associated with power operation are not relevant after the fuel has been removed from the reactor. Furthermore, handling of spent fuel assemblies will continue to be controlled under work procedures designed to minimize the likelihood and consequences of a fuel handling accident. In addition, emergency plans and procedures will remain in place to protect the health and safety of the public while the possibility of significant radiological releases exists.

Section 4.3.9 of the GEIS assessed the range of possible radiological accidents during decommissioning and separated them into two general categories; fuel related accidents and non-fuel related accidents. Fuel related accidents have the potential to be more severe and zirconium fire accidents, in particular, could produce offsite doses that exceed EPA's protective action guides (Reference 14). As part of its effort to develop generic, risk-informed requirements for decommissioning, the NRC staff performed analysis of the offsite radiological consequences of beyond-design-basis spent fuel pool accidents using fission product inventories at 30 and 90 days and 2, 5, and 10 years. The results of the study indicate that the risk at spent fuel pools is low and well within the NRC's Quantitative Health Objectives. The generic risk is low primarily due to the very low likelihood of a zirconium fire. (Reference 3)

The potential for decommissioning activities to result in radiological releases not involving spent fuel (i.e., releases related to decontamination, dismantlement, and waste handling activities) will be minimized by use of procedures designed to minimize the likelihood and consequences of such releases.

Therefore, ENGC concludes that the impacts of PNPS decommissioning on radiological accidents are small and are bounded by the previously issued GEIS.

5.1.10 Occupational Issues

Occupational issues are related to human health and safety. Section 4.3.10 of the GEIS evaluates physical, chemical, ergonomic, and biological hazards. ENGC has reviewed these occupational hazards in the GEIS and concluded that the decommissioning approach chosen for PNPS poses no unique hazards from what was evaluated in the GEIS. ENGC will continue to maintain appropriate administrative controls and requirements to ensure occupational hazards are minimized and that applicable federal, state and local occupational safety standards and requirements continue to be met. Therefore, ENGC concludes that the impacts of PNPS decommissioning on occupational issues are bounded by the GEIS.

5.1.11 Cost

Decommissioning costs for PNPS are discussed in Section 4.0 and in Attachment 1 to this report. Section 4.3.11 of the GEIS recognizes that an evaluation of decommissioning cost is not a National Environmental Policy Act requirement. Therefore, a bounding analysis is not applicable.

5.1.12 Socioeconomics

Decommissioning of PNPS is expected to result in negative socioeconomic impacts. As PNPS transitions from an operating plant to a shutdown plant and into the different phases of decommissioning, an overall decrease in plant staff will occur. The lost wages of these plant staff will result in decreases in revenues available to support the local economy and local tax authorities. Some laid-off workers may relocate, thus potentially impacting the local cost of housing and availability of public services.

Section 4.3.12 of the GEIS evaluated changes in workforce and population, changes in local tax revenues, and changes in public services. The evaluation also examined plants that permanently shut down early and selected the SAFSTOR option. The GEIS determined that this situation is likely to have negative impacts. The GEIS concluded that socioeconomic impacts are neither detectable nor destabilizing and that mitigation measures are not warranted. Therefore, ENGC concludes that the impacts of PNPS decommissioning on socioeconomic impacts are bounded by the GEIS.

5.1.13 Environmental Justice

Executive Order 12898 dated February 16, 1994, directs Federal executive agencies to consider environmental justice under the National Environmental Policy Act. It is designed to ensure that low-income and minority populations do not experience disproportionately high and adverse human health or environmental effects because of Federal actions.

Section 4.4.6 of the SEIS (Reference 7) analyzed 2000 census data within 50 miles of PNPS to identify minority and low income populations. The SEIS analysis concluded that there were no census block groups within the 6-mile PNPS region that exceeded the NRC thresholds defining minority populations. The closest census block groups that exceeded the NRC minority population thresholds was located 25 miles northwest of PNPS in Massachusetts. The closest census block group exceeding the threshold defining a low-income population was in the same location 25 miles northwest of the PNPS Site. The analysis was based on 2000 census data and remains valid for this decommissioning analysis because the population in the PNPS region has not changed appreciably since 2000.

TABLE 5.3
Plymouth and Barnstable Counties Updated Population Growth, 2000-2015

	Plymouth County		Barnstable County	
Year	Population	Percent Annual Growth	Population	Percent Annual Growth
2000	472,822(a)	-----	222,230(a)	-----
2010	494,919(b)	0.5	215,888(c)	-0.3
2015 Estimate	510,393(b)	0.6	214,333(c)	-0.1

(a) Reference 7, Table 2-13
(b)USCB 2017a
(c)USCB 2017b

Section 4.13.3 of the GEIS reviewed environmental justice decommissioning impacts related to land use, environmental and human health, and socioeconomics. ENGC does not anticipate any offsite land disturbances during decommissioning, thus the land use impacts are not applicable for PNPS. In addition as previously discussed in Section 5.1.12, it was determined that socioeconomic impacts from decommissioning are bounded by the GEIS. Potential impacts to minority and low-income populations would mostly consist of radiological effects. Based on the radiological environmental monitoring program data from PNPS, the SEIS determined that the radiation and radioactivity in the environmental media monitored around the plant have been well within applicable regulatory limits. As a result, the SEIS found that no disproportionately high and adverse human health impacts would be expected in special pathway receptor populations (i.e., minority and/or low income populations) in the region as a result of subsistence consumption of water, local food, fish, and wildlife.

Therefore, ENGC concludes that the impacts of PNPS decommissioning on environmental justice are small and are bounded by the GEIS.

5.1.14 Cultural, Historic, and Archeological Resources

In 1972, in advance of construction of the station, an archaeological survey was conducted of the 517 acre parcel of land on which the PNPS facility and the Jordan Road transmission line were proposed. This survey was conducted by the Archaeological Research Department of Plymouth Plantation and the Brown University Department of Anthropology. This survey identified a total of 25 archaeological sites: 24 historic sites and one prehistoric site. The 24 historic sites were determined to not be significant and no further work was recommended. The one prehistoric site was the subject of a more intensive investigation, which concluded that the site was not eligible for listing. This more intensive archaeological survey, conducted by the two previously mentioned groups in collaboration with the Massachusetts Archaeological Society, further concluded that the land around the proposed power station site showed no evidence of prehistoric occupation. (Reference 7, Section 2.2.9.2.1)

During the renewal of the PNPS operating license, NRC determined that there were no National Register eligible or listed archaeological or historic above ground resources identified on the PNPS site based on a review of the Massachusetts Historical Commission files. The 1972 archaeological survey identified 25 archaeological sites (24 historic and one prehistoric), all of which were eventually determined to be ineligible for listing on the National Register. This testing also concluded that there is no evidence of prehistoric occupation in the area around the station (Reference 7, Section 4.4.5.1).

The NRC's conclusion was based on: 1) no prehistoric archaeological sites have been identified on the PNPS property, and 2) environmental review procedures have been put in place at PNPS regarding undertakings that involve land disturbing activities in undisturbed surface and subsurface areas as well as modifications to historic structures.

The cultural, historic, and archeological impact evaluation conducted in the GEIS (Reference 6) focused on similar attributes as the SEIS (Reference 7). The GEIS evaluated direct effects such as land clearing and indirect effects such as erosion and siltation. The conclusion for the license renewal evaluation is also applicable to the decommissioning period because: 1) decommissioning activities will be primarily contained to disturbed areas located away from areas of existing or high potential for archaeological sites 2) construction activities that disturb one acre or greater of soil are permitted by EPA and BMPs are required to control sediment and the effects of erosion, and 3) environmental protection procedures pertaining to archaeological and cultural resources will remain in effect during decommissioning.

Therefore, ENGC concludes that the impacts of PNPS decommissioning on cultural, historic, and archeological resources are small and are bounded by the GEIS.

5.1.15 Aesthetic Issues

During decommissioning, the impact of activities on aesthetic resources will be temporary and remain consistent with the aesthetics of an industrial plant. In most cases, Section 4.3.15 of the GEIS concludes that impacts such as dust, construction disarray, and noise would not easily be detectable offsite.

The GEIS concluded that the retention of structures during a SAFSTOR period or the retention of structures onsite at the time the license is terminated is likewise not an increased visual impact, but instead a continuation of the visual impact analyzed in the facility construction or operations final environmental statement.

After the decommissioning process is complete, site restoration activities will result in structures being removed from the site and the site being backfilled, graded and landscaped as needed. The GEIS concludes that the removal of structures is generally considered beneficial to the aesthetic impacts of the site.

Therefore, ENGC concludes that the impacts of PNPS decommissioning on aesthetic issues are bounded by the GEIS.

5.1.16 Noise

General noise levels during the decommissioning process are not expected to be any more severe than during refueling outages and are not expected to present an audible intrusion on the surrounding community. Some decommissioning activities may result in higher than normal onsite noise levels (i.e., some types of demolition activities). However, these noise levels would be temporary and are not expected to experience an audible intrusion on the surrounding community.

Section 4.3.16 of the GEIS indicates that noise impacts are not detectable or destabilizing and makes a generic conclusion that potential noise impacts are small. Based on the standard decommissioning approach proposed for PNPS, ENGC concludes that the impacts of PNPS decommissioning on noise are bounded by the GEIS.

5.1.17 Transportation

The transportation impacts of decommissioning are dependent on the number of shipments to and from the plant, the types of shipments, the distance the material is shipped, and the radiological waste quantities and disposal plans. The shipments to and from the plant would primarily result from construction activities associated with the ISFSI relocation and shipments of radioactive wastes and non-radioactive wastes associated with dismantlement and disposal of structures, systems and components.

The estimated cubic feet of radioactive waste associated with PNPS decommissioning that will either be processed, destined for land disposal (Class A, B and C), or placed in a geologic repository (Greater than Class C) is summarized as follows:

- Recycle/Potentially contaminated waste: 596,942 cubic feet
- Class A: 262,602 cubic feet
- Class B: 1,753 cubic feet
- Class C: 742 cubic feet
- Greater than Class C (GTCC): 817 cubic feet

Table 4-7 of the GEIS estimated that the volume of land needed for LLRW (Class A, B and C) disposal from the referenced BWR was 636,000 cubic feet under the SAFSTOR alternative. ENGC presently estimates the LLRW volume of Class A, B, and C (other than recycle waste) for PNPS that is destined for shallow land disposal is approximately 265,097 cubic feet using the SAFSTOR alternative which is far below the GEIS bounding volume.

The quantity of recycle/potentially contaminated waste reflects the volume of bulk material such as ductwork before it is processed. This recycle / potentially contaminated waste volume (596,942 cubic feet) is shipped off-site to a licensed waste processing vendor for volume reduction, survey and release, decontamination, segregation, or other appropriate methods of waste minimization. Recycle waste before processing is expected to comprise 69 percent of the overall PNPS waste volume and would have negligible radiological impacts. The current Decommissioning GEIS does not consider recycle waste.

ENGC must comply with applicable regulations when shipping radioactive waste from decommissioning. The NRC has concluded in Section 4.3.17 of the GEIS that these regulations are adequate to protect the public against unreasonable risk from the transportation of radioactive materials.

The number of GTCC waste shipments during decommissioning is expected to be below the number referenced in Table 4-6 of the GEIS. These shipments will occur over an extended period of time and will not result in significant changes to local traffic density or patterns, the need for construction of new methods of transportation, or significant dose to workers or the public.

In addition, shipments of non-radioactive wastes from the site are not expected to result in measurable deterioration of affected roads or a destabilizing increase in traffic density.

Therefore, ENGC concludes that the impacts of PNPS decommissioning on transportation are bounded by the GEIS.

5.1.18 Irreversible and Irretrievable Commitment of Resources

Irreversible commitments are commitments of resources that cannot be recovered, and irretrievable commitments of resources are those that are lost for only a period of time.

Uranium is a natural resource that is irretrievably consumed during power operation. After the plant is shutdown, uranium is no longer consumed. The use of the environment (air, water, land) is not considered to represent a significant irreversible or irretrievable resource commitment, but rather a relatively short-term investment. Since the PNPS site will be decommissioned to meet the unrestricted release criteria found in 10 CFR 20.1402, the land is not considered an irreversible resource. The only irretrievable resources that would occur during decommissioning would be materials used to decontaminate the facility (e.g., rags, solvents, gases, and tools), and the fuel used for decommissioning activities and transportation of materials to and from the site. However, the use of these resources is minor.

While the GEIS does not specify quantitative bounds for commitment of irreversible and irretrievable resources, ENGC concludes that the impacts of PNPS decommissioning on these resources are negligible and consistent with the conclusions of the GEIS.

5.2 Environmental Impacts of License Termination - NUREG-1496

According to the schedule provided in Section 3 of this report, a license termination plan for PNPS will not be developed until approximately two years prior to the final site decontamination which is currently assumed to be approximately the year 2078. At that time, a supplemental environmental report will be submitted as required by 10 CFR 50.82(a)(9). While detailed planning for license termination activities will not be performed until after the SAFSTOR dormancy period, the absence of any unique site-specific factors, significant groundwater contamination, unusual demographics, or impediments to achieving unrestricted release support an expectation that impacts resulting from license termination will be similar to those evaluated in NUREG-1496 (Reference 6).

5.3 Discussion of Decommissioning in the Supplemental Environmental Impact Statement (SEIS)

As part of the PNPS license renewal process, decommissioning was discussed in Section 7.0 of the SEIS (Reference 7). Identified were six issues related to decommissioning as follows:

- Radiation Doses
- Waste Management
- Air Quality
- Water Quality
- Ecological Resources
- Socioeconomic Impacts

The NRC staff did not identify any new and significant information during their independent review of the PNPS license renewal environmental report (Reference 11), the site audit, or the scoping process for license renewal. The NRC concluded that there are no impacts related to these issues beyond those discussed in the GEIS for license renewal (Reference 12) or the GEIS for decommissioning (Reference 3). For the issues identified above, the license renewal and decommissioning GEISs both concluded the impacts are small. The NRC found no site-specific issues related to decommissioning. There are no contemplated decommissioning activities that would alter that conclusion.

5.4 Additional Considerations

The following considerations are relevant to concluding that decommissioning activities will not result in significant environmental impacts not previously reviewed:

- The release of effluents will continue to be controlled by plant license requirements and plant procedures.
- ENGC will continue to comply with the Offsite Dose Calculation Manual, Radiological Environmental Monitoring Program, and the Groundwater Protection Initiative Program during decommissioning.
- Releases of non-radiological effluents will continue to be controlled per the requirements of the NPDES permit and applicable Commonwealth of Massachusetts permits.

- Systems used to treat or control effluents during power operation will either be maintained or replaced by temporary or mobile systems for the decommissioning activities.
- Radiation protection principles used during plant operations will remain in effect during decommissioning.
- Sufficient decontamination and source term reduction prior to dismantlement will be performed to ensure that occupational dose and public exposure will be maintained below applicable limits.
- Transport of radioactive waste will be in accordance with plant procedures, applicable Federal regulations, and the requirements of the receiving facility.
- Site access control during decommissioning will minimize or eliminate radiation release pathways to the public.

Additionally, NUREG-2157, Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel, found that the generic environmental impacts of ongoing spent fuel storage are small (Reference 13).

5.5 Conclusions

Based on the above discussions, ENGC concludes that the environmental impacts associated with planned PNPS site-specific decommissioning activities are less than and bounded by the impacts addressed by previously issued environmental impact statements. Specifically, the environmental impacts are bounded by the GEIS (Reference 3) and SEIS (Reference 7).

1. The postulated impacts associated with the decommissioning method chosen, SAFSTOR, have already been considered in the SEIS and GEIS.
2. There are no unique aspects of PNPS or of the decommissioning techniques to be utilized that would invalidate the conclusions reached in the SEIS and GEIS.
3. The methods assumed to be employed to dismantle and decontaminate PNPS are standard construction-based techniques fully considered in the SEIS and GEIS.

Therefore, it can be concluded that the environmental impacts associated with the site-specific decommissioning activities for PNPS will be bounded by appropriate previously issued environmental impact statements.

10 CFR 50.82(a)(6)(ii) states that licensees shall not perform any decommissioning activities, as defined in 10 CFR 50.2 that result in significant environmental impacts not previously reviewed.

No such impacts have been currently identified. ENGC will conduct ongoing reviews during the decommissioning process to assure identification of any such impacts.

6.0 REFERENCES

1. Regulatory Guide 1.185, Standard Format and Content for Post-Shutdown Decommissioning Activities Report, Revision 1. June 2013.

2. Letter, Entergy Nuclear Operations, Inc., to USNRC, Notification of Permanent Cessation of Power Operations, Pilgrim Station, November 10, 2015 (ADAMS Accession No. ML15328A053).

3. NUREG-0586, Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities: Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors, Final Report. November 2002.

4. AIF/NESP-036, A Guideline for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates. May 1986.

5. Regulatory Guide 1.159, Assuring the Availability of Funds for Decommissioning Nuclear Reactors, Revision 2. October 2011.

6. NUREG-1496, Generic Environmental Impact Statement in Support of Rulemaking on Radiological Criteria for License Termination of NRC-Licensed Nuclear Facilities. July 1997.

7. NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 29, Regarding Pilgrim Nuclear Power Station. July 2007.

8. Entergy Nuclear Pilgrim, LLC NPDES Draft Permit No. MA0003557 October 2014.

9. Entergy Nuclear Pilgrim, LLC Groundwater Discharge Permit #SE 389-4. November 4, 2016.

10. PAG Manual, Protective Action Guides and Planning Guidance for Radiological Incidents, EPA-400/R-17/001. January 2017.

11. Pilgrim Nuclear Power Station, License Renewal Application. Appendix E, Applicant's Environmental Report. January 2006.

12. NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Power Plants. June 2013.

13. NUREG-2157, Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel, Final Report. September 2014.

14. NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual. August 2000.

15. USCB (U.S. Census Bureau). 2017a. American Fact Finder - Community Facts, 2010 and 2015 Population Estimates, Plymouth County, Massachusetts. Retrieved from https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml (accessed September 7, 2018).

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18. USCB. 2017d. American Fact Finder, Profile of General Population and Housing Characteristics: 2010 Demographic Profile Data, Barnstable County, Massachusetts. Retrieved from https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF (accessed September 7, 2018).

ATTACHMENT 1

PNPS Site-Specific Decommissioning Cost Estimate

Document E11-1724-001, Rev. 0

SITE-SPECIFIC DECOMMISSIONING COST ESTIMATE

for the

PILGRIM NUCLEAR POWER STATION

prepared for

Entergy Nuclear Generation Company

prepared by

TLG Services, Inc.
Bridgewater, Connecticut

November 2018

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No.	Date	Item Revised	Reason for Revision
0	11-14-2018		Original Issue

EXECUTIVE SUMMARY

This report presents a site-specific estimate of the cost to decommission the Pilgrim Nuclear Power Station (PNPS) following the scheduled cessation of plant operations. By letter dated November 10, 2015[1], Entergy Nuclear Operations (ENO) notified the NRC that it intended to permanently cease power operations of PNPS no later than June 1, 2019. ENO will submit a supplement to this letter certifying the date on which operations have ceased, or will cease, in accordance with 10 CFR 50.82(a)(1)(i) and 10 CFR 50.4(b)(8). Upon docketing of the certifications required by 10 CFR 50.82(a)(1)(i) and 10 CFR 50.82(a)(1)(ii), pursuant to 10 CFR 50.82(a)(2), the 10 CFR Part 50 license for PNPS will no longer authorize operation of the reactor or emplacement or retention of fuel in the reactor vessel.

This estimate has been prepared for PNPS to comply with the requirements of 10 CFR 50.82(a)(8)(iii).[2] It relies upon the detailed planning that has been performed in anticipation of the pending cessation of operations and the site-specific, technical information from an earlier evaluation prepared in 2008,[3] updated to reflect current assumptions pertaining to the disposition of the nuclear unit and relevant industry experience in undertaking such projects.

The current estimate is designed to provide Entergy Nuclear Generation Company (ENGC) with sufficient information to assess its financial obligations, as they pertain to the decommissioning of the nuclear unit. It is not a detailed budget and engineering document, but a financial analysis prepared in advance of the detailed budgeting and engineering work that will be required to carry out the decommissioning.

The estimate does include the cost for the detailed planning (and budgeting) for placing the unit in safe-storage and moving the spent fuel from the pool located within the reactor building to an on-site, interim storage facility. It may not reflect the actual plan to decommission PNPS; the plan may differ from the assumptions made in this analysis based on facts that exist at the time the plant is dismantled.

PNPS intends to decommission the plant using the NRC-approved SAFSTOR alternative. The projected total cost to decommission the nuclear unit, after an extended period of safe storage, is estimated at $1.661 billion, as reported in 2018

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1 Letter, Entergy Nuclear Operations, Inc., to USNRC, Notification of Permanent Cessation of Power Operations, Pilgrim Station, November 10, 2015 (ADAMS Accession No. ML15328A053)

2 Within 2 years following permanent cessation of operations, if not already submitted, the licensee shall submit a site-specific decommissioning cost estimate.

3 "Preliminary Decommissioning Cost Analysis for the Pilgrim Nuclear Power Station," Document E11-5690-003, Rev. 0, TLG Services, Inc., July 2008

dollars. The cost includes monies anticipated to be spent for operating license termination (radiological remediation), interim spent fuel management and site restoration activities. The cost is based on several key assumptions in areas of regulation, component characterization, high-level radioactive waste management, low-level radioactive waste disposal, performance uncertainties (contingency) and site remediation and restoration requirements. A discussion of the assumptions relied upon in this analysis is provided in Section 3, along with schedules of annual expenditures. A sequence of significant project activities is provided in Section 4 along with a timeline for the scenario. A detailed cost report, used to generate the summary tables presented within this document, is provided in Appendix C.

The estimate includes the continued operation of the reactor building as an interim wet fuel storage facility for approximately three and one half years after operations cease. During this time period, the spent fuel residing in the storage pool will be transferred to an independent spent fuel storage installation (ISFSI) at the site, the spent fuel storage racks removed, and the pool cleaned out and drained. The ISFSI will remain operational until the Department of Energy (DOE) is able to complete the transfer of the spent fuel to a federal facility (e.g., a monitored retrievable storage facility).[4]

DOE has breached its obligations to remove fuel from reactor sites, and has also failed to provide the plant owner with information about how it will ultimately perform. DOE officials have stated that DOE does not have an obligation to accept already-canistered fuel without an amendment to DOE's contracts with plant licensees to remove the fuel (the "Standard Contract"), but DOE has not explained what any such amendment would involve. Consequently, the plant owner has no information or expectations on how DOE will remove fuel from the site in the future. In the absence of information about how DOE will perform, and for purposes of this analysis only, it is assumed that DOE will accept already-canistered fuel. (It is recognized that the canisters may not be licensed or licensable for transportation when DOE performs.) If this assumption is incorrect, it is assumed that DOE will have liability for costs incurred to transfer the fuel to DOE-supplied containers.

[4] Projected expenditures for spent fuel management identified in the cost analyses do not consider the outcome of the litigation (including compensation for damages) with the DOE with regard to the delays incurred by PNPS in the timely removal of spent fuel from the site. As such, this analysis takes no credit for collection of damages, even though utilities are now routinely being awarded such damages in the courts. Collection of spent fuel damages from the DOE is expected to provide the majority of funds needed for spent fuel management following shutdown.

Alternatives and Regulations

The Nuclear Regulatory Commission (NRC) provided general decommissioning requirements in a rule adopted on June 27, 1988.[5] In this rule, the NRC set forth technical and financial criteria for decommissioning licensed nuclear facilities. The regulations addressed planning needs, timing, funding methods, and environmental review requirements for decommissioning. The rule also defined three decommissioning alternatives as being acceptable to the NRC: DECON, SAFSTOR, and ENTOMB.

> DECON is defined as "the alternative in which the equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations."[6]
>
> SAFSTOR is defined as "the alternative in which the nuclear facility is placed and maintained in a condition that allows the nuclear facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use."[7] Decommissioning is required to be completed within 60 years, although longer time periods will be considered when necessary to protect public health and safety.
>
> ENTOMB is defined as "the alternative in which radioactive contaminants are encased in a structurally long-lived material, such as concrete; the entombed structure is appropriately maintained and continued surveillance is carried out until the radioactive material decays to a level permitting unrestricted release of the property."[8] As with the SAFSTOR alternative, decommissioning is currently required to be completed within 60 years, although longer time periods will also be considered when necessary to protect public health and safety.
>
> The 60-year restriction has limited the practicality for the ENTOMB alternative at commercial reactors that generate significant amounts of

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5 U.S. Code of Federal Regulations, Title 10, Parts 30, 40, 50, 51, 70 and 72 "General Requirements for Decommissioning Nuclear Facilities," Nuclear Regulatory Commission, Federal Register Volume 53, Number 123 (p 24018 et seq.), June 27, 1988

6 Ibid. Page FR24022, Column 3

7 Ibid. Page FR24022, Column 3

8 Ibid. Page FR24023, Column 2

long-lived radioactive material. In 1997, the Commission directed its staff to re-evaluate this alternative and identify the technical requirements and regulatory actions that would be necessary for entombment to become a viable option. The resulting evaluation provided several recommendations, however, rulemaking has been deferred pending the completion of additional research studies (e.g., on engineered barriers).

In a draft regulatory basis document published in March 2017 in support of rulemaking that would amend NRC regulations concerning nuclear plant decommissioning, the NRC staff proposed removing any discussion of the ENTOMB option from existing guidance documents since the method is not deemed practically feasible.

In 1996, the NRC published revisions to its general requirements for decommissioning nuclear power plants to clarify ambiguities and codify procedures and terminology as a means of enhancing efficiency and uniformity in the decommissioning process.[9] The amendments allow for greater public participation and better define the transition process from operations to decommissioning. Regulatory Guide 1.184, issued in July 2000, (as revised in October 2013), further described the methods and procedures that are acceptable to the NRC staff for implementing the requirements of the 1996 revised rule that relate to the initial activities and the major phases of the decommissioning process. The costs and schedules presented in this analysis follow the general guidance and sequence in the amended regulations. The format and content of the estimates is also consistent with the recommendations of Regulatory Guide 1.202, issued in February 2005.[10]

In 2011, the NRC issued regulations to improve decommissioning planning and thereby reduce the likelihood that any current operating facility will become a legacy site.[11] The regulations require licensees to report additional details in their decommissioning cost estimate, including a decommissioning estimate for the ISFSI. This estimate is provided in Appendix D.

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9 U.S. Code of Federal Regulations, Title 10, Parts 2, 50, and 51, "Decommissioning of Nuclear Power Reactors," Nuclear Regulatory Commission, Federal Register Volume 61, (p 39278 et seq.), July 29, 1996

10 "Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors," Regulatory Guide 1.202, Nuclear Regulatory Commission, February 2005

11 U.S. Code of Federal Regulations, Title 10, Parts 20, 30, 40, 50, 70, and 72, "Decommissioning Planning," Nuclear Regulatory Commission, Federal Register Volume 76, (p 35512 et seq.), June 17, 2011

Basis of the Cost Estimate

For planning purposes, the SAFSTOR decommissioning alternative has been selected by ENGC for PNPS. In SAFSTOR, the facility is placed in a safe and stable condition and maintained in that state, allowing levels of radioactivity to decrease through radioactive decay. After the safe storage period, the facility is decontaminated and dismantled, removing residual radioactivity so as to permit termination of the operating license and unrestricted use of the site.

Additional dry storage capacity will be added to accommodate all the spent fuel assemblies generated during operations. The spent fuel will remain in storage until it can be transferred to a DOE facility. Based upon the performance assumptions discussed herein, ENGC anticipates that the removal of spent fuel from the site could be completed by the end of year 2062.

For purposes of this analysis, the plant is assumed to remain in safe-storage until 2073, at which time decommissioning will commence. The start date allows sufficient time to accomplish the activities described in this document and to terminate the operating license within the required 60-year time period.

Methodology

Entergy's Nuclear Decommissioning Organization, the plant staff, and numerous other corporate entities and subject matter experts have been engaged in the planning and engineering needed to transition the nuclear unit and its operating organization from power generation to safe-storage. This information was used to create working budgets and the forecast for the first three and one half years following the cessation of operations, or until the spent fuel is relocated to the ISFSI (years 2019 through 2022), and the plant secured for long-term storage.

These same organizations provided substantial input into estimating the annual costs associated with maintaining the station in a dormancy state (years 2023 through 2072).

The methodology used to develop the estimate for the deferred decontamination and dismantling activities, and restoration of the site, described within this document (years 2073 through 2080) follows the basic approach originally presented in the cost estimating guidelines[12] developed by the Atomic Industrial Forum (now Nuclear Energy Institute). This reference describes a unit factor method for determining decommissioning activity costs. The unit factors used in this analysis

12 T.S. LaGuardia et al., "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986

incorporate site-specific costs and the latest available information on worker productivity in decommissioning.

An activity duration critical path is used to determine the total decommissioning program schedule. This is required for calculating the carrying costs, which include program management, administration, field engineering, equipment rental, quality assurance, and security. This systematic approach for assembling decommissioning estimates ensures a high degree of confidence in the reliability of the resulting costs.

The estimates also reflect lessons learned from TLG's involvement in the Shippingport Station Decommissioning Project, completed in 1989, as well as the decommissioning of the Cintichem reactor, hot cells and associated facilities, completed in 1997. In addition, the planning and engineering for the Rancho Seco, Trojan, Yankee Rowe, Big Rock Point, Maine Yankee, Humboldt Bay-3, Oyster Creek, Connecticut Yankee, Crystal River, Vermont Yankee and Fort Calhoun nuclear units have provided additional insight into the process, the regulatory aspects, and the technical challenges of decommissioning commercial nuclear units.

Contingency

Consistent with cost estimating practice, contingencies are applied to the decontamination and dismantling costs developed as "specific provision for unforeseeable elements of cost within the defined project scope, particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events which will increase costs are likely to occur."[13] The cost elements in the estimates are based on ideal conditions; therefore, the types of unforeseeable events that are almost certain to occur in decommissioning, based on industry experience, are addressed through a percentage contingency applied on a line-item basis. This contingency factor is a nearly universal element in all large-scale construction and demolition projects. It should be noted that contingency, as used in this analysis, does not account for the escalation of costs (due to inflationary and market forces) over the safe-storage and decommissioning period.

Contingency funds are expected to be fully expended throughout the program. As such, inclusion of contingency is necessary to provide assurance that sufficient funding will be available to accomplish the intended tasks.

[13] Project and Cost Engineers' Handbook, Second Edition, American Association of Cost Engineers, Marcel Dekker, Inc., New York, New York, p. 239.

Low-Level Radioactive Waste Management

The contaminated and activated material generated in the decontamination and dismantling of a commercial nuclear reactor is generally classified as low-level radioactive waste, although not all of the material is suitable for shallow-land disposal. With the passage of the "Low-Level Radioactive Waste Disposal Act" in 1980 and its Amendments of 1985,[14] the states became ultimately responsible for the disposition of low-level radioactive waste generated within their own borders.

With the exception of Texas, no new compact facilities have been successfully sited, licensed, and constructed. The Texas Compact disposal facility is now operational and waste is being accepted from generators within the Compact by the operator, Waste Control Specialists (WCS). The facility is also able to accept limited volumes of non-Compact waste.

Disposition of the various waste streams produced by the decommissioning process considered all options and services currently available to PNPS. The majority of the low-level radioactive waste designated for direct disposal (Class A[15]) can be sent to Energy*Solutions*' facility in Clive, Utah. Therefore, disposal costs for Class A waste were based upon Entergy's most recent *General Services Agreement* with Energy*Solutions*. This facility is not licensed to receive the higher activity portion (Classes B and C) of the decommissioning waste stream.

The WCS facility is able to receive the Class B and C waste. As such, for this analysis, Class B and C waste was assumed to be shipped to the WCS facility and disposal costs for the waste were based upon Entergy's current services agreement with WCS.

The dismantling of the components residing closest to the reactor core generates radioactive waste that may be considered unsuitable for shallow-land disposal (i.e., low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the NRC for Class C radioactive waste (GTCC)). The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned the federal government the responsibility for the disposal of this material. The Act also stated that the beneficiaries of the activities resulting in the generation of such radioactive waste bear all reasonable costs of disposing of such waste. However, to date, the federal government has not identified a cost, if any, for GTCC disposal or a schedule for acceptance.

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14 "Low-Level Radioactive Waste Policy Amendments Act of 1985," Public Law 99-240, January 15, 1986

15 Waste is classified in accordance with U.S. Code of Federal Regulations, Title 10, Part 61.55

For purposes of this analysis only, the GTCC radioactive waste is assumed to be packaged and disposed of in a manner similar to high-level waste and at a cost equivalent to that envisioned for the spent fuel. The GTCC is packaged in the same canisters used for spent fuel and shipped directly to a federal facility as it is generated (since the spent fuel, in this scenario, has already been removed from the site prior to the start of decommissioning).

A significant portion of the waste material generated during decommissioning may only be potentially contaminated by radioactive materials. This waste can be analyzed on site or shipped off site to licensed facilities for further analysis, for processing and/or for conditioning/recovery. Reduction in the volume of low-level radioactive waste requiring disposal in a licensed low-level radioactive waste disposal facility can be accomplished through a variety of methods, including analyses and surveys or decontamination to eliminate the portion of waste that does not require disposal as radioactive waste, compaction, incineration or metal melt. The estimates reflect the savings from waste recovery/volume reduction.

High-Level Radioactive Waste Management

Congress passed the "Nuclear Waste Policy Act" (NWPA) in 1982, assigning the federal government's long-standing responsibility for disposal of the spent nuclear fuel created by the commercial nuclear generating plants to the DOE. The DOE was to begin accepting spent fuel by January 31, 1998; however, to date no progress in the removal of spent fuel from commercial generating sites has been made.

Today, the country is at an impasse on high-level waste disposal, despite DOE's submittal of its License Application for a geologic repository to the NRC in 2008. The Obama administration eliminated the budget for the repository program while promising to "conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle … and make recommendations for a new plan."[16] Towards this goal, the Obama administration appointed a Blue Ribbon Commission on America's Nuclear Future (Blue Ribbon Commission) to make recommendations for a new plan for nuclear waste disposal. The Blue Ribbon Commission's charter included a requirement that it consider "[o]ptions for safe storage of used nuclear fuel while final disposition pathways are selected and deployed."[17]

On January 26, 2012, the Blue Ribbon Commission issued its "Report to the Secretary of Energy" containing a number of recommendations on nuclear waste

16 "Advisory Committee Charter, Blue Ribbon Commission on America's Nuclear Future," Appendix A, January 2012

17 Ibid.

disposal. Two of the recommendations that may impact decommissioning planning are:

- "[T]he United States [should] establish a program that leads to the timely development of one or more consolidated storage facilities"[18]
- "[T]he United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste."[19]

In January 2013, the DOE issued the "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," in response to the recommendations made by the Blue Ribbon Commission and as "a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel..."[20]

"With the appropriate authorizations from Congress, the Administration currently plans to implement a program over the next 10 years that:

- Sites, designs and licenses, constructs and begins operations of a pilot interim storage facility by 2021 with an initial focus on accepting used nuclear fuel from shut-down reactor sites;
- Advances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and
- Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048."[21]

The NRC's review of DOE's license application to construct a geologic repository at Yucca Mountain was suspended in 2011 when the Obama administration significantly reduced the budget for completing that work. However, the US Court of Appeals for the District of Columbia Circuit issued a writ of mandamus (in

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18 "Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy," January 2012

19 Ibid., p.27

20 "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," U.S. DOE, January 11, 2013

21 Ibid., p.2

August 2013)[22] ordering NRC to comply with federal law and resume its review of DOE's Yucca Mountain repository license application to the extent allowed by previously appropriated funding for the review. That review is now complete with the publication of the five-volume safety evaluation report. A supplement to DOE's environmental impact statement and adjudicatory hearing on the contentions filed by interested parties must be completed before a licensing decision can be made. Although the DOE proposed it would start fuel acceptance in 2025, no progress has been made in the repository program since DOE's 2013 strategy was issued except for the completion of the Yucca Mountain safety evaluation report. Because of this continued delay, this estimate revises the assumed start date for DOE fuel acceptance from 2025 to 2030.

Holtec International submitted a license application to the NRC on March 30, 2017 for a consolidated interim spent fuel storage facility in southeast New Mexico called HI-STORE CIS (Consolidated Interim Storage) under the provisions of 10 CFR Part 72. The application is currently under NRC review.

Waste Control Specialists submitted an application to the NRC on April 28, 2016, to construct and operate a Consolidated Interim Storage Facility (CISF) at its West Texas facility. On April 18, 2017, WCS requested that the NRC temporarily suspend all safety and environmental review activities, as well as public participation activities associated with WCS's license application. In March 2018, WCS and Orano USA, announced their intent to form a joint venture to license the facility. In June 2018, the joint venture, Interim Storage Partners, submitted a renewed application and requested that the NRC resume its review of the revised CISF license application.

On May 10, 2018, the U.S. House of Representatives passed H.R. 3053, the "Nuclear Waste Policy Amendments Act of 2018." Proposed to amend the Nuclear Waste Policy Act of 1982, the legislation, if approved by the Senate and signed by the President, would provide the DOE the authority to site, construct, and operate one or more Monitored Retrieval Storage (MRS) facilities while a permanent repository is licensed and constructed and/or to enter into an MRS agreement with a non-Federal entity for temporary storage.

Completion of the decommissioning process is dependent upon the DOE's ability to remove spent fuel from the site in a timely manner. DOE's repository program assumes that spent fuel allocations will be accepted for disposal from the nation's commercial nuclear plants, with limited exceptions, in the order (the "queue") in which it was discharged from the reactor.[23] ENGC's current spent fuel management plan for

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22 U.S. Court of Appeals for the District Of Columbia Circuit, In Re: Aiken County, et al, Aug. 2013

23 In 2008, the DOE issued a report to Congress in which it concluded that it did not have authority,

the PNPS spent fuel is based in general upon: 1) a 2030 start date for DOE initiating transfer of commercial spent fuel from the industry to a federal facility (not necessarily a final repository), and 2) an assumed schedule for spent fuel receipt by the DOE for the Pilgrim fuel. The DOE's generator allocation/receipt schedules are based upon the oldest fuel receiving the highest priority. Assuming a maximum rate of transfer of 3,000 metric tons of uranium (MTU)/year, [24] the removal of spent fuel from the site could be completed in 2062. Different DOE acceptance schedules may result in different completion dates.

The NRC requires that licensees establish a program to manage and provide funding for the caretaking of all irradiated fuel at the reactor site until title of the fuel is transferred to the DOE.[25] Interim storage of the fuel, until the DOE has completed the transfer, will be in the reactor building's spent fuel storage pool, as well as at an on-site ISFSI.

An ISFSI, operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K[26]), has been constructed to support continued plant operations. Additional storage capacity will be added to accommodate all the spent fuel generated during operations. Once the spent fuel storage pool is emptied the reactor building can be prepared for long term storage.

ENGC's position is that the DOE has a contractual obligation to accept the spent fuel earlier than the projections set out above consistent with its contract commitments. No assumption made in this study should be interpreted to be inconsistent with this claim. However, at this time, including the cost of storing spent fuel in this study is the most reasonable approach because it insures the availability of sufficient

under present law, to accept spent nuclear fuel for interim storage from decommissioned commercial nuclear power reactor sites. However, the Blue Ribbon Commission, in its final report, noted that: "[A]ccepting spent fuel according to the OFF [Oldest Fuel First] priority ranking instead of giving priority to shutdown reactor sites could greatly reduce the cost savings that could be achieved through consolidated storage if priority could be given to accepting spent fuel from shutdown reactor sites before accepting fuel from still-operating plants. …. The magnitude of the cost savings that could be achieved by giving priority to shutdown sites appears to be large enough (i.e., in the billions of dollars) to warrant DOE exercising its right under the Standard Contract to move this fuel first." For planning purposes only, this estimate does not assume that PNPS, as a permanently shutdown unit, will receive priority; the fuel removal schedule assumed in this estimate is based upon DOE acceptance of fuel according to the "Oldest Fuel First" priority ranking. The plant owner will seek the most expeditious means of removing fuel from the site when DOE commences performance.

24 "Acceptance Priority Ranking & Annual Capacity Report," DOE/RW-0567, July 2004

25 U.S. Code of Federal Regulations, Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," Subpart 54 (bb), "Conditions of Licenses"

26 U.S. Code of Federal Regulations, Title 10, Part 72, Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites"

decommissioning funds at the end of the station's life if, contrary to its contractual obligation, the DOE has not performed earlier.

Site Restoration

The efficient removal of the contaminated materials at the site may result in damage to many of the site structures. Blasting, coring, drilling, and the other decontamination activities can substantially damage power block structures, potentially weakening the footings and structural supports. It is unreasonable to anticipate that these structures would be repaired and preserved after the radiological contamination is removed. The cost to dismantle site structures with a work force already mobilized is more efficient and less costly than if the process is deferred.

Consequently, this study assumes that non-essential site structures addressed by this analysis are removed, once remediation is complete, to a nominal depth of three feet below the local grade level wherever possible. The site is then graded and stabilized.

Summary

The estimate to decommission PNPS assumes the removal of all contaminated and activated plant components and structural materials such that the owner may then have unrestricted use of the site with no further requirements for an operating license. Low-level radioactive waste, other than GTCC waste, is sent to a commercial processor for treatment/conditioning or to a controlled disposal facility.

Decommissioning is accomplished within the 60-year period required by current NRC regulations. In the interim, the spent fuel remains in storage at the site until such time that the transfer to a DOE facility is complete.

The SAFSTOR alternative evaluated in this analysis is described in Section 2. The assumptions are presented in Section 3, along with schedules of annual expenditures. The major cost contributors are identified in Section 6, with detailed activity costs, waste volumes, and associated manpower requirements delineated in Appendix C. The major cost components are also identified in the cost summary provided at the end of this section.

The cost elements are assigned to one of three subcategories: NRC License Termination (radiological remediation), Spent Fuel Management, and Site Restoration. The subcategory "NRC License Termination" is used to accumulate costs that are consistent with "decommissioning" as defined by the NRC in its financial assurance regulations (i.e., 10 CFR §50.75). In situations where the long-term management of spent fuel is not an issue, the cost reported for this subcategory is generally sufficient to terminate a reactor's operating license.

The "Spent Fuel Management" subcategory contains costs associated with adding dry storage capacity, containerization and transfer of spent fuel to the ISFSI, and the operation of the ISFSI until such time that the transfer of all fuel from this facility to an off-site location is complete. It does not include any costs related to the final disposal of the spent fuel.

"Site Restoration" is used to capture costs associated with the dismantling and demolition of buildings and facilities demonstrated to be free from contamination. This includes structures never exposed to radioactive materials, as well as those facilities that have been decontaminated to appropriate levels. Structures are assumed to be removed to a nominal depth of three feet and backfilled to conform to local grade.

It should be noted that the costs assigned to these subcategories are allocations. Delegation of cost elements is for the purposes of comparison (e.g., with NRC financial guidelines) or to permit specific financial treatment (e.g., ARO determinations). In reality, there can be considerable interaction between the activities in the three subcategories. For example, an owner may decide to remove non-contaminated structures early in the project to improve access to highly contaminated facilities or plant components. In these instances, the non-contaminated removal costs could be reassigned from Site Restoration to an NRC License Termination support activity. However, in general, the allocations represent a reasonable accounting of those costs that can be expected to be incurred for the specific subcomponents of the total estimated program cost, if executed as described.

As noted within this document, the estimate was developed and costs are presented in 2018 dollars. The estimate does not reflect the escalation of costs (due to inflationary and market forces) over the safe-storage and decommissioning period.

The decommissioning subperiods and milestone dates for the analyzed SAFSTOR decommissioning alternative are identified in Table 1. The cost projected for license termination (in accordance with 10 CFR 50.75) is shown in Table 2, along with the costs for spent fuel management and site restoration. The schedule of expenditures for license termination activities is provided in Table 3.

TABLE 1
DECOMMISSIONING SCHEDULE AND PLANT STATUS SUMMARY

Decommissioning Activities / Plant Status	Start	End	Approximate Duration (years)
Pre-Shutdown Planning	2018	May 2019	1.0
Period 1: Transition from Operations			
Plant Shutdown	May 31, 2019	--------	--------
Preparations for SAFSTOR Dormancy	May 31, 2019	March 2020	0.84
Period 2: SAFSTOR Dormancy			
Dormancy w/Wet Fuel Storage	March 2020	2022	2.8
Dormancy w/Dry Fuel Storage	2022	2062	40.0
Dormancy w/No Fuel Storage	2062	2073	10.4
Period 3: Preparations for Dismantling & Decontamination (D&D)			
Preparations for D&D	2073	2074	1.5
Period 4: Dismantling & Decontamination (D&D)			
Large Component Removal	2074	2076	1.4
Plant Systems Removal and Building Decontamination	2076	2078	2.3
License Termination	2078	2079	0.7
Period 5: Site Restoration			
Site Restoration	2079	2080	1.5
Total from Shutdown to Completion of License Termination	---------	--------	60

TABLE 2
DECOMMISSIONING COST SUMMARY
(thousands, of 2018 dollars)

Decommissioning Periods	**License Termination**	**Spent Fuel Management**	**Site Restoration**	**Total**
Pre-Shutdown Planning and Period 1: Transition from Operations	$144,683	$93,869	$0	$238,552
Period 2: SAFSTOR Dormancy				
Wet Fuel Storage	$125,888	$134,770	$0	$260,658
Dry Fuel Storage	$245,489	$191,611	$0	$437,100
No Fuel Storage	$49,031	$0	$0	$49,031
Period 3: Preparations for Dismantling & Decontamination (D&D)				
Site Reactivation	$46,701	$0	$571	$47,271
Decommissioning Preparation	$35,482	$0	$451	$35,933
Period 4: Dismantling & Decontamination D&D):				
Large Component Removal	$225,394	$0	$369	$225,763
Plant Systems Removal and Building Remediation	$281,263	$0	$881	$282,143
License Termination	$33,840	$0	$0	$33,840
Period 5: Site Restoration	$225	$0	$50,743	$50,967
Total [a]	$1,187,994	$420,250	$53,014	$1,661,258

[a] Columns may not add due to rounding

TABLE 3
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2018	0	0	0	0	19,142	19,142
2019	45,256	1,040	1,409	276	52,043	100,024
2020	22,178	1,040	1,572	539	36,245	61,574
2021	13,526	454	1,157	323	30,572	46,032
2022	13,526	454	1,157	323	28,339	43,799
2023	2,276	130	524	7	11,579	14,516
2024	2,282	130	525	7	3,953	6,897
2025	2,276	130	524	7	3,322	6,259
2026	2,276	130	524	7	2,947	5,884
2027	2,276	130	524	7	2,947	5,884
2028	2,282	130	525	7	2,953	5,897
2029	2,276	130	524	7	2,947	5,884
2030	2,276	130	524	7	2,947	5,884
2031	2,276	130	524	7	2,947	5,884
2032	2,282	130	525	7	2,953	5,897
2033	2,276	130	524	7	2,947	5,884
2034	2,276	130	524	7	2,947	5,884
2035	2,276	130	524	7	2,947	5,884
2036	2,282	130	525	7	2,953	5,897
2037	2,276	130	524	7	2,947	5,884
2038	2,276	130	524	7	2,947	5,884
2039	2,276	130	524	7	2,947	5,884
2040	2,282	130	525	7	2,953	5,897
2041	2,276	130	524	7	2,947	5,884
2042	2,276	130	524	7	2,947	5,884
2043	2,276	130	524	7	2,947	5,884
2044	2,282	130	525	7	2,953	5,897
2045	2,276	130	524	7	2,947	5,884
2046	2,276	130	524	7	2,947	5,884
2047	2,276	130	524	7	2,947	5,884
2048	2,282	130	525	7	2,953	5,897
2049	2,276	130	524	7	2,947	5,884

TABLE 3 (continued)
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2050	2,276	130	524	7	2,947	5,884
2051	2,276	130	524	7	2,947	5,884
2052	2,282	130	525	7	2,953	5,897
2053	2,276	130	524	7	2,947	5,884
2054	2,276	130	524	7	2,947	5,884
2055	2,276	130	524	7	2,947	5,884
2056	2,282	130	525	7	2,953	5,897
2057	2,276	130	524	7	2,947	5,884
2058	2,276	130	524	7	2,947	5,884
2059	2,276	130	524	7	2,947	5,884
2060	2,282	130	525	7	2,953	5,897
2061	2,276	130	524	7	2,947	5,884
2062	2,276	130	524	7	2,947	5,884
2063	1,663	298	216	6	2,514	4,697
2064	1,668	298	217	6	2,521	4,710
2065	1,663	298	216	6	2,514	4,697
2066	1,663	298	216	6	2,514	4,697
2067	1,663	298	216	6	2,514	4,697
2068	1,668	298	217	6	2,521	4,710
2069	1,663	298	216	6	2,514	4,697
2070	1,663	298	216	6	2,514	4,697
2071	1,663	298	216	6	2,514	4,697
2072	1,668	298	217	6	2,521	4,710
2073	22,411	1,183	1,324	21	3,694	28,634
2074	38,252	8,293	2,154	5,384	7,668	61,751
2075	47,682	24,256	2,053	68,469	17,586	160,046
2076	63,341	15,092	1,775	41,144	16,992	138,344
2077	66,082	10,159	1,621	26,451	16,606	120,920
2078	56,725	7,373	1,230	17,765	13,112	96,205
2079	15,548	693	178	12	2,457	18,888
2080	137	0	0	0	0	137
Total	512,400	78,223	38,769	161,050	397,552	1,187,994

1. INTRODUCTION

This report presents a site-specific estimate of the cost to decommission the Pilgrim Nuclear Power Station (PNPS) following the scheduled cessation of plant operations. The estimate is designed to provide Entergy Nuclear Generation Company (ENGC) with sufficient information to assess its financial obligations, as they pertain to the decommissioning of the nuclear unit.

The analysis relies upon site-specific, technical information from an earlier evaluation prepared in 2008,[1]* updated to reflect current assumptions pertaining to the disposition of the nuclear plant and relevant industry experience in undertaking such projects. The costs are based on several key assumptions in areas of regulation, component characterization, high-level radioactive waste management, low-level radioactive waste disposal, performance uncertainties (contingency) and site restoration requirements.

The analysis is not a detailed engineering evaluation, but rather an estimate prepared in advance of the detailed engineering required to carry out the decommissioning of the nuclear unit. It may not reflect the actual plan to decommission PNPS; the plan may differ from the assumptions made in this analysis based on facts that exist at the time the plant is dismantled.

The 2008 plant inventory, the basis for the decontamination and dismantling requirements and cost, and the decommissioning waste streams, were reviewed for this analysis. There were no substantive changes made to the plant that would impact decommissioning except for the additions of the K1, LLRW, Trash Compaction and Maintenance Warehouse structures.

1.1 OBJECTIVES OF STUDY

The objectives of this study are to prepare a comprehensive estimate of the costs to decommission PNPS, to provide a sequence or schedule for the associated activities, and to develop waste stream projections from the decontamination and dismantling activities.

The original operating license for Pilgrim (DPR-35) was issued in 1972 for 40 years of operation, with expiration at midnight on June 8, 2012. Pursuant to an application that was submitted to the Nuclear Regulatory Commission (NRC) in January 2006, on May 29, 2012, the NRC renewed Pilgrim's operating license for an additional 20 years, i.e., to June 8, 2032.

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* References are provided in Section 7 of the document

By letter dated November 10, 2015[2], ENO has since notified the NRC that it intended to permanently cease power operations of PNPS no later than June 1, 2019. ENO will submit a supplement to this letter certifying the date on which operations have ceased, or will cease, in accordance with 10 CFR 50.82(a)(1)(i) and 10 CFR 50.4(b)(8). Upon docketing of the certifications required by 10 CFR 50.82(a)(1)(i) and 10 CFR 50.82(a)(1)(ii), pursuant to 10 CFR 50.82(a)(2), the 10 CFR Part 50 license for PNPS will no longer authorize operation of the reactor or emplacement or retention of fuel in the reactor vessel.

1.2 SITE DESCRIPTION

Pilgrim is located on the western shore of Cape Cod Bay in the town of Plymouth, Plymouth County, Massachusetts. It is 38 miles southeast of Boston, Massachusetts and 44 miles east of Providence, Rhode Island. The station comprises a single boiling water reactor, designed and fabricated by General Electric Company, producing steam for direct use in the steam turbine. Supporting facilities were engineered and constructed by Bechtel Corporation.

The reactor vessel and the recirculation system are contained within the drywell of a pressure suppression system housed within the reactor building. The system consists of a drywell, a pressure suppression chamber that stores a large volume of water (torus), and a connecting submerged vent system between the drywell and water pool, isolation valves, containment cooling systems, and other service equipment. The reactor building encloses the pressure suppression primary containment thereby providing a secondary containment.

In July 2002, Entergy Nuclear Operations, Inc. requested an amendment to its facility operating license to increase the maximum authorized power level from 1998 megawatts-thermal (MWt) to 2,028 MWt. This increase corresponds to an output of approximately 690 megawatts-electric (MWe). The request was subsequently approved, the uprate was implemented, and the unit is operating at the higher level.

Heat produced in the reactor is converted to electrical energy by the power conversion system. A turbine-generator system converts the thermal energy of steam produced by the reactor into mechanical shaft power and then into electrical energy. The turbine consists of a double-flow, high pressure cylinder and two double-flow, low pressure cylinders all aligned in tandem. The generator is a direct-driven 1800 rpm conductor-cooled, synchronous generator. The turbine is operated in a closed feedwater cycle which condenses the steam;

the heated feedwater is returned to the reactor. Heat rejected in the main condensers is removed by the circulating water system.

The circulating water system provides the heat sink required for removal of waste heat in the power plant's thermal cycle. This system has the principal function of removing heat by absorbing this energy in the main condenser. Circulating water is drawn from the Cape Cod Bay (Atlantic Ocean) with heated cooling water returned to the bay.

1.3 REGULATORY GUIDANCE

The Nuclear Regulatory Commission (NRC or Commission) provided initial decommissioning requirements in its rule "General Requirements for Decommissioning Nuclear Facilities," issued in June 1988.[3] This rule set forth financial criteria for decommissioning licensed nuclear power facilities. The regulation addressed decommissioning planning needs, timing, funding methods, and environmental review requirements. The intent of the rule was to ensure that decommissioning would be accomplished in a safe and timely manner and that adequate funds would be available for this purpose. Subsequent to the rule, the NRC issued Regulatory Guide 1.159, "Assuring the Availability of Funds for Decommissioning Nuclear Reactors,"[4] which provided additional guidance to the licensees of nuclear facilities on the financial methods acceptable to the NRC staff for complying with the requirements of the rule. The regulatory guide addressed the funding requirements and provided guidance on the content and form of the financial assurance mechanisms indicated in the rule.

The rule defined three decommissioning alternatives as being acceptable to the NRC: DECON, SAFSTOR, and ENTOMB. The DECON alternative assumes that any contaminated or activated portion of the plant's systems, structures and facilities are removed or decontaminated to levels that permit the site to be released for unrestricted use shortly after the cessation of plant operations, while the SAFSTOR and ENTOMB alternatives defer the process.

The rule also placed limits on the time allowed to complete the decommissioning process. For all alternatives, the process is restricted in overall duration to 60 years, unless it can be shown that a longer duration is necessary to protect public health and safety. At the conclusion of a 60-year dormancy period (or longer if the NRC approves such a case), the site would still require significant remediation to meet the unrestricted release limits for license termination.

The ENTOMB alternative has not been viewed as a viable option for power reactors due to the significant time required to isolate the long-lived radionuclides for decay to permissible levels. However, with rulemaking permitting the controlled release of a site,[6] the NRC did re-evaluate the alternative. The resulting feasibility study, based upon an assessment by Pacific Northwest National Laboratory, concluded that the method did have conditional merit for some, if not most reactors. The staff also found that additional rulemaking would be needed before this option could be treated as a generic alternative.

The NRC had considered rulemaking to alter the 60-year time for completing decommissioning and to clarify the use of engineered barriers for reactor entombments.[5] However, the NRC's staff has subsequently recommended that rulemaking be deferred, based upon several factors (e.g., no licensee has committed to pursuing the entombment option, the unresolved issues associated with the disposition of greater-than-Class C material (GTCC), and the NRC's current priorities), at least until after the additional research studies are complete. The Commission concurred with the staff's recommendation.

In a draft regulatory basis document published in March 2017 in support of rulemaking that would amend NRC regulations concerning nuclear plant decommissioning, the NRC staff proposes removing any discussion of the ENTOMB option from existing guidance documents since the method is not deemed practically feasible.

In 1996, the NRC published revisions to the general requirements for decommissioning nuclear power plants.[7] When the decommissioning regulations were adopted in 1988, it was assumed that the majority of licensees would decommission at the end of the facility's operating licensed life. Since that time, several licensees permanently and prematurely ceased operations. Exemptions from certain operating requirements were required once the reactor was defueled to facilitate the decommissioning. Each case was handled individually, without clearly defined generic requirements. The NRC amended the decommissioning regulations in 1996 to clarify ambiguities and codify procedures and terminology as a means of enhancing efficiency and uniformity in the decommissioning process. The amendments allow for greater public participation and better define the transition process from operations to decommissioning.

Under the revised regulations, licensees will submit written certification to the NRC within 30 days after the decision to cease operations. Certification will also be required once the fuel is permanently removed from the reactor vessel.

Submittal of these notices, along with related changes to Technical Specifications, entitle the licensee to a fee reduction and eliminate the obligation to follow certain requirements needed only during operation of the reactor. The regulation at 10 CFR 50.82(a)(4)(i) requires the licensee to submit a Post-Shutdown Decommissioning Activities Report (PSDAR) to the NRC either before or not later than 2 years after permanent cessation of operations. The PSDAR describes the planned decommissioning activities, the associated sequence and schedule, and an estimate of expected costs. Prior to completing decommissioning, the licensee is required to submit an application to the NRC to terminate the license, which includes a license termination plan (LTP).

In 2011, the NRC issued regulations to improve decommissioning planning and thereby reduce the likelihood that any current operating facility will become a legacy site.[8] The regulations require licensees to report additional details in their decommissioning cost estimate including a decommissioning estimate for the ISFSI. This estimate is provided in Appendix D.

1.3.1 High-Level Radioactive Waste Management

Congress passed the "Nuclear Waste Policy Act"[9] (NWPA) in 1982, assigning the federal government's long-standing responsibility for disposal of the spent nuclear fuel created by the commercial nuclear generating plants to the DOE. It was to begin accepting spent fuel by January 31, 1998; however, to date no progress in the removal of spent fuel from commercial generating sites has been made.

Today, the country is at an impasse on high-level waste disposal, even with the License Application for a geologic repository submitted by the DOE to the NRC in 2008. The Obama administration cut the budget for the repository program while promising to "conduct a comprehensive review of policies for managing the back end of the nuclear fuel cycle … and make recommendations for a new plan." Towards this goal, the Obama administration appointed a Blue Ribbon Commission on America's Nuclear Future (Blue Ribbon Commission) to make recommendations for a new plan for nuclear waste disposal. The Blue Ribbon Commission's charter includes a requirement that it consider "[o]ptions for safe storage of used nuclear fuel while final disposition pathways are selected and deployed."[10]

On January 26, 2012, the Blue Ribbon Commission issued its "Report to the Secretary of Energy" containing a number of recommendations on nuclear waste disposal. Two of the recommendations that may impact decommissioning planning are:

- "[T]he United States [should] establish a program that leads to the timely development of one or more consolidated storage facilities"
- "[T]he United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste."[11]

In January 2013, the DOE issued the "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," in response to the recommendations made by the Blue Ribbon Commission and as "a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel..."[12]

"With the appropriate authorizations from Congress, the Administration currently plans to implement a program over the next 10 years that:

- Sites, designs and licenses, constructs and begins operations of a pilot interim storage facility by 2021 with an initial focus on accepting used nuclear fuel from shut-down reactor sites;
- Advances toward the siting and licensing of a larger interim storage facility to be available by 2025 that will have sufficient capacity to provide flexibility in the waste management system and allows for acceptance of enough used nuclear fuel to reduce expected government liabilities; and
- Makes demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048."

The NRC's review of DOE's license application to construct a geologic repository at Yucca Mountain was suspended in 2011 when the Obama administration significantly reduced the budget for completing that work. However, the US Court of Appeals for the District of Columbia Circuit issued a writ of mandamus (in August 2013)[13] ordering NRC to comply with federal law and resume its review of DOE's Yucca Mountain repository license application to the extent allowed by previously appropriated funding for the review. That review is now complete with the publication of the five-volume safety evaluation report. A supplement to DOE's environmental impact statement and adjudicatory hearing on the contentions filed by interested parties must be completed before a licensing decision can be made. Although the DOE proposed it would start fuel acceptance in 2025, no progress has been made in the repository program since DOE's 2013 strategy was issued except for the completion of the Yucca Mountain safety evaluation report. Because of this continued delay, this estimate revises the assumed start date for DOE fuel acceptance from 2025 to 2030.

Holtec International submitted a license application to the NRC on March 30, 2017 for a consolidated interim spent fuel storage facility in southeast New Mexico called HI-STORE CIS (Consolidated Interim Storage) under the provisions of 10 CFR Part 72. The application is currently under NRC review.

Waste Control Specialists submitted an application to the NRC on April 28, 2016, to construct and operate a Consolidated Interim Storage Facility (CISF) at its West Texas facility. On April 18, 2017, WCS requested that the NRC temporarily suspend all safety and environmental review activities, as well as public participation activities associated with WCS's license application. In March 2018, WCS and Orano USA, announced their intent to form a joint venture to license the facility. In June 2018, the joint venture, Interim Storage Partners, submitted a renewed application and requested that the NRC resume its review of the revised CISF license application.

On May 10, 2018, the U.S. House of Representatives passed H.R. 3053, the "Nuclear Waste Policy Amendments Act of 2018." Proposed to amend the Nuclear Waste Policy Act of 1982, the legislation, if approved by the Senate and signed by the President, would provide the DOE the authority to site, construct, and operate one or more Monitored Retrieval Storage (MRS) facilities while a permanent repository is licensed and constructed and/or to enter into an MRS agreement with a non-Federal entity for temporary storage.

Completion of the decommissioning process is dependent upon the DOE's ability to remove spent fuel from the site in a timely manner. DOE's repository program assumes that spent fuel allocations will be accepted for disposal from the nation's commercial nuclear plants, with limited exceptions, in the order (the "queue") in which it was discharged from the reactor. ENGC's current spent fuel management plan for the PNPS spent fuel is based in general upon: 1) a 2030 start date for DOE initiating transfer of commercial spent fuel from the industry to a federal facility (not necessarily a final repository), and 2) an assumed schedule for spent fuel receipt by the DOE for the PNPS fuel. The DOE's generator allocation/receipt schedules are based upon the oldest fuel receiving the highest priority. Assuming a maximum rate of transfer of 3,000 metric tons of uranium (MTU)/year, as reflected in DOE's latest Acceptance Priority Ranking and Annual Capacity Report dated June 2004 (DOE/RW-0567),[14] the removal of spent fuel from the site could be completed in 2062. Different DOE acceptance schedules may result in different completion dates.

The NRC requires that licensees establish a program to manage and provide funding for the caretaking of all irradiated fuel at the reactor site until title of the fuel is transferred to the DOE.[15] Interim storage of the fuel, until the DOE has completed the transfer, will be in the reactor building's spent fuel storage pool, as well as at an on-site ISFSI.

An ISFSI, operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K,[16] has been constructed to support continued plant operations. Additional storage capacity will be added to accommodate all the spent fuel generated during operations. Once the spent fuel storage pool is emptied the reactor building can be prepared for long term storage.

ENGC's position is that the DOE has a contractual obligation to accept PNPS's fuel earlier than the projections set out above consistent with its contract commitments. No assumption made in this study should be interpreted to be inconsistent with this claim. However, at this time, including the cost of storing spent fuel in this study is the most reasonable approach because it insures the availability of sufficient decommissioning funds at the end of the station's life if, contrary to its contractual obligation, the DOE has not performed earlier.

DOE has breached its obligations to remove fuel from reactor sites, and has also failed to provide the plant owner with information about how it will ultimately perform. DOE officials have stated that DOE does not have an obligation to accept already-canistered fuel without an amendment to DOE's contracts with plant licensees to remove the fuel (the "Standard Contract"), but DOE has not explained what any such amendment would involve. Consequently, the plant owner has no information or expectations on how DOE will remove fuel from the site in the future. In the absence of information about how DOE will perform, and for purposes of this analysis only, it is assumed that DOE will accept already-canistered fuel. (It is recognized that the canisters may not be licensed or licensable for transportation when DOE performs.) If this assumption is incorrect, it is assumed that DOE will have liability for costs incurred to transfer the fuel to DOE-supplied containers.

1.3.2 Low-Level Radioactive Waste Management

The contaminated and activated material generated in the decontamination and dismantling of a commercial nuclear reactor is classified as low-level (radioactive) waste, although not all of the material is suitable for "shallow-land" disposal. With the passage of the "Low-Level Radioactive Waste Policy Act" in 1980,[17] and its Amendments of 1985,[18] the states became ultimately responsible for the disposition of low-level radioactive waste generated within their own borders.

With the exception of Texas, no new compact facilities have been successfully sited, licensed, and constructed. The Texas Compact disposal facility is now operational and waste is being accepted from generators within the Compact by the operator, Waste Control Specialists (WCS). The facility is also able to accept limited volumes of non-Compact waste.

Disposition of the various waste streams produced by the decommissioning process considered all options and services currently available to Entergy. The majority of the low-level radioactive waste designated for direct disposal (Class A[19]) can be sent to Energy*Solutions*' facility in Clive, Utah. Therefore, disposal costs for Class A waste were based upon Entergy's most recent *General Services Agreement* with Energy*Solutions*. This facility is not licensed to receive the higher activity portion (Classes B and C) of the decommissioning waste stream.

The WCS facility is able to receive the Class B and C waste. As such, for this analysis, Class B and C waste was assumed to be shipped to the WCS facility and disposal costs for the waste were based upon Entergy's current services agreement with WCS.

The dismantling of the components residing closest to the reactor core generates radioactive waste that may be considered unsuitable for shallow-land disposal (i.e., low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the NRC for Class C radioactive waste (GTCC)). The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned the federal government the responsibility for the disposal of this material. The Act also stated that the beneficiaries of the activities resulting in the generation of such radioactive waste bear all reasonable costs of disposing of such waste. However, to date, the federal government has not identified a cost, if any, for GTCC disposal or a schedule for acceptance.

For purposes of this analysis only, the GTCC radioactive waste is assumed to be packaged and disposed of in a manner similar to high-level waste and at a cost equivalent to that envisioned for the spent fuel. The GTCC is packaged in the same canisters used for spent fuel and shipped directly to a federal facility as it is generated (since the spent fuel, in this scenario, has already been removed from the site prior to the start of decommissioning).

A significant portion of the waste material generated during decommissioning may only be potentially contaminated by radioactive materials. This waste can be analyzed on site or shipped off site to licensed facilities for further analysis, for processing and/or for conditioning/recovery. Reduction in the volume of low-level radioactive waste requiring disposal in a licensed low-level radioactive waste disposal facility can be accomplished through a variety of methods, including analyses and surveys or decontamination to eliminate the portion of waste that does not require disposal as radioactive waste, compaction, incineration or metal melt. The estimates reflect the savings from waste recovery/volume reduction.

1.3.3 Radiological Criteria for License Termination

In 1997, the NRC published Subpart E, "Radiological Criteria for License Termination,"[20] amending 10 CFR Part 20. This subpart provides radiological criteria for releasing a facility for unrestricted use. The regulation states that the site can be released for unrestricted use if radioactivity levels are such that the average member of a critical group would not receive a Total Effective Dose Equivalent (TEDE) in excess of 25 millirem per year, and provided that residual radioactivity has been reduced to levels that are As Low As Reasonably Achievable (ALARA). The decommissioning estimates assume that the PNPS site will be remediated to a residual level consistent with the NRC-prescribed level.

It should be noted that the NRC and the Environmental Protection Agency (EPA) differ on the amount of residual radioactivity considered acceptable in site remediation. The EPA has two limits that apply to radioactive materials. An EPA limit of 15 millirem per year is derived from criteria established by the Comprehensive Environmental

Response, Compensation, and Liability Act (CERCLA or Superfund).[21] An additional and separate limit of 4 millirem per year, as defined in 40 CFR §141.66, is applied to drinking water.[22]

On October 9, 2002, the NRC signed an agreement with the EPA on the radiological decommissioning and decontamination of NRC-licensed sites. The Memorandum of Understanding (MOU)[23] provides that EPA will defer exercise of authority under CERCLA for the majority of facilities decommissioned under NRC authority. The MOU also includes provisions for NRC and EPA consultation for certain sites when, at the time of license termination, (1) groundwater contamination exceeds EPA-permitted levels; (2) NRC contemplates restricted release of the site; and/or (3) residual radioactive soil concentrations exceed levels defined in the MOU.

The MOU does not impose any new requirements on NRC licensees and should reduce the involvement of the EPA with NRC licensees who are decommissioning. Most sites are expected to meet the NRC criteria for unrestricted use, and the NRC believes that only a few sites will have groundwater or soil contamination in excess of the levels specified in the MOU that trigger consultation with the EPA. However, if there are other hazardous materials on the site, the EPA may be involved in the cleanup. As such, the possibility of dual regulation remains for certain licensees. The present study does not include any costs for this occurrence.

2. DECOMMISSIONING ALTERNATIVE

Costs were determined for decommissioning PNPS for the NRC-approved SAFSTOR decommissioning alternative. The following sections describe the basic activities associated with the SAFSTOR alternative. Although detailed procedures for each activity identified are not provided, and the actual sequence of work may vary, the activity descriptions provide a basis not only for estimating but also for the expected scope of work (i.e., engineering and planning at the time of decommissioning).

The conceptual approach that the NRC has described in its regulations divides decommissioning into three phases. The initial phase commences with the effective date of permanent cessation of operations and involves the transition of both plant and licensee from reactor operations (i.e., power production) to facility de-activation and closure. During the first phase, notification is to be provided to the NRC certifying the permanent cessation of operations and the removal of fuel from the reactor vessel. The licensee is then prohibited from reactor operation.

The second phase encompasses activities during the storage period or during major decommissioning activities, or a combination of the two. The third phase pertains to the activities involved in license termination. The decommissioning estimate developed for PNPS is also divided into phases or periods; however, demarcation of the phases is based upon major milestones within the project or significant changes in the projected expenditures.

2.1 PERIOD 1 - PREPARATIONS

The NRC defines SAFSTOR as, "A method of decommissioning in which a nuclear facility is placed and maintained in a condition that allows the facility to be safely stored and subsequently decontaminated (deferred decontamination) to levels that permit release for unrestricted use." The facility is left intact (during the dormancy period), with structures maintained in a stable condition. Systems that are not required to support the spent fuel, heating ventilation and air conditioning, the site emergency plan or site security are drained, de-energized, and secured. Access to contaminated areas is maintained for inspection and maintenance.

2.1.1 <u>Engineering and Planning</u>

In anticipation of the cessation of plant operations, detailed preparations are undertaken to provide a smooth transition from plant operations to site decommissioning. Through implementation of a staffing transition plan, the organization required to manage the intended decommissioning activities is assembled from available plant staff and outside resources. Preparations include the planning for permanent defueling of the reactor, revision of technical specifications applicable to the operating conditions and requirements, addition of security barriers, a limited characterization of the facility and major components, and the development of the PSDAR.

2.1.2 Site Preparations

The process of placing the plant in safe-storage will include, but is not limited to, the following activities:

- Creation of an organizational structure to support the decommissioning plan and evolving emergency planning and site security requirements.
- Revision of technical specifications, plans and operating procedures appropriate to the operating conditions and requirements.
- Characterization of the facility and major components as may be necessary to plan and prepare for the dormancy phase.
- Isolation of the spent fuel pool and reconfiguring fuel pool support systems so that draining and de-energizing may commence in other areas of the plant.
- Adding additional dry storage capacity for all the spent fuel assemblies generated during operations.
- Deactivation (de-energizing and /or draining) of systems that are no longer required during the dormancy period.
- Processing and disposal of water and water filter and treatment media not required to support dormancy operation.
- Disposition of incidental waste that may be present prior to the start of the dormancy period, such as excess tools and equipment and waste produced while deactivating systems and preparing the facility for dormancy.
- Reconfiguration of power, lighting, heating, ventilation, fire protection, and any other services needed to support long-term storage and periodic plant surveillance and maintenance.
- Stabilization by fixing or removing loose incidental surface contamination to facilitate future building access and plant maintenance. Decontamination of high-dose areas is not anticipated.

- Performance of interim radiation surveys of the plant, posting caution signs and establishing access requirements, where appropriate.
- Maintenance of appropriate barriers for contaminated and radiation areas.
- Reconfiguration of security boundaries and surveillance systems, as required.

The following is a general discussion of the planned reconfiguration expected after plant shutdown.

Electrical Systems

The electrical system will undergo a series of reconfigurations between shutdown and the time all spent fuel has been transferred to dry storage. The reconfigurations will be performed to improve system flexibility and operational control, reduce operating and maintenance expenses, and to provide diverse means of aligning the power sources to the station loads particularly for Spent Fuel Pool-related systems and critical security equipment. The ISFSI facility will require installation of a new electrical distribution system independent of the existing station service and will also include a new diesel generator and uninterruptable power supply system.

Mechanical Systems

Following shutdown, as applicable, fluid filled systems will be drained and abandoned, and resins removed based on an evaluation of system category, functionality, and plant configuration. System categories include: 1) Balance of Plant (BOP), 2) Emergency Core Cooling System (ECCS), 3) Nuclear Steam Safety System (NSSS), 4) Spent Fuel Pool Cooling (SFPC), and 5) Dry Fuel Storage (DFS). Plant configurations include: 1) Post-shutdown (fuel in the reactor), 2) Post-defuel (no fuel in the reactor); 3) Post-gates in (no fuel in reactor, spent fuel pool is physically isolated from the reactor); 4) Reactor vessel drained; 5) Reduced risk of zirconium fire (spent fuel is in the spent fuel pool); and 6) Post-dry fuel storage (all spent fuel in dry fuel storage). The plant configuration and functionality of each system within the plant configuration as it evolves will determine when a system can be drained and abandoned.

Ventilation and Heating Systems

Ventilation will be reconfigured for the Turbine Building (TB) and Reactor Building (RB) to support remaining systems and habitability. Fluid filled systems in the TB will either be drained or freeze protection installed, and the heating steam secured. The RB ventilation system will be reconfigured to maintain building temperature to support habitability and the functioning of Fuel Pool Cooling systems, Fire Protection systems, and Dry Fuel Storage systems.

Fire Protection Systems

Active and passive features of the Fire Protection (FP) systems will be revised based on a fire hazards analysis. The fire hazards analysis provides a comprehensive evaluation of the facility's fire hazards, the fire protection capability relative to the identified hazards, and the ability to protect spent fuel and other radioactive materials from potential fire-induced releases. The fire hazards analysis will be reevaluated and revised as necessary to reflect the unique or different fire protection issues and strategies associated with decommissioning. It is expected that as the plant’s systems are drained, the combustible loading footprint shrinks, and the hazards are removed, the FP systems, features and requirements will be reduced or eliminated.

Maintenance of Systems Critical to Decommissioning

There are no currently identified mechanical systems that will be critical to the final decommissioning process. As such, mechanical systems will be abandoned after all spent fuel has been transferred to Dry Fuel Storage, with the exception of systems required to maintain habitability during dormancy. The site power distribution system will be abandoned with the possible exception of Motor Control Centers that are required to support ventilation and lighting. The organization responsible for the final dismantlement will be expected to establish necessary temporary services, including electrical and cranes.

2.2 PERIOD 2 - DORMANCY

Activities required during the early dormancy period while spent fuel is stored in the fuel pool will be substantially different than those activities required during dry fuel or no fuel storage.

Early activities include operating and maintaining the spent fuel pool and its associated systems, and transferring spent fuel from the pool to the ISFSI. Assuming the timely receipt of the required regulatory approvals, the ISFSI modification is estimated to be completed in 2020. Spent fuel transfer is expected to be complete by mid-year 2022. After the fuel transfer is completed, the pool and systems will be drained and de-energized for long-term storage.

Dormancy activities will include a 24-hour security force, preventive and corrective maintenance on security systems, area lighting, general building maintenance, freeze protection heating, ventilation of buildings for periodic habitability, routine radiological inspections of contaminated structures, maintenance of structural integrity, and a site environmental and radiation monitoring program. A fire protection program will be maintained.

Security during the dormancy period will be conducted primarily to safeguard the spent fuel on site and prevent unauthorized entry. Security barriers, sensors, alarms, and other surveillance equipment will be maintained as required to provide security.

An environmental surveillance program will be carried out during the dormancy period to monitor for radioactive material in the environment. Appropriate procedures will be established and initiated for potential releases that exceed prescribed limits. The environmental surveillance program will consist of a version of the program in effect during normal plant operations that will be modified to reflect the plant's conditions and risks at the time.

Late in dormancy, activities will include transferring the spent fuel from the ISFSI to the DOE. For planning purposes, ENGC's current spent fuel management plan for the PNPS spent fuel is based, in general, upon the following projections: 1) a 2030 start date for the DOE initiating transfer of commercial spent fuel to a federal facility, 2) allocations and acceptance priority for PNPS spent fuel, and 3) a 2062 completion date for removal of all PNPS spent fuel. Transfer could occur earlier if the DOE is successful in implementing its current strategy for the management and acceptance of spent fuel. The ISFSI pad and facilities will be decommissioned at the time of plant decommissioning or after DOE has removed all spent fuel from the site.

2.3 PERIOD 3 - PREPARATIONS FOR DECOMMISSIONING

Prior to the commencement of decommissioning operations, preparations will be undertaken to reactivate site services and prepare for decommissioning. Preparations include engineering and planning, a site characterization, and the assembly of a decommissioning management organization. This would likely include the development of work plans, specifications and procedures.

2.4 PERIOD 4 - DECOMMISSIONING (DISMANTLING AND DECONTAMINATION)

Following the preparations for decommissioning, physical decommissioning activities will take place. This includes the removal and disposal of contaminated and activated components and structures, leading to the termination of the 10 CFR 50 operating license. Although much of the radioactivity will decrease during the dormancy period due to decay of ^{60}Co and other short-lived radionuclides, the internal components of the reactor vessel will still exhibit radiation dose rates that will likely require remote sectioning under water due to the presence of long-lived radionuclides such as ^{94}Nb, ^{59}Ni, and ^{63}Ni. Portions of the sacrificial shield and primary containment walls may also be radioactive due to the presence of activated trace elements with longer half-lives (such as ^{152}Eu and ^{154}Eu). It is assumed that radioactive contamination on structures, systems, and component surfaces will not have decayed to levels that will permit unrestricted release. These surfaces will be surveyed and items dispositioned in accordance with the existing radioactive release criteria.

Significant decommissioning activities in this phase include:

- Reconfiguration and modification of site structures and facilities, as needed, to support decommissioning operations. Modifications may also be required to the reactor or other buildings to facilitate movement of equipment and materials, support the segmentation of the reactor vessel and reactor vessel internals, and for large component removal.
- Design and fabrication of temporary and longer-term shielding to support removal and transportation activities, construction of contamination control envelopes, and the procurement of specialty tooling.
- Procurement or leasing of shipping cask, cask liners, and industrial packages for the disposition of low-level radioactive waste (LLRW).
- Decontamination of components and piping systems, as required, to control (minimize) worker exposure.
- Disposition of the turbine, condenser, main steam piping, and associated equipment; with appropriate dispositioning based upon radiological surveys.
- Disposition of systems and components.

- Removal of the recirculation pumps and associated piping for controlled disposal.
- Contaminated material will be characterized and segregated for additional offsite processing (disassembly, chemical cleaning, volume reduction, and waste treatment), and/or packaged for controlled disposal at a low-level radioactive waste disposal facility.
- Disposition of control rod blades.
- Disassembly and segmentation of the reactor vessel internals. This will likely involve use of remotely operated equipment within the reactor cavity, covered with a contamination control envelope. The cavity water level will likely need to be maintained just below the cut to maintain the working area dose rates ALARA. Some of this material may exceed Class C disposal requirements. This will be packaged for transfer to the DOE.
- Segmentation of the reactor vessel. Similar to the internals some of this work may involve the use of remotely operated equipment.
- Removal of the steel liners from the drywell, torus, refueling pool and spent fuel pool, disposing of the activated and/or contaminated sections as radioactive waste.
- Disposition of the activated and contaminated portions of the concrete sacrificial shield and primary containment walls and contaminated concrete surfaces that exceed the material release criteria.
- Material likely to be free of contamination may be surveyed and released for unrestricted disposition, e.g., as scrap, recycle, or general disposal, or sent to an off-site NRC / Agreement State licensed processor for radiological evaluation and appropriate disposition.
- Remediation of contaminated surface soil or sub-surface media will be performed as necessary to meet the unrestricted use criteria in 10 CFR 20.1402.
- Underground piping (or similar items) and associated soil will be removed as necessary to meet license termination criteria.

At least two years prior to the anticipated date of license termination, a License Termination Plan (LTP) will be submitted to the NRC. That plan will include: a site characterization, description of the remaining dismantling / removal activities, plans for remediation of remaining radioactive materials, developed site-specific Derived Concentration Guideline Levels (DCGLs), plans for the final status (radiation) survey (FSS), designation of the end use of the site, an updated cost estimate to complete the decommissioning, and associated environmental concerns.

The FSS plan will identify the radiological surveys to be performed once the decontamination activities are completed and will be developed using the guidance provided in the "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)."[24] This document incorporates statistical approaches to survey design and data evaluation. It also identifies state-of-the-art, commercially available instrumentation and procedures for conducting radiological surveys. Use of this guidance ensures that the surveys are conducted in a manner that provides a high degree of confidence that applicable NRC criteria are satisfied. Once the FSS is complete, the results will be submitted to the NRC, along with a request for termination of the NRC license.

2.5 PERIOD 5 – SITE RESTORATION

After the NRC terminates the license, site restoration activities will be performed. ENO currently assumes that remaining clean structures will be removed to a nominal depth of three feet below the surrounding grade level. Affected area(s) would then be backfilled with suitable fill materials, graded, and appropriate erosion controls established. The unused portion of non-contaminated concrete rubble produced by the demolition activities will be transported to an offsite area for appropriate disposal as construction debris.

3. COST ESTIMATE

The cost estimate prepared for decommissioning PNPS consider the unique features of the site, including the nuclear steam supply system, electric power generating systems, structures and supporting facilities. The basis of the estimate, including the sources of information relied upon, the estimating methodology employed, site-specific considerations, and other pertinent assumptions, is described in this section.

3.1 BASIS OF ESTIMATES

The current estimate was developed using the site-specific, technical information relied upon in the decommissioning analysis prepared in 2008. This information was reviewed for the current analysis and updated as deemed appropriate. The site-specific considerations and assumptions used in the previous evaluation were also revisited. Modifications were incorporated where new information was available or experience from ongoing decommissioning programs provided viable alternatives or improved processes.

3.2 METHODOLOGY

The methodology used to develop the estimates follows the basic approach originally presented in the AIF/NESP-036 study report, "Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates,"[25] and the DOE "Decommissioning Handbook."[26] These documents present a unit factor method for estimating decommissioning activity costs, which simplifies the estimating calculations. Unit factors for concrete removal ($/cubic yard), steel removal ($/ton), and cutting costs ($/inch) are developed using local labor rates. The activity-dependent costs are estimated with the item quantities (cubic yards and tons), developed from plant drawings and inventory documents. Removal rates and material costs for the conventional disposition of components and structures rely upon information available in the industry publication, "Building Construction Cost Data," published by RSMeans.[27]

The unit factor method provides a demonstrable basis for establishing reliable cost estimates. The detail provided in the unit factors, including activity duration, labor costs (by craft), and equipment and consumable costs, ensures that essential elements have not been omitted. Appendix A presents the detailed development of a typical unit factor. Appendix B provides the values contained within one set of factors developed for this analysis.

Regulatory Guide 1.184 [28] Revision 1, issued in October 2013, describes the methods and procedures that are acceptable to the NRC staff for implementing the requirements that relate to the initial activities and the major phases of the decommissioning process. The costs and schedules presented in this analysis follow the general guidance and sequence in the regulations. The format and content of the estimates is also consistent with the recommendations of Regulatory Guide 1.202,[29] issued February 2005.

This analysis reflects lessons learned from TLG's involvement in the Shippingport Station Decommissioning Project, completed in 1989, as well as the decommissioning of the Cintichem reactor, hot cells, and associated facilities, completed in 1997. In addition, the planning and engineering for the Rancho Seco, Trojan, Yankee Rowe, Big Rock Point, Maine Yankee, Humboldt Bay-3, Oyster Creek, Connecticut Yankee, Crystal River, Vermont Yankee and Fort Calhoun nuclear units have provided additional insight into the process, the regulatory aspects, and the technical challenges of decommissioning commercial nuclear units.

Work Difficulty Factors

TLG has historically applied work difficulty adjustment factors (WDFs) to account for the inefficiencies in working in a power plant environment. WDFs are assigned to each unique set of unit factors, commensurate with the inefficiencies associated with working in confined, hazardous environments. The ranges used for the WDFs are as follows:

- Access Factor 10% to 20%
- Respiratory Protection Factor 10% to 50%
- Radiation/ALARA Factor 10% to 15%
- Protective Clothing Factor 10% to 30%
- Work Break Factor 8.33%

The factors and their associated range of values were developed in conjunction with the AIF/NESP-036 study. The application of the factors is discussed in more detail in that publication.

Scheduling Program Durations

The unit factors, adjusted by the WDFs as described above, are applied against the inventory of materials to be removed in the radiological controlled areas. The resulting labor-hours, or crew-hours, are used in the development of the decommissioning program schedule, using resource loading and event sequencing considerations. The scheduling of conventional removal and dismantling activities is based upon productivity information available from the "Building Construction Cost Data" publication.

An activity duration critical path is used to determine the total decommissioning program schedule. The schedule is relied upon in calculating the carrying costs, which include program management, administration, field engineering, equipment rental, and support services such as quality control and security. This systematic approach for assembling decommissioning estimates ensures a high degree of confidence in the reliability of the resulting costs.

3.3 FINANCIAL COMPONENTS OF THE COST MODEL

TLG's proprietary decommissioning cost model, DECCER, produces a number of distinct cost elements. These direct expenditures, however, do not comprise the total cost to accomplish the project goal, i.e., license termination, spent fuel management and site restoration.

3.3.1 Contingency

Inherent in any cost estimate that does not rely on historical data is the inability to specify the precise source of costs imposed by factors such as tool breakage, accidents, illnesses, weather delays, and labor stoppages. In the DECCER cost model, contingency fulfills this role. Contingency is added to each line item to account for costs that are difficult or impossible to develop analytically. Such costs are historically inevitable over the duration of a job of this magnitude; therefore, this cost analysis includes funds to cover these types of expenses.

The activity- and period-dependent costs are combined to develop the total decommissioning cost. A contingency is then applied on a line-item basis, using one or more of the contingency types listed in the AIF/NESP-036 study. "Contingencies" are defined in the American Association of Cost Engineers "Project and Cost Engineers' Handbook"[30] as "specific provision for unforeseeable elements of cost within the defined project scope; particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events which will increase costs are likely to occur." The cost elements in this analysis are based upon ideal conditions and maximum efficiency; therefore, consistent with industry practice, contingency is included. In the AIF/NESP-036 study, the types of unforeseeable events that are likely to occur in decommissioning are discussed and guidelines are provided for a contingency percentage in each category. It should be noted that contingency, as used in this analysis, does not account for price escalation and inflation in the cost of decommissioning over the remaining operating life of the station.

Contingency funds are an integral part of the total cost to complete the decommissioning process. Exclusion of this component puts at risk a successful completion of the intended tasks and, potentially, subsequent related activities. For this study, TLG examined the major activity-related problems (decontamination, segmentation, equipment handling, packaging, transport, and waste disposal) that necessitate a contingency. Individual activity contingencies ranged from 10% to 75%, depending on the degree of difficulty judged to be appropriate from TLG's actual decommissioning experience. The contingency values used in this study are as follows:

- Decontamination 50%
- Contaminated Component Removal 25%
- Contaminated Component Packaging 10%
- Contaminated Component Transport 15%
- Low-Level Radioactive Waste Disposal 25%

- Low-Level Radioactive Waste Processing 15%
- Reactor Segmentation 75%
- NSSS Component Removal 25%
- Reactor Waste Packaging 25%
- Reactor Waste Transport 25%

- Reactor Vessel Component Disposal 50%
- GTCC Disposal 15%
- Non-Radioactive Component Removal 15%
- Heavy Equipment and Tooling 15%
- Supplies 25%

- Engineering 15%
- Energy 15%
- Insurance, Taxes and Fees 10%
- Characterization and Termination Surveys 30%
- Operations and Maintenance Expense 15%
- ISFSI Decommissioning 25%

The contingency values are applied to the appropriate components of the estimates on a line item basis. A composite value is then reported at the end of the detailed estimate (as provided in Appendix C). A contingency of 25% is applied to the subtotal of the ISFSI decommissioning costs.

3.3.2 Financial Risk

In addition to the routine uncertainties addressed by contingency, another cost element that is sometimes necessary to consider when bounding decommissioning costs relates to uncertainty, or risk. Examples can include changes in work scope, pricing, job performance, and other variations that could conceivably, but not necessarily, occur. Consideration is sometimes necessary to generate a level of confidence in the estimate, within a range of probabilities. TLG considers these types of costs under the broad term "financial risk." Included within the category of financial risk are:

- Transition activities and costs: ancillary expenses associated with reducing the size of the labor force 50% to 80% shortly after the cessation of plant operations, national or company-mandated retraining, and retention incentives for key personnel.
- Delays in approval of the decommissioning plan due to intervention, public participation in local community meetings, legal challenges, and national and local hearings.
- Changes in the project work scope from the baseline estimate, involving the discovery of unexpected levels of contaminants, contamination in places not previously expected, contaminated soil previously undiscovered (either radioactive or hazardous material contamination), variations in plant inventory or configuration not indicated by the as-built drawings.
- Regulatory changes, for example, affecting worker health and safety, site release criteria, waste transportation, and disposal.
- Policy decisions altering national commitments (e.g., in the ability to accommodate certain waste forms for disposition, or in the timetable for such, or the start and rate of acceptance of spent fuel by the DOE).
- Pricing changes for basic inputs such as labor, energy, materials, and waste disposal.

This cost study does not add any additional costs to the estimate for financial risk, since there is insufficient historical data from which to project future liabilities. Consequently, the areas of uncertainty or risk are revisited periodically and addressed through repeated revisions or updates of the base estimates.

3.4 SITE-SPECIFIC CONSIDERATIONS

There are a number of site-specific considerations that affect the method for dismantling and removal of equipment from the site and the degree of restoration required. The cost impact of the considerations identified below is included in this cost study.

3.4.1 Spent Fuel Management

The cost to dispose the spent fuel generated from plant operations is not reflected within the estimates to decommission PNPS. Ultimate disposition of the spent fuel is within the province of the DOE's Waste Management System, as defined by the Nuclear Waste Policy Act. As such, the disposal cost is financed by a surcharge paid into the DOE's waste fund during operations. On November 19, 2013, the U.S. Court of Appeals for the D.C. Circuit ordered the Secretary of the Department of Energy to suspend collecting annual fees for nuclear waste disposal from nuclear power plant operators until the DOE has conducted a legally adequate fee assessment.

The NRC does, however, require licensees to establish a program to manage and provide funding for the management of all irradiated fuel at the reactor site until title of the fuel is transferred to the Secretary of Energy. This requirement is prepared for through inclusion of certain high-level waste cost elements within the estimates, as described below.

Completion of the decommissioning process is highly dependent upon the DOE's ability to remove spent fuel from the site. DOE's repository program assumes that spent fuel is accepted for disposal from the nation's commercial nuclear plants in the order (the "queue") in which it was removed from service ("oldest fuel first"). The DOE contracts provide mechanisms for altering the oldest fuel first allocation scheme, including emergency deliveries, exchanges of allocations amongst utilities and the option of providing priority acceptance from permanently shutdown nuclear reactors. Because it is unclear how these mechanisms may operate once DOE begins accepting spent fuel from commercial reactors, this study assumes that DOE will accept spent fuel in an oldest fuel first order. The timing for removal of spent fuel from the site is based upon the DOE's most recently published annual acceptance rates of 400 MTU/year for year 1, 3,800 MTU total for years 2 through 4 and 3,000 MTU/year for year 5 and beyond.[31]

ISFSI

Due to DOE's inability to remove fuel from the site, an ISFSI has been constructed at the site and fuel casks have been emplaced thereon to support continued plant operations. Additional storage capacity will be added to accommodate all the spent fuel generated during operations. Assuming that DOE begins accepting commercial spent fuel from the industry in 2030, DOE's generator allocation/receipt schedules are based upon the oldest fuel receiving the highest priority, and a maximum rate of transfer of 3,000 metric tons of uranium (MTU)/year, as reflected in DOE's latest Acceptance Priority Ranking and Annual Capacity Report dated June 2004 (DOE/RW-0567), the removal of spent fuel from the site could be completed in 2062. Different DOE acceptance schedules may result in different completion dates. It is acknowledged that the plant owner will seek the most expeditious means of removing fuel from the site when DOE commences performance.

Operation and maintenance costs for the spent fuel pool and the ISFSI are included within the estimates and address the cost for staffing the facility, as well as security, insurance, and licensing fees. The estimates include the costs to purchase, load, and transfer the multi-purpose spent fuel storage canisters (MPCs) from the pool to the ISFSI. Costs are also provided for transfer of the MPCs to the DOE from the ISFSI (although it is acknowledged that this may not occur and that the fuel in the MPCs may have to be repackaged at DOE expense).

Canister Loading and Transfer

The estimates include the cost for the labor and equipment to load and transfer the spent fuel canisters to the ISFSI from the wet storage pool – based upon HOLTEC's HI-STORM dry storage system (68-assembly capacity MPCs). For estimating purposes, an allowance is used for the cost to transfer the fuel from the ISFSI into the DOE transport cask.

Operations and Maintenance

The estimates also include the cost of operating and maintaining the spent fuel pool and the ISFSI, respectively. Pool operations are expected to continue approximately three and one half years after the cessation of operations. It is assumed that the time period provides the necessary cooling period for the final core to meet the dry cask storage vendor's system specifications. ISFSI operating costs are based upon the previously stated assumptions on fuel transfer and DOE performance (in removing the fuel from the site).

<u>ISFSI Decommissioning</u>

In accordance with 10 CFR §72.30, licensees must have a proposed decommissioning plan for the ISFSI site and facilities that includes a cost estimate for the plan. The plan needs to contain sufficient information on the proposed practices and procedures for the decontamination of the ISFSI and for the disposal of residual radioactive materials after all spent fuel, high-level radioactive waste, and reactor-related GTCC waste have been removed.

The dry storage vendor does not expect the concrete casks to have any interior or exterior radioactive surface contamination. Any neutron activation of the steel and concrete is also expected to be extremely small. However, the decommissioning estimate is based on the premise that some of the concrete casks will contain low levels of neutron-induced residual radioactivity that would necessitate remediation at the time of decommissioning. As an allowance, 9 casks are assumed to be affected, i.e., contain residual radioactivity. The allowance is based upon the number of casks required for the final core off-load (i.e., 580 offloaded assemblies, 68 assemblies per cask) which results in 9 overpacks. It is assumed that these are the final casks offloaded; consequently they have the least time for radioactive decay of any neutron activation products.

No contamination or activation of the ISFSI pad is assumed. It would be expected that this assumption would be confirmed as a result of good radiological practice of surveying potentially impacted areas after each spent fuel transfer campaign. As such, only verification surveys are included for the pad in the decommissioning estimate. The estimate is limited to costs necessary to terminate the ISFSI's NRC license and meet the §20.1402 criteria for unrestricted use.

In accordance with the specific requirements of 10 CFR §72.30 for the ISFSI work scope, the cost estimate for decommissioning the ISFSI reflects: 1) the cost of an independent contractor performing the decommissioning activities; 2) an adequate contingency factor; and 3) the cost of meeting the criteria for unrestricted use. The cost summary for decommissioning the ISFSI is presented in Appendix D.

GTCC

The dismantling of the reactor internals is expected to generate radioactive waste considered unsuitable for shallow land disposal (i.e., low-level radioactive waste with concentrations of radionuclides that exceed the limits established by the NRC for Class C radioactive waste (GTCC)). The Low-Level Radioactive Waste Policy Amendments Act of 1985 assigned the federal government the responsibility for the disposal of this material. The Act also stated that the beneficiaries of the activities resulting in the generation of such radioactive waste bear all reasonable costs of disposing of such waste. Although the DOE is responsible for disposing of GTCC waste, any costs for that service have not been determined. For purposes of this estimate, the GTCC radioactive waste has been assumed to be packaged in the same canisters used to store spent fuel and disposed of as high-level waste, at a cost equivalent to that envisioned for the spent fuel. The number of canisters required (two) and the packaged volume for GTCC was based upon experience at Maine Yankee (e.g., the constraints on loading as identified in the canister's certificate of compliance).

It is assumed only for purposes of these estimates that the DOE would not accept this waste prior to completing the transfer of spent fuel. Therefore, until such time as the DOE is ready to accept GTCC waste, it is assumed that this material would remain in storage at the PNPS site. It is acknowledged, however, that the plant owner will seek the most expeditious means of removing GTCC from the site when DOE commences performance.

3.4.2 Reactor Vessel and Internal Components

The reactor pressure vessel and internal components are segmented for disposal in shielded, reusable transportation casks. Segmentation is performed in the refueling canal, where a turntable and remote cutter are installed. The vessel is segmented in place, using a mast-mounted cutter supported off the lower head and directed from a shielded work platform installed overhead in the reactor cavity. Transportation cask specifications and transportation regulations dictate the segmentation and packaging methodology.

Intact disposal of reactor vessel shells has been successfully demonstrated at several of the sites that have been decommissioned. Access to navigable waterways has allowed these large packages to be transported to the Barnwell disposal site with minimal overland travel.

Intact disposal of the reactor vessel and internal components can provide savings in cost and worker exposure by eliminating the complex segmentation requirements, isolation of the GTCC material, and transport/storage of the resulting waste packages. Portland General Electric (PGE) was able to dispose of the Trojan reactor as an intact package (including the internals). However, its location on the Columbia River simplified the transportation analysis since:

- the reactor package could be secured to the transport vehicle for the entire journey, i.e., the package was not lifted during transport,
- there were no man-made or natural terrain features between the plant site and the disposal location that could produce a large drop, and
- transport speeds were very low, limited by the overland transport vehicle and the river barge.

As a member of the Northwest Compact, PGE had a site available for disposal of the package - the US Ecology facility in Washington State. The characteristics of this arid site proved favorable in demonstrating compliance with land disposal regulations.

It is not known whether this option will be available when PNPS is ultimately dismantled. Future viability of this option will depend upon the ultimate location of the disposal site, as well as the disposal site licensee's ability to accept highly radioactive packages and effectively isolate them from the environment. Additionally, with BWRs, the diameter of the reactor vessel may severely limit overland transport. Consequently, the study assumes that the reactor vessel will require segmentation, as a bounding condition.

3.4.3 Primary System Components

In the SAFSTOR scenario, the reactor recirculation system components are not assumed to be decontaminated (by chemical agents). The 50 year dormancy is expected to provide the necessary reduction in work area dose rates for dismantling operations.

Reactor recirculation piping is cut from the reactor vessel once the water level in the vessel (used for personnel shielding during dismantling and cutting operations in and around the vessel) is dropped below the nozzle zone. The piping is boxed and transported by shielded van. The reactor recirculation pumps and motors are lifted out intact, packaged, and transported for processing and/or disposal.

3.4.4 Main Turbine and Condenser

The main turbine is dismantled using conventional maintenance procedures. The turbine rotors and shafts are removed to a laydown area. The lower turbine casings are removed from their anchors by controlled demolition. The main condensers are also disassembled and moved to a laydown area. Material is then prepared for transportation to an off-site recycling facility where it is surveyed and designated for either decontamination or volume reduction, conventional disposal, or controlled disposal. Components are packaged and readied for transport in accordance with the intended disposition.

3.4.5 Transportation Methods

Contaminated piping, components, and structural material other than the highly activated reactor vessel and internal components will qualify as LSA-I, II or III or Surface Contaminated Object, SCO-I or II, as described in Title 49.[32] The contaminated material will be packaged in Industrial Packages (IP-1, IP-2, or IP-3, as defined in subpart 10 CFR §173.411) for transport unless demonstrated to qualify as their own shipping containers. The reactor vessel and internal components are expected to be transported in accordance with 10 CFR Part 71, in Type B containers. It is conceivable that the reactor, due to its limited specific activity, could qualify as LSA II or III. However, the high radiation levels on the outer surface would require that additional shielding be incorporated within the packaging so as to attenuate the dose to levels acceptable for transport.

Any fuel cladding failure that occurred during the lifetime of the plant is assumed to have released fission products at sufficiently low levels that the buildup of quantities of long-lived isotopes (e.g., ^{137}Cs, ^{90}Sr, or transuranics) has been prevented from reaching levels exceeding those that permit the major reactor components to be shipped under current transportation regulations and disposal requirements.

Transport of the highly activated metal, produced in the segmentation of the reactor vessel and internal components, will be by shielded truck cask. Cask shipments may exceed 95,000 pounds, including vessel segment(s), supplementary shielding, cask tie-downs, and tractor-trailer. The maximum level of activity per shipment assumed permissible was based upon the license limits of the available shielded transport casks. The segmentation scheme for the vessel and internal segments is designed to meet these limits.

The transport of large intact components (e.g., large heat exchangers and other oversized components) will be by a combination of truck, rail, and/or multi-wheeled transporter.

Transportation costs for Class A radioactive material requiring controlled disposal are based upon the route and mileage to the Energy*Solutions* facility in Clive, Utah. Transportation costs for the higher activity Class B and C radioactive material are based upon the route and mileage to the WCS facility in Andrews County, Texas. Transportation cost for the GTCC material is assumed to be included within the disposal charge. Transportation costs for off-site waste processing are based upon the route and mileage to Oak Ridge, Tennessee. Truck transport costs were developed from published tariffs from Tri-State Motor Transit.[33]

3.4.6 Low-Level Radioactive Waste Disposal

To the greatest extent practical, metallic material generated in the decontamination and dismantling processes is processed to reduce the total cost of controlled disposal. Material meeting the regulatory and/or site release criterion, is released as scrap, requiring no further cost consideration. Conditioning (preparing the material to meet the waste acceptance criteria of the disposal site) and recovery of the waste stream is performed off site at a licensed processing center. Any material leaving the site is subject to a survey and release charge, at a minimum.

The mass of radioactive waste generated during the various decommissioning activities at the site is shown on a line-item basis in the detailed Appendix C, and summarized in Section 5. The quantified waste summaries shown in these tables are consistent with 10 CFR Part 61 classifications. Commercially available steel containers are presumed to be used for the disposal of piping, small components, and concrete. Larger components can serve as their own containers, with proper closure of all openings, access ways, and penetrations. The volumes are calculated based on the exterior package dimensions for containerized material or a specific calculation for components serving as their own waste containers.

The more highly activated reactor components will be shipped in reusable, shielded truck casks with disposable liners. In calculating disposal costs, the burial fees are applied against the liner volume, as well as the special handling requirements of the payload. Packaging efficiencies are lower for the highly activated materials (greater than Class A waste), where high concentrations of gamma-emitting radionuclides limit the capacity of the shipping canisters.

The cost to dispose of the lowest level waste and the majority of the material generated from the decontamination and dismantling activities is based upon Entergy's most recent services agreement with Energy*Solutions*. Disposal costs for the higher activity waste (Class B and C) is based upon Entergy's current agreement with WCS.

3.4.7 Site Conditions Following Decommissioning

The NRC will amend or terminate the site license if it determines that site remediation has been performed in accordance with the license termination plan, and that the terminal radiation survey and associated documentation demonstrate that the facility is suitable for release. The NRC's involvement in the decommissioning process will end at this point. Building codes and environmental regulations will dictate the next step in the decommissioning process, as well as owner's own future plans for the site.

A significant amount of the below grade piping is located around the perimeter of the power block. The estimate includes a cost to excavate this area to an average depth of twelve feet so as to expose the piping, duct bank, conduit, and any near-surface grounding grid. The overburden is surveyed and stockpiled on site for future use in backfilling the below grade voids.

The electrical switchyard remains after PNPS is decommissioned in support of the regional transmission and distribution system. The discharge canal and breakwater are also abandoned in place. Structures are removed to a nominal depth of three feet below grade. The voids are backfilled with clean debris and capped with soil. The site is then re-graded to conform to the adjacent landscape. Vegetation is established to inhibit erosion. These "non-radiological costs" are included in the total cost of decommissioning.

Concrete rubble generated from demolition activities is processed and made available as clean fill for the power block foundations. Additional fill is brought in to cap the power block excavations and to permit seeding for erosion control.

The estimate includes the disposal of approximately 14,000 cubic feet of contaminated soil.

3.5 ASSUMPTIONS

The following are the major assumptions made in the development of the estimates for decommissioning the site.

3.5.1 Estimating Basis

Decommissioning costs are reported in the year of projected expenditure; however, the values are provided in 2018 dollars.

The 2008 plant inventory, the basis for the decontamination and dismantling requirements and cost, and the decommissioning waste streams, were reviewed for this analysis. There were no substantive changes made to the plant that would impact decommissioning except for the additions of the K1, LLRW, Trash Compaction and Maintenance Warehouse structures.

The study follows the principles of ALARA through the use of work duration adjustment factors. These factors address the impact of activities such as radiological protection instruction, mock-up training, and the use of respiratory protection and protective clothing. The factors lengthen a task's duration, increasing costs and lengthening the overall schedule. ALARA planning is considered in the costs for engineering and planning, and in the development of activity specifications and detailed procedures. Changes to worker exposure limits may impact the decommissioning cost and project schedule.

3.5.2 Labor Costs

For purposes of this estimate, it is assumed that ENO (or a comparable organization) will manage the decontamination and dismantling of the nuclear unit, in addition to maintaining site security, radiological health and safety, quality assurance and overall site administration during the decommissioning. A Decommissioning Operations Contractor (DOC) will provide the supervisory staff needed to oversee the labor subcontractors, consultants, and specialty contractors engaged to perform the field work associated with the decontamination and dismantling efforts. An independent contractor is assumed in the decommissioning of the ISFSI, as described in Section 3.4.1).

Reduction in the operating organization is assumed to be handled through normal company human resource practices (e.g., reassignment and outplacement). An allowance is included for severance, however, the severance is intended for the decommissioning organization only (i.e., not for reduction in the plant operating staff that is not retained for decommissioning. Severance for the non-essential (to decommissioning) operations personnel is typically considered to be an operating expense).

Personnel costs are based upon average salary information provided by ENO. Overhead costs are included for site and corporate support, reduced commensurate with the staffing of the project.

The craft labor required to decontaminate and dismantle the nuclear plant is acquired through standard site contracting practices. The current cost of labor at the site is used as an estimating basis.

This estimate includes additional plant staffing resources to support the decommissioning engineering, planning, and licensing efforts for the plant, prior to the cessation of operations (one year duration). Costs for an external Decommissioning Project Organization (DPO) for project oversight are also included, as well as costs for external support contractors and consultants.

A profile of the staffing levels for decommissioning, including contractors and craft, is provided in Figure 3.1. Staffing levels and management support will vary based upon the amount and type of decommissioning work. Craft manpower levels decrease after systems removal and structures decontamination and drop substantially during the license termination survey period. However, craft levels increase again during the site restoration period due to the work associated with structures demolition.

Security, while reduced from operating levels, is maintained throughout the decommissioning for access control, material control, and to safeguard the spent fuel (in accordance with the requirements of 10 CFR Part 37, Part 72, and Part 73). Security costs include provisions for institutional overtime and recurring expenses while the pool is still operational. Once the fuel has been transferred to the DOE in 2062, the security organization will be reduced to Part 37 requirements.

3.5.3 Design Conditions

Activation levels in the vessel and internal components are based upon an activation analysis prepared by WMG, Inc.[34] The activation source terms were adjusted for the SAFSTOR decay period.

The disposal cost for the control blades removed from the vessel with the final core load is included within the estimate. Disposition of any blades stored in the pools from operations is considered an operating expense and therefore not accounted for in the decommissioning estimate.

Activation of the reactor building structures is assumed to be confined to the sacrificial shield and pedestal.

3.5.4 General

Transition Activities

Existing warehouses are cleared of non-essential material and remain for use by Entergy and its subcontractors. The warehouses are removed once they are no longer needed. The plant's operating staff performs the following activities at no additional cost or credit to the project during the transition period:

- Drain and collect fuel oils, lubricating oils, and transformer oils for recycle and/or sale.
- Drain and collect acids, caustics, and other chemical stores for recycle and/or sale.
- Process operating waste inventories. Disposal of operating wastes (e.g., filtration media, resins) during this initial period is not considered a decommissioning expense.

Scrap and Salvage

The existing plant equipment is considered obsolete and suitable for scrap as deadweight quantities only. Entergy will make economically reasonable efforts to salvage equipment following final plant shutdown. However, dismantling techniques assumed by TLG for equipment in this analysis are not consistent with removal techniques required for salvage (resale) of equipment. Experience has indicated that some buyers wanted equipment stripped down to very specific requirements before they would consider purchase. This required expensive rework after the equipment had been removed from its installed location. Since placing a salvage value on this machinery and equipment would be speculative, and the value would be small in comparison to the overall decommissioning expenses, this analysis does not attempt to quantify the value that an owner may realize based upon those efforts.

It is assumed, for purposes of this analysis, that any value received from the sale of scrap generated in the dismantling process would be more than offset by the on-site processing costs. The dismantling techniques assumed in the decommissioning estimates do not include the additional cost for size reduction and preparation to meet "furnace ready" conditions. For example, the recovery of copper from electrical cabling may require the removal and disposition of any contaminated insulation, an added expense. With a volatile market, the potential profit margin in scrap recovery is highly speculative, regardless of the ability to free release this material. This assumption is an implicit recognition of scrap value in the disposal of clean metallic waste at no additional cost to the project.

Furniture, tools, mobile equipment such as forklifts, trucks, bulldozers, and other property is removed at no cost or credit to the decommissioning project. Disposition may include relocation to other facilities. Spare parts are also made available for alternative use.

Energy

For estimating purposes, the plant is assumed to be de-energized, with the exception of those facilities associated with spent fuel storage. Replacement power costs are used to calculate the cost of energy consumed during decommissioning for tooling, lighting, ventilation, and essential services.

Emergency Planning

The estimate includes FEMA, state and local fees associated with emergency planning.

Insurance

Costs for continuing coverage (nuclear liability and property insurance) following cessation of plant operations and during decommissioning are included and based upon current operating premiums. Reductions in premiums, throughout the decommissioning process, are based upon the guidance provided in SECY-00-0145, "Integrated Rulemaking Plan for Nuclear Power Plant Decommissioning."[35] The NRC's financial protection requirements are based on various reactor (and spent fuel) configurations.

Taxes

Property taxes are included within the estimate for the years 2019 and 2020.

Site Modifications

The perimeter fence and in-plant security barriers will be moved, as appropriate, to conform to the Site Security Plan in force during the various stages of the project.

3.6 COST ESTIMATE SUMMARY

Summaries of the decommissioning costs and annual expenditures are provided in Table 3.2. The schedules are based upon the costs reported in Appendix C.

The cost elements in Table C are assigned to one of three subcategories: "License Termination," "Spent Fuel Management," and "Site Restoration." The subcategory "License Termination" is used to accumulate costs that are consistent with "decommissioning" as defined by the NRC in its financial assurance regulations (i.e., 10 CFR §50.75). The cost reported for this subcategory is generally sufficient to terminate the plant's operating license, recognizing that there may be some additional cost impact from spent fuel management. The License Termination cost subcategory also includes costs to decommission the ISFSI (as required by 10 CFR §72.30). The basis for the ISFSI decommissioning cost is provided in Appendix D.

The "Spent Fuel Management" subcategory contains costs associated with the containerization and transfer of spent fuel from the pool to the ISFSI, and the transfer of the multipurpose canisters from the ISFSI to the DOE. Costs are also included for the operations of the pool and management of the ISFSI until such time that the transfer of all fuel from this facility to an off-site location (e.g., interim storage facility) is complete.

"Site Restoration" is used to capture costs associated with the dismantling and demolition of buildings and facilities demonstrated to be free from contamination. This includes structures never exposed to radioactive materials, as well as those facilities that have been decontaminated to appropriate levels. Structures are assumed to be removed to a nominal depth of three feet and backfilled to conform to local grade.

The disposal of the GTCC is assumed to be concurrent with the disposal of the other reactor internals. While designated for disposal at the geologic repository along with the spent fuel, GTCC waste is still classified as low-level radioactive waste and, as such, included as a “License Termination” expense.

Decommissioning costs are reported in 2018 dollars. Costs are not inflated, escalated, or discounted over the period of expenditure (or projected lifetime of the plant). The schedules are based upon the detailed activity costs reported in Appendix C, along with the timeline presented in Section 4.

TABLE 3.1
SPENT FUEL MANAGEMENT SCHEDULE
(Fuel Assembly Totals by Location)

Year	Pool Inventory	ISFSI Inventory	DOE Acceptance[1]
2018	2,378	1,156	
2019	2,958	1,156	
2020	2,958	1,156	
2021	2,958	1,156	
2022	-	4,114	
2023		4,114	
2024		4,114	
2025		4,114	
2026		4,114	
2027		4,114	
2028		4,114	
2029		4,114	
2030		4,094	20
2031		3,962	132
2032		3,534	428
2033		3,534	-
2034		3,442	92
2035		3,210	232
2036		2,986	224
2037		2,986	-
2038		2,794	192
2039		2,794	-
2040		2,794	-
2041		2,626	168
2042		2,486	140
2043		2,350	136
2044		2,350	-
2045		2,144	206
2046		2,128	16
2047		1,984	144
2048		1,840	144
2049		1,676	164

TABLE 3.1 (continued)
SPENT FUEL MANAGEMENT SCHEDULE
(Fuel Assembly Totals by Location)

Year	Pool Inventory	ISFSI Inventory	DOE Acceptance[1]
2050		1,676	-
2051		1,516	160
2052		1,356	160
2053		1,356	-
2054		1,200	156
2055		1,048	152
2056		1,048	-
2057		896	152
2058		896	-
2059		752	144
2060		580	172
2061		580	-
2062		-	580
Total			4,114

[1] DOE acceptance schedule provided by Energy Resources International, Inc., assuming industry acceptance begins in year 2030. The schedule is provided for illustrative purposes only. It is expected that ENGC will seek to accelerate acceptance based on shutdown reactor priority, exchanges of acceptance allocations and other contractual provisions.

TABLE 3.2
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2018	4,033	12,100	0	0	19,142	35,275
2019	57,094	36,553	1,409	276	64,708	160,040
2020	34,789	29,355	1,572	539	50,013	116,268
2021	25,798	24,684	1,157	323	42,968	94,930
2022	25,798	24,684	1,157	323	40,735	92,697
2023	6,464	130	524	7	20,273	27,398
2024	6,481	130	525	7	4,075	11,219
2025	6,464	130	524	7	3,444	10,569
2026	6,464	130	524	7	3,069	10,194
2027	6,464	130	524	7	3,069	10,194
2028	6,481	130	525	7	3,075	10,219
2029	6,464	130	524	7	3,069	10,194
2030	6,464	130	524	7	3,069	10,194
2031	6,550	389	524	7	3,069	10,539
2032	6,783	1,036	525	7	3,075	11,427
2033	6,464	130	524	7	3,069	10,194
2034	6,507	259	524	7	3,069	10,366
2035	6,636	648	524	7	3,069	10,884
2036	6,611	519	525	7	3,075	10,737
2037	6,464	130	524	7	3,069	10,194
2038	6,593	518	524	7	3,069	10,711
2039	6,464	130	524	7	3,069	10,194
2040	6,481	130	525	7	3,075	10,219
2041	6,593	518	524	7	3,069	10,711
2042	6,550	389	524	7	3,069	10,539
2043	6,550	389	524	7	3,069	10,539
2044	6,481	130	525	7	3,075	10,219
2045	6,593	518	524	7	3,069	10,711
2046	6,464	130	524	7	3,069	10,194
2047	6,550	389	524	7	3,069	10,539
2048	6,568	389	525	7	3,075	10,564
2049	6,593	518	524	7	3,069	10,711

TABLE 3.2 (continued)
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2050	6,464	130	524	7	3,069	10,194
2051	6,550	389	524	7	3,069	10,539
2052	6,568	389	525	7	3,075	10,564
2053	6,464	130	524	7	3,069	10,194
2054	6,550	389	524	7	3,069	10,539
2055	6,550	389	524	7	3,069	10,539
2056	6,481	130	525	7	3,075	10,219
2057	6,550	389	524	7	3,069	10,539
2058	6,464	130	524	7	3,069	10,194
2059	6,550	389	524	7	3,069	10,539
2060	6,611	519	525	7	3,075	10,737
2061	6,464	130	524	7	3,069	10,194
2062	6,852	1,294	524	7	3,069	11,746
2063	1,663	298	216	6	2,514	4,697
2064	1,668	298	217	6	2,521	4,710
2065	1,663	298	216	6	2,514	4,697
2066	1,663	298	216	6	2,514	4,697
2067	1,663	298	216	6	2,514	4,697
2068	1,668	298	217	6	2,521	4,710
2069	1,663	298	216	6	2,514	4,697
2070	1,663	298	216	6	2,514	4,697
2071	1,663	298	216	6	2,514	4,697
2072	1,668	298	217	6	2,521	4,710
2073	22,736	1,183	1,324	21	3,694	28,959
2074	38,964	8,295	2,154	5,384	7,668	62,464
2075	47,918	24,281	2,053	68,469	17,586	160,307
2076	63,669	15,103	1,775	41,144	16,992	138,683
2077	66,458	10,162	1,621	26,451	16,606	121,298
2078	56,977	7,375	1,230	17,765	13,112	96,460
2079	28,238	4,772	305	12	5,397	38,724
2080	19,909	6,356	198	0	4,580	31,044
Total	770,385	220,980	39,095	161,050	469,748	1,661,258

TABLE 3.2a
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2018	0	0	0	0	19,142	19,142
2019	45,256	1,040	1,409	276	52,043	100,024
2020	22,178	1,040	1,572	539	36,245	61,574
2021	13,526	454	1,157	323	30,572	46,032
2022	13,526	454	1,157	323	28,339	43,799
2023	2,276	130	524	7	11,579	14,516
2024	2,282	130	525	7	3,953	6,897
2025	2,276	130	524	7	3,322	6,259
2026	2,276	130	524	7	2,947	5,884
2027	2,276	130	524	7	2,947	5,884
2028	2,282	130	525	7	2,953	5,897
2029	2,276	130	524	7	2,947	5,884
2030	2,276	130	524	7	2,947	5,884
2031	2,276	130	524	7	2,947	5,884
2032	2,282	130	525	7	2,953	5,897
2033	2,276	130	524	7	2,947	5,884
2034	2,276	130	524	7	2,947	5,884
2035	2,276	130	524	7	2,947	5,884
2036	2,282	130	525	7	2,953	5,897
2037	2,276	130	524	7	2,947	5,884
2038	2,276	130	524	7	2,947	5,884
2039	2,276	130	524	7	2,947	5,884
2040	2,282	130	525	7	2,953	5,897
2041	2,276	130	524	7	2,947	5,884
2042	2,276	130	524	7	2,947	5,884
2043	2,276	130	524	7	2,947	5,884
2044	2,282	130	525	7	2,953	5,897
2045	2,276	130	524	7	2,947	5,884
2046	2,276	130	524	7	2,947	5,884
2047	2,276	130	524	7	2,947	5,884
2048	2,282	130	525	7	2,953	5,897
2049	2,276	130	524	7	2,947	5,884

TABLE 3.2a (continued)
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2050	2,276	130	524	7	2,947	5,884
2051	2,276	130	524	7	2,947	5,884
2052	2,282	130	525	7	2,953	5,897
2053	2,276	130	524	7	2,947	5,884
2054	2,276	130	524	7	2,947	5,884
2055	2,276	130	524	7	2,947	5,884
2056	2,282	130	525	7	2,953	5,897
2057	2,276	130	524	7	2,947	5,884
2058	2,276	130	524	7	2,947	5,884
2059	2,276	130	524	7	2,947	5,884
2060	2,282	130	525	7	2,953	5,897
2061	2,276	130	524	7	2,947	5,884
2062	2,276	130	524	7	2,947	5,884
2063	1,663	298	216	6	2,514	4,697
2064	1,668	298	217	6	2,521	4,710
2065	1,663	298	216	6	2,514	4,697
2066	1,663	298	216	6	2,514	4,697
2067	1,663	298	216	6	2,514	4,697
2068	1,668	298	217	6	2,521	4,710
2069	1,663	298	216	6	2,514	4,697
2070	1,663	298	216	6	2,514	4,697
2071	1,663	298	216	6	2,514	4,697
2072	1,668	298	217	6	2,521	4,710
2073	22,411	1,183	1,324	21	3,694	28,634
2074	38,252	8,293	2,154	5,384	7,668	61,751
2075	47,682	24,256	2,053	68,469	17,586	160,046
2076	63,341	15,092	1,775	41,144	16,992	138,344
2077	66,082	10,159	1,621	26,451	16,606	120,920
2078	56,725	7,373	1,230	17,765	13,112	96,205
2079	15,548	693	178	12	2,457	18,888
2080	137	0	0	0	0	137
Total	512,400	78,223	38,769	161,050	397,552	1,187,994

TABLE 3.2b
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2018	4,033	12,100	0	0	0	16,133
2019	11,838	35,513	0	0	12,665	60,016
2020	12,611	28,315	0	0	13,768	54,694
2021	12,272	24,230	0	0	12,396	48,898
2022	12,272	24,230	0	0	12,396	48,898
2023	4,188	0	0	0	8,694	12,882
2024	4,200	0	0	0	122	4,322
2025	4,188	0	0	0	122	4,310
2026	4,188	0	0	0	122	4,310
2027	4,188	0	0	0	122	4,310
2028	4,200	0	0	0	122	4,322
2029	4,188	0	0	0	122	4,310
2030	4,188	0	0	0	122	4,310
2031	4,274	259	0	0	122	4,655
2032	4,501	906	0	0	122	5,529
2033	4,188	0	0	0	122	4,310
2034	4,231	129	0	0	122	4,482
2035	4,361	518	0	0	122	5,000
2036	4,329	388	0	0	122	4,839
2037	4,188	0	0	0	122	4,310
2038	4,317	388	0	0	122	4,827
2039	4,188	0	0	0	122	4,310
2040	4,200	0	0	0	122	4,322
2041	4,317	388	0	0	122	4,827
2042	4,274	259	0	0	122	4,655
2043	4,274	259	0	0	122	4,655
2044	4,200	0	0	0	122	4,322
2045	4,317	388	0	0	122	4,827
2046	4,188	0	0	0	122	4,310
2047	4,274	259	0	0	122	4,655
2048	4,286	259	0	0	122	4,667
2049	4,317	388	0	0	122	4,827

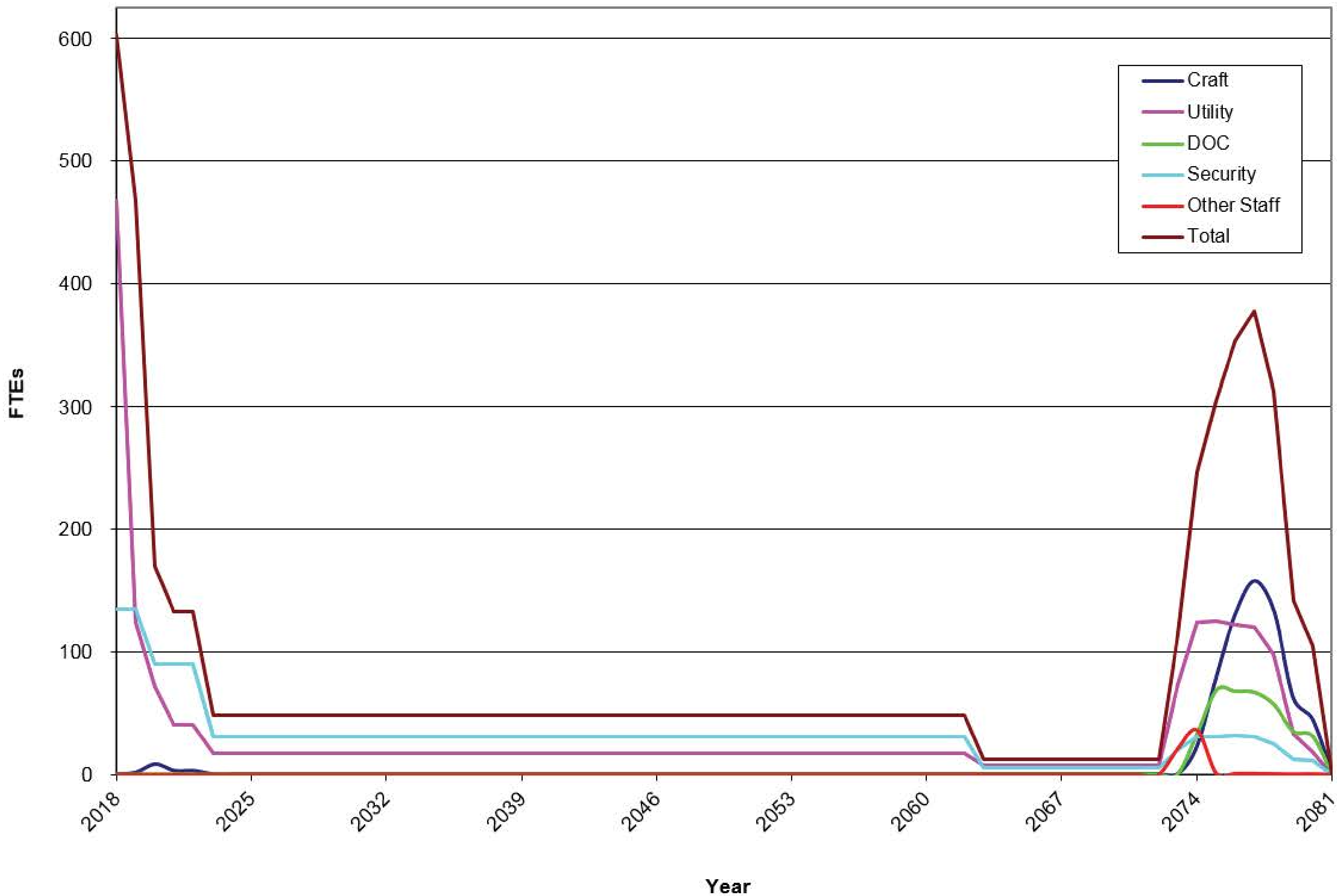
TABLE 3.2b (continued)
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2050	4,188	0	0	0	122	4,310
2051	4,274	259	0	0	122	4,655
2052	4,286	259	0	0	122	4,667
2053	4,188	0	0	0	122	4,310
2054	4,274	259	0	0	122	4,655
2055	4,274	259	0	0	122	4,655
2056	4,200	0	0	0	122	4,322
2057	4,274	259	0	0	122	4,655
2058	4,188	0	0	0	122	4,310
2059	4,274	259	0	0	122	4,655
2060	4,329	388	0	0	122	4,839
2061	4,188	0	0	0	122	4,310
2062	4,576	1,164	0	0	122	5,862
Total	223,294	132,279	0	0	64,677	420,250

TABLE 3.2c
SITE RESTORATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equip. & Materials	Energy	Waste Disposal	Other	Total
2018-72	0	0	0	0	0	0
2073	325	0	0	0	0	325
2074	712	2	0	0	0	713
2075	236	25	0	0	0	261
2076	328	11	0	0	0	339
2077	376	3	0	0	0	379
2078	252	2	0	0	0	254
2079	12,690	4,079	127	0	2,939	19,836
2080	19,772	6,356	198	0	4,580	30,907
Total	34,691	10,478	326	0	7,519	53,014

FIGURE 3.1
SITE STAFFING LEVELS
(Full Time Equivalent Positions)



4. SCHEDULE ESTIMATE

The schedules for the decommissioning scenarios considered in this analysis follow the sequences presented in the AIF/NESP-036 study, with minor changes to reflect recent experience and site-specific constraints. In addition, the scheduling has been revised to reflect the spent fuel management described in Section 3.4.1.

A schedule or sequence of activities for the decommissioning scenario is presented in Figure 4.1. The scheduling sequence is based on the fuel being removed from the spent fuel pool in three years. The key activities listed in the schedule do not reflect a one-to-one correspondence with those activities in the cost table, but reflect dividing some activities for clarity and combining others for convenience. The schedule was prepared using the "Microsoft Project Professional" computer software.[36]

4.1 SCHEDULE ESTIMATE ASSUMPTIONS

The schedule reflects the results of a precedence network developed for the site decommissioning activities, i.e., a PERT (Program Evaluation and Review Technique) Software Package. The work activity durations used in the precedence network reflect the actual man-hour estimates from the cost table, adjusted by stretching certain activities over their slack range and shifting the start and end dates of others. The following assumptions were made in the development of the decommissioning schedule:

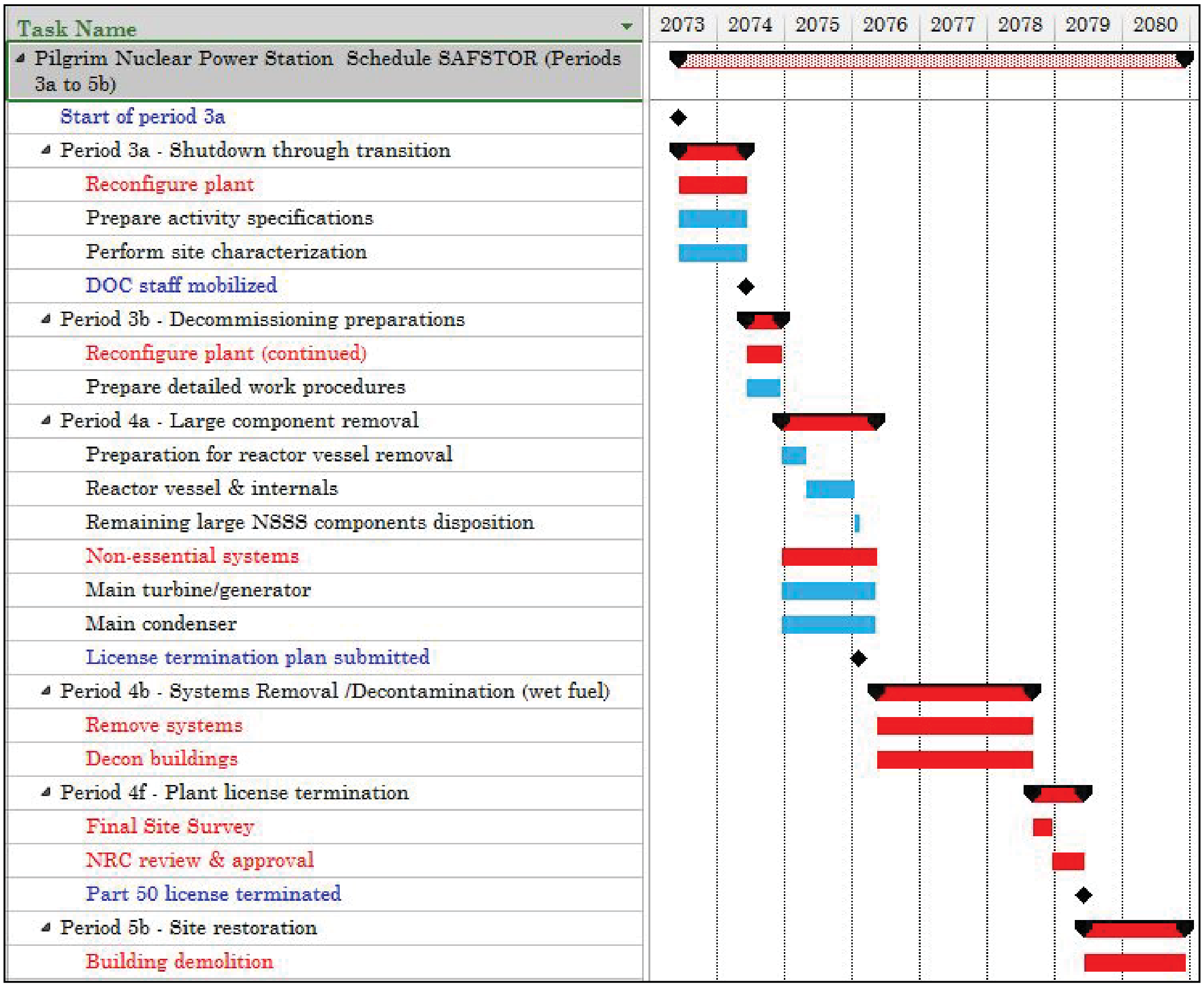
- The reactor building is isolated until such time that all spent fuel has been discharged from the spent fuel pool to the ISFSI. Decontamination and dismantling of the storage pool is initiated once the transfer of spent fuel is complete.
- All work (except reactor vessel and reactor vessel internals removal and the spent fuel loading campaigns) is performed during an 8-hour workday, 5 days per week, with no overtime.
- Reactor and internals removal activities are performed by using separate crews for different activities working on different shifts, with a corresponding backshift charge for the second shift.
- Multiple crews work parallel activities to the maximum extent possible, consistent with optimum efficiency, adequate access for cutting, removal and laydown space, and with the stringent safety measures necessary during demolition of heavy components and structures.

4.2 PROJECT SCHEDULE

The period-dependent costs presented in the detailed cost tables are based upon the durations developed in the schedules for decommissioning. Durations are established between several milestones in each project period; these durations are used to establish a critical path for the entire project. In turn, the critical path duration for each period is used as the basis for determining the period-dependent costs.

A project timeline is provided in Figure 4.2, with milestone dates based on the 2019 shutdown date. The fuel pool is emptied approximately three years after shutdown, while ISFSI operations continue until the DOE can complete the removal of spent fuel from the site.

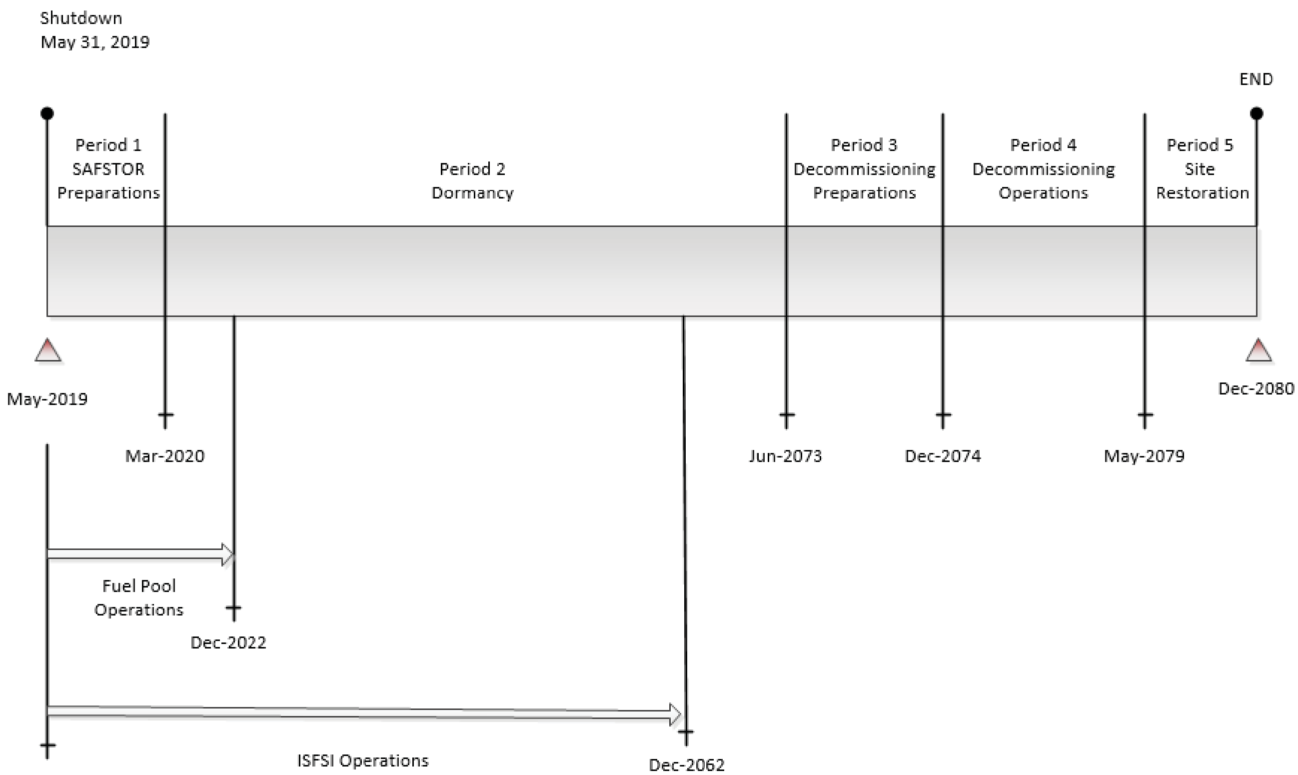
FIGURE 4.1
ACTIVITY SCHEDULE



LEGEND

1. Red scheduling bars indicate critical path activities
2. Blue scheduling bars associated with major decommissioning periods, e.g., Period 1a, indicate overall duration of that period
3. Diamond symbols indicate major milestones

FIGURE 4.2
DECOMMISSIONING TIMELINE
(not to scale)



5. RADIOACTIVE WASTES

The objectives of the decommissioning process are the removal of all radioactive material from the site that would restrict its future use and the termination of the NRC license. This currently requires the remediation of all radioactive material at the site in excess of applicable legal limits. Under the Atomic Energy Act,[37] the NRC is responsible for protecting the public from sources of ionizing radiation. Title 10 of the Code of Federal Regulations delineates the production, utilization, and disposal of radioactive materials and processes. In particular, Part 71 defines radioactive material as it pertains to transportation and Part 61 specifies its disposition.

Most of the materials being transported for controlled burial are categorized as Low Specific Activity (LSA) or Surface Contaminated Object (SCO) materials containing Type A quantities, as defined in 49 CFR Parts 173-178. Shipping containers are required to be Industrial Packages (IP-1, IP-2 or IP-3, as defined in 49 CFR §173.411). For this study, commercially available steel containers are presumed to be used for the disposal of piping, small components, and concrete. Larger components can serve as their own containers, with proper closure of all openings, access ways, and penetrations.

The destinations for the various waste streams from decommissioning are identified in Figures 5.1 and 5.2. The volumes are shown on a line-item basis in Appendix C and summarized in Table 5.1. The volumes are calculated based on the exterior dimensions for containerized material and on the displaced volume of components serving as their own waste containers.

The reactor vessel and internals are categorized as large quantity shipments and, accordingly, will be shipped in reusable, shielded truck casks with disposable liners. In calculating disposal costs, the burial fees are applied against the liner volume, as well as the special handling requirements of the payload. Packaging efficiencies are lower for the highly activated materials (greater than Type A quantity waste), where high concentrations of gamma-emitting radionuclides limit the capacity of the shipping canisters.

No process system containing/handling radioactive substances at shutdown is presumed to meet material release criteria by decay alone (i.e., systems radioactive at shutdown will still be radioactive over the time period during which the decommissioning is accomplished, due to the presence of long-lived radionuclides). While the dose rates decrease with time, radionuclides such as ^{137}Cs will still control the disposition requirements.

The waste material produced in the decontamination and dismantling of the nuclear plant is primarily generated during Period 2. Material that is considered potentially contaminated when removed from the radiological controlled area is sent to processing facilities in Tennessee for conditioning and disposal. Heavily contaminated components and activated materials are routed for controlled disposal. The disposal volumes reported in the tables reflect the savings resulting from reprocessing and recycling.

For purposes of constructing the estimate, the current cost for disposal at Energy*Solutions* facility in Clive, Utah was used for a majority of the radioactive waste produced from the decommissioning activities. Separate rates were used for containerized waste and large components. Demolition debris including miscellaneous steel, scaffolding, and concrete was disposed of at a bulk rate. The decommissioning waste stream also included resins and dry active waste.

Since the Energy*Solutions* facility is not currently able to receive the more highly radioactive components generated in the decontamination and dismantling of the reactor, disposal costs for the Class B and C material were based upon Entergy's current agreement with WCS for the Andrews County disposal facility.

FIGURE 5.1
RADIOACTIVE WASTE DISPOSITION

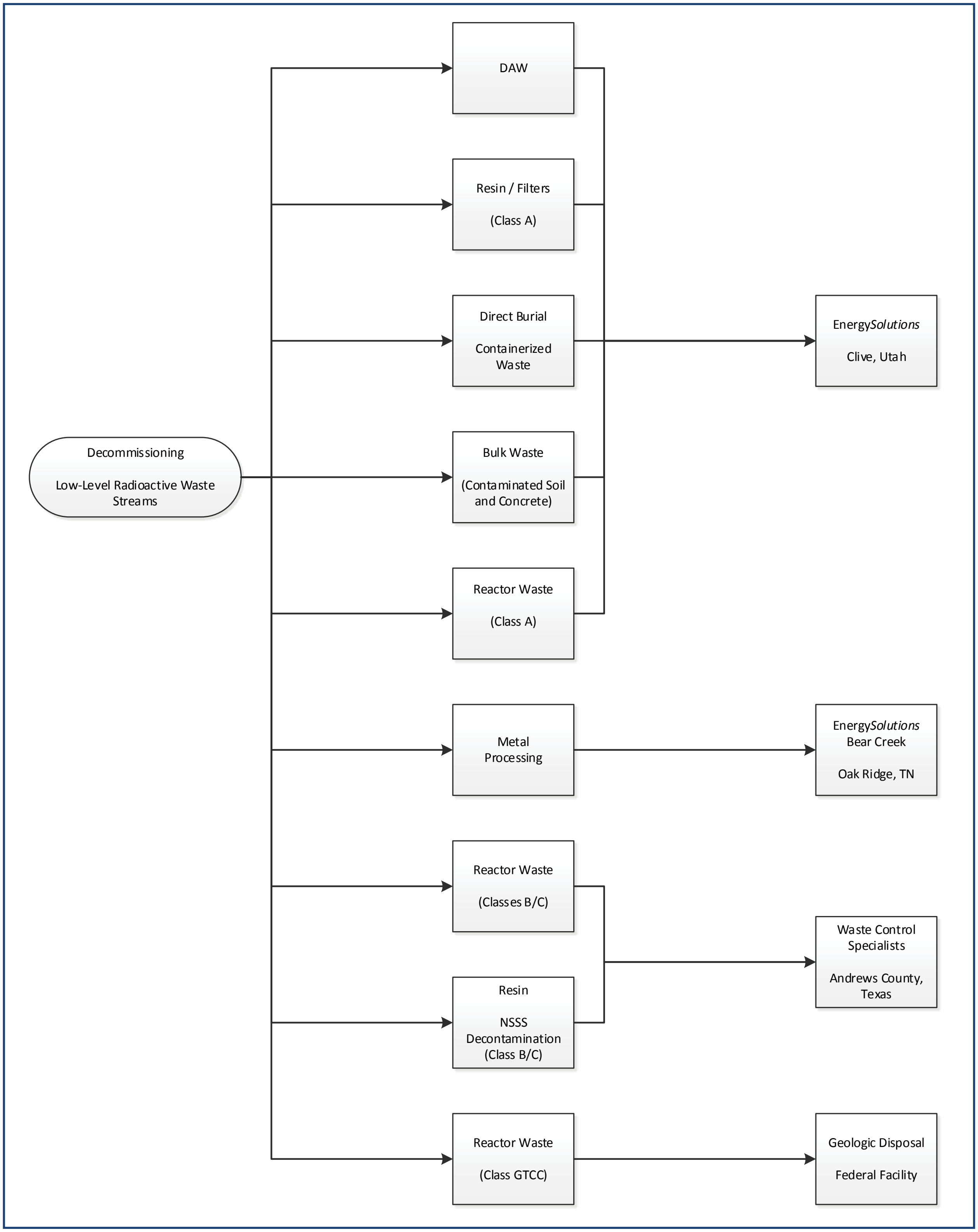
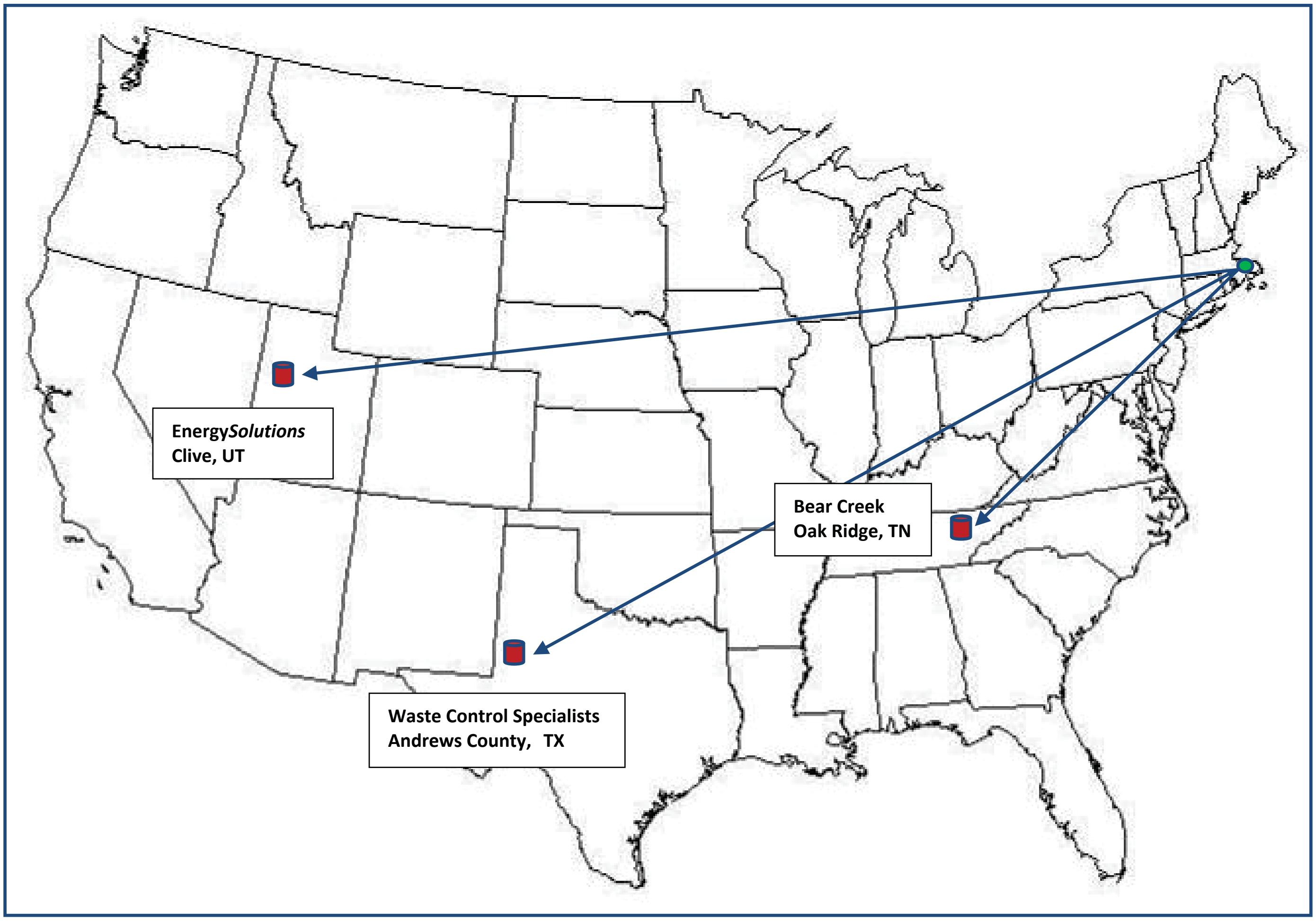


FIGURE 5.2
DECOMMISSIONING WASTE DESTINATIONS
RADIOLOGICAL



The figure indicates the destinations for the low-level radioactive waste designated for direct disposal (Clive, Utah and Andrews County, Texas) and processing/ recovery (Oak Ridge, Tennessee).

Disposal options (and destinations) for GTCC are still being evaluated.

TABLE 5.1
DECOMMISSIONING WASTE SUMMARY

Waste	Cost Basis	Class [1]	Waste Volume (cubic feet)	Mass (pounds)
Low-Level Radioactive Waste (near-surface disposal)	Energy*Solutions* Containerized	A	88,453	5,624,824
	Energy*Solutions* Bulk	A	174,149	7,487,311
	WCS	B	1,753	165,640
	WCS	C	742	81,096
Greater than Class C (geologic repository)	Spent Fuel Equivalent	GTCC	817	169,336
Total (Direct Disposal)[2]			265,913	13,528,206
Processed/Conditioned (off-site recycling/recovery center)	Recycling Vendors	A	596,942	24,470,490

[1] Waste is classified according to the requirements as delineated in Title 10 CFR, Part 61.55

[2] Columns may not add due to rounding

6. RESULTS

The analysis to estimate the costs to decommission PNPS relied upon the site-specific, technical information developed for a previous analysis prepared in 2008. While not an engineering study, the estimates provide the owner with sufficient information to assess their financial obligations, as they pertain to the eventual decommissioning of the nuclear station.

The estimate described in this report is based on numerous fundamental assumptions, including regulatory requirements, project contingencies, low-level radioactive waste disposal practices, high-level radioactive waste management options, and site restoration requirements.

The cost projected for radiological remediation, dismantling the structures, and managing the spent fuel is estimated to be $1.661.2 billion. The majority of this cost (approximately 71.5%) is associated with the physical decontamination and dismantling of the nuclear plant so that the operating license can be terminated. Another 25.3% is associated with the management, interim storage, and eventual transfer of the spent fuel. The remaining 3.2% is for the demolition of the designated structures and limited restoration of the site.

The primary cost contributors, identified in Table 6.1, are either labor-related or associated with the management and disposition of the radioactive waste. Program management is the largest single contributor to the overall cost. The magnitude of the expense is a function of both the size of the organization required to manage the decommissioning, as well as the duration of the program.

As described in this report, the spent fuel pool will remain operational for approximately three and one half years following the cessation of operations. The pool will be isolated which will allow decommissioning operations to proceed in and around the pool area. Over the time period, the spent fuel will be packaged into canisters and transferred to the ISFSI.

The cost for waste disposal includes only those costs associated with the controlled disposition of the low-level radioactive waste generated from decontamination and dismantling activities, including plant equipment and components, structural material, filters, resins and dry-active waste. As described in Section 5, disposition of the majority of the low-level radioactive material requiring controlled disposal is at the Energy*Solutions*' facility. Highly activated components, requiring additional isolation from the environment (GTCC), are packaged for geologic disposal. The cost of geologic disposal is based upon a cost equivalent for spent fuel.

A significant portion of the metallic waste is designated for additional processing and treatment at an off-site facility. Processing reduces the volume of material requiring controlled disposal through such techniques and processes as survey and sorting, decontamination, and volume reduction. The material that cannot be unconditionally released is packaged for controlled disposal at one of the currently operating facilities. The cost identified in the summary tables for processing is all-inclusive, incorporating the ultimate disposition of the material.

Removal costs reflect the labor-intensive nature of the decommissioning process, as well as the management controls required to ensure a safe and successful program. Decontamination and packaging costs also have a large labor component that is based upon prevailing wages. Non-radiological demolition is a natural extension of the decommissioning process. The methods employed in decontamination and dismantling are generally destructive and indiscriminate in inflicting collateral damage. With a work force mobilized to support decommissioning operations, non-radiological demolition can be an integrated activity and a logical expansion of the work being performed in the process of terminating the operating license.

The reported cost for transport includes the tariffs and surcharges associated with moving large components and/or overweight shielded casks overland, as well as the general expense, e.g., labor and fuel, of transporting material to the destinations identified in this report. For purposes of this analysis, material is primarily moved overland by truck.

Decontamination is used to reduce the plant's radiation fields and minimize worker exposure. Slightly contaminated material or material located within a contaminated area is sent to an off-site processing center, i.e., this analysis does not assume that contaminated plant components and equipment can be decontaminated for uncontrolled release in-situ. Centralized processing centers have proven to be a more economical means of handling the large volumes of material produced in the dismantling of a nuclear plant.

License termination survey costs are associated with the labor intensive and complex activity of verifying that contamination has been removed from the site to the levels specified by the regulating agency. This process involves a systematic survey of all remaining plant surface areas and surrounding environs, sampling, isotopic analysis, and documentation of the findings. The status of any plant components and materials not removed in the decommissioning process will also require confirmation and will add to the expense of surveying the facilities alone.
The remaining costs include allocations for heavy equipment and temporary services, as well as for other expenses such as regulatory fees and the premiums for nuclear insurance. While site operating costs are greatly reduced following the

final cessation of plant operations, certain administrative functions do need to be maintained either at a basic functional or regulatory level.

TABLE 6.1
DECOMMISSIONING COST ELEMENTS
(thousands of 2018 dollars)

Cost Element	Total	Percentage
Preparations for Safe-Storage	32,497	2.0
PNPS Projects	30,130	1.8
Decontamination	16,770	1.0
Removal	172,716	10.4
Packaging	16,255	1.0
Transportation	18,828	1.1
Waste Disposal	95,053	5.7
Off-site Waste Processing	71,574	4.3
Program Management [1]	424,299	25.5
Security	176,042	10.6
ISFSI and Spent Fuel Pool Operating Costs	12,580	0.8
DFS [2]	176,373	10.6
Insurance	52,899	3.2
Energy	39,321	2.4
Characterization and Licensing Surveys	27,248	1.6
Property Taxes	16,467	1.0
Site O&M	70,626	4.3
Corporate A&G	98,899	6.0
Regulatory / NRC	18,427	1.1
NDO Contingency	80,741	4.9
Legal	7,015	0.4
ETR Oversight	4,140	0.2
Finance & Interest	6,740	0.4
Defueling Credit	-12,492	-0.8
Emergency Planning	8,111	0.5
Total [3]	1,661,258	100.0

Cost Category	Total	Percentage
License Termination	1,187,994	71.5
Spent Fuel Management	420,250	25.3
Site Restoration	53,014	3.2
Total [3]	1,661,258	100.0

[1] Includes engineering costs
[2] Excludes program management costs (staffing) but includes costs for spent fuel loading/transfer costs
[3] Columns may not add due to rounding

7. REFERENCES

1. "Preliminary Decommissioning Cost Analysis for the Pilgrim Nuclear Power Station," Document E11-5690-003, Rev. 0, TLG Services, Inc., July 2008

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9. "Nuclear Waste Policy Act of 1982," 42 U.S. Code 10101, et seq. [Open]

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11. "Blue Ribbon Commission on America's Nuclear Future, Report to the Secretary of Energy," p. 27, 32, January 2012 [Open]

12. "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste," U.S. DOE, January 11, 2013 [Open]

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15. U.S. Code of Federal Regulations, Title 10, Part 50, "Domestic Licensing of Production and Utilization Facilities," Subpart 54 (bb), "Conditions of Licenses" [Open]

16. U.S. Code of Federal Regulations, Title 10, Part 72, Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites" [Open]

17. "Low-Level Radioactive Waste Policy Act," Public Law 96-573, 1980 [Open]

18. "Low-Level Radioactive Waste Policy Amendments Act of 1985," Public Law 99-240, January 15, 1986 [Open]

19. U.S. Code of Federal Regulations, Title 10, Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste" [Open]

20. U.S. Code of Federal Regulations, Title 10, Part 20, Subpart E, "Final Rule, Radiological Criteria for License Termination," 62 Fed. Reg. 39058, July 21, 1997 [Open]

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28. "Decommissioning of Nuclear Power Reactors," Regulatory Guide 1.184, Nuclear Regulatory Commission, October 2013 [Open]

29. "Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors," Regulatory Guide 1.202, Nuclear Regulatory Commission, February 2005 [Open]

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35. SECY-00-0145, "Integrated Rulemaking Plan for Nuclear Power Plant Decommissioning," June 2000

36. "Microsoft Project Professional," Microsoft Corporation, Redmond, WA

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APPENDIX A

UNIT COST FACTOR DEVELOPMENT

APPENDIX A
UNIT COST FACTOR DEVELOPMENT

Example: Unit Factor for Removal of Contaminated Heat Exchanger < 3,000 lbs.

1. SCOPE

Heat exchangers weighing < 3,000 lbs. will be removed in one piece using a crane or small hoist. They will be disconnected from the inlet and outlet piping. The heat exchanger will be sent to the waste processing area.

2. CALCULATIONS

Act ID	Activity Description	Activity Duration (minutes)	Critical Duration (minutes)*
a	Remove insulation	60	(b)
b	Mount pipe cutters	60	60
c	Install contamination controls	20	(b)
d	Disconnect inlet and outlet lines	60	60
e	Cap openings	20	(d)
f	Rig for removal	30	30
g	Unbolt from mounts	30	30
h	Remove contamination controls	15	15
i	Remove, wrap, send to waste processing area	60	60
	Totals (Activity/Critical)	355	255

Duration adjustment(s):	
+ Respiratory protection adjustment (50% of critical duration)	128
+ Radiation/ALARA adjustment (15% of critical duration)	38
Adjusted work duration	421
+ Protective clothing adjustment (30% of adjusted duration)	126
Productive work duration	547
+ Work break adjustment (8.33 % of productive duration)	46
Total work duration (minutes)	593

***** Total duration = 9.883 hr *****

* alpha designators indicate activities that can be performed in parallel

APPENDIX A
(continued)

3. LABOR REQUIRED

Crew	Number	Duration (hours)	Rate ($/hr)	Cost
Laborers	3.00	9.883	$69.13	$2,049.64
Craftsmen	2.00	9.883	$85.29	$1,685.84
Foreman	1.00	9.883	$91.07	$900.04
General Foreman	0.25	9.883	$96.60	$238.67
Fire Watch	0.05	9.883	$69.13	$34.16
Health Physics Technician	1.00	9.883	$67.29	$665.03
Total Labor Cost				$5,573.38

4. EQUIPMENT & CONSUMABLES COSTS

Equipment Costs	none
Consumables/Materials Costs	
-Universal Sorbent 50 @ $0.59 sq ft {1}	$29.50
-Tarpaulins (oil resistant/fire retardant) 50 @ $0.46/sq ft {2}	$23.00
-Gas torch consumables 1 @ $19.74/hr x 1 hr {3}	$19.74
Subtotal cost of equipment and materials	$72.24
Overhead & profit on equipment and materials @ 16.25 %	$11.74
Total costs, equipment & material	$83.98

TOTAL COST:

Removal of contaminated heat exchanger <3000 pounds:	**$5,657.36**
Total labor cost:	$5,573.38
Total equipment/material costs:	$83.98
Total craft labor man-hours required per unit:	72.15

5. NOTES AND REFERENCES

- Work difficulty factors were developed in conjunction with the Atomic Industrial Forum’s (now NEI) program to standardize nuclear decommissioning cost estimates and are delineated in Volume 1, Chapter 5 of the “Guidelines for Producing Commercial Nuclear Power Plant Decommissioning Cost Estimates," AIF/NESP-036, May 1986.

- References for equipment & consumables costs:

    1. www.mcmaster.com online catalog, McMaster Carr Spill Control (7193T88)
    2. R.S. Means (2018) Division 01 56, Section 13.60-0600, page 23
    3. R.S. Means (2018) Division 01 54 33, Section 40-6360, page 734

- Material and consumable costs were adjusted using the regional indices for Brockton, Massachusetts

APPENDIX B

UNIT COST FACTOR LISTING
(DECON: Power Block Structures Only)

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of clean instrument and sampling tubing, $/linear foot	0.75
Removal of clean pipe 0.25 to 2 inches diameter, $/linear foot	8.04
Removal of clean pipe >2 to 4 inches diameter, $/linear foot	11.42
Removal of clean pipe >4 to 8 inches diameter, $/linear foot	21.98
Removal of clean pipe >8 to 14 inches diameter, $/linear foot	42.64
Removal of clean pipe >14 to 20 inches diameter, $/linear foot	55.40
Removal of clean pipe >20 to 36 inches diameter, $/linear foot	81.52
Removal of clean pipe >36 inches diameter, $/linear foot	96.88
Removal of clean valve >2 to 4 inches	146.83
Removal of clean valve >4 to 8 inches	219.84
Removal of clean valve >8 to 14 inches	426.41
Removal of clean valve >14 to 20 inches	554.04
Removal of clean valve >20 to 36 inches	815.25
Removal of clean valve >36 inches	968.77
Removal of clean pipe hanger for small bore piping	49.63
Removal of clean pipe hanger for large bore piping	179.09
Removal of clean pump, <300 pound	370.18
Removal of clean pump, 300-1000 pound	1,020.35
Removal of clean pump, 1000-10,000 pound	4,048.49
Removal of clean pump, >10,000 pound	7,827.60
Removal of clean pump motor, 300-1000 pound	427.65
Removal of clean pump motor, 1000-10,000 pound	1,683.78
Removal of clean pump motor, >10,000 pound	3,788.52
Removal of clean heat exchanger <3000 pound	2,174.92
Removal of clean heat exchanger >3000 pound	5,471.96
Removal of clean feedwater heater/deaerator	15,418.54
Removal of clean moisture separator/reheater	31,689.34
Removal of clean tank, <300 gallons	476.25
Removal of clean tank, 300-3000 gallon	1,502.95
Removal of clean tank, >3000 gallons, $/square foot surface area	12.51

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of clean electrical equipment, <300 pound	201.59
Removal of clean electrical equipment, 300-1000 pound	696.25
Removal of clean electrical equipment, 1000-10,000 pound	1,392.50
Removal of clean electrical equipment, >10,000 pound	3,307.67
Removal of clean electrical transformer < 30 tons	2,297.13
Removal of clean electrical transformer > 30 tons	6,615.34
Removal of clean standby diesel generator, <100 kW	2,346.32
Removal of clean standby diesel generator, 100 kW to 1 MW	5,237.13
Removal of clean standby diesel generator, >1 MW	10,841.94
Removal of clean electrical cable tray, $/linear foot	18.88
Removal of clean electrical conduit, $/linear foot	8.25
Removal of clean mechanical equipment, <300 pound	201.59
Removal of clean mechanical equipment, 300-1000 pound	696.25
Removal of clean mechanical equipment, 1000-10,000 pound	1,392.50
Removal of clean mechanical equipment, >10,000 pound	3,307.67
Removal of clean HVAC equipment, <300 pound	243.77
Removal of clean HVAC equipment, 300-1000 pound	836.61
Removal of clean HVAC equipment, 1000-10,000 pound	1,667.34
Removal of clean HVAC equipment, >10,000 pound	3,307.67
Removal of clean HVAC ductwork, $/pound	0.79
Removal of contaminated instrument and sampling tubing, $/linear foot	2.02
Removal of contaminated pipe 0.25 to 2 inches diameter, $/linear foot	28.29
Removal of contaminated pipe >2 to 4 inches diameter, $/linear foot	48.15
Removal of contaminated pipe >4 to 8 inches diameter, $/linear foot	76.22
Removal of contaminated pipe >8 to 14 inches diameter, $/linear foot	149.95
Removal of contaminated pipe >14 to 20 inches diameter, $/linear foot	180.48
Removal of contaminated pipe >20 to 36 inches diameter, $/linear foot	250.86
Removal of contaminated pipe >36 inches diameter, $/linear foot	296.45
Removal of contaminated valve >2 to 4 inches	588.37
Removal of contaminated valve >4 to 8 inches	694.69

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of contaminated valve >8 to 14 inches	1,438.46
Removal of contaminated valve >14 to 20 inches	1,835.12
Removal of contaminated valve >20 to 36 inches	2,447.52
Removal of contaminated valve >36 inches	2,903.51
Removal of contaminated pipe hanger for small bore piping	192.12
Removal of contaminated pipe hanger for large bore piping	640.10
Removal of contaminated pump, <300 pound	1,225.91
Removal of contaminated pump, 300-1000 pound	2,847.99
Removal of contaminated pump, 1000-10,000 pound	9,507.36
Removal of contaminated pump, >10,000 pound	23,115.38
Removal of contaminated pump motor, 300-1000 pound	1,213.78
Removal of contaminated pump motor, 1000-10,000 pound	3,851.68
Removal of contaminated pump motor, >10,000 pound	8,662.55
Removal of contaminated heat exchanger <3000 pound	5,657.36
Removal of contaminated heat exchanger >3000 pound	16,417.38
Removal of contaminated feedwater heater/deaerator	40,789.65
Removal of contaminated moisture separator/reheater	89,294.45
Removal of contaminated tank, <300 gallons	2,039.81
Removal of contaminated tank, >300 gallons, $/square foot	40.73
Removal of contaminated electrical equipment, <300 pound	965.68
Removal of contaminated electrical equipment, 300-1000 pound	2,323.23
Removal of contaminated electrical equipment, 1000-10,000 pound	4,480.36
Removal of contaminated electrical equipment, >10,000 pound	8,906.78
Removal of contaminated electrical cable tray, $/linear foot	46.78
Removal of contaminated electrical conduit, $/linear foot	22.82
Removal of contaminated mechanical equipment, <300 pound	1,076.13
Removal of contaminated mechanical equipment, 300-1000 pound	2,598.21
Removal of contaminated mechanical equipment, 1000-10,000 pound	5,000.83
Removal of contaminated mechanical equipment, >10,000 pound	8,906.78
Removal of contaminated HVAC equipment, <300 pound	1,076.13

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Removal of contaminated HVAC equipment, 300-1000 pound	2,598.21
Removal of contaminated HVAC equipment, 1000-10,000 pound	5,000.83
Removal of contaminated HVAC equipment, >10,000 pound	8,906.78
Removal of contaminated HVAC ductwork, $/pound	2.70
Removal/plasma arc cut of contaminated thin metal components, $/linear in.	5.22
Additional decontamination of surface by washing, $/square foot	10.70
Additional decontamination of surfaces by hydrolasing, $/square foot	45.75
Decontamination rig hook up and flush, $/ 250 foot length	9,077.11
Chemical flush of components/systems, $/gallon	19.99
Removal of clean standard reinforced concrete, $/cubic yard	80.31
Removal of grade slab concrete, $/cubic yard	91.38
Removal of clean concrete floors, $/cubic yard	487.97
Removal of sections of clean concrete floors, $/cubic yard	1,494.56
Removal of clean heavily rein concrete w/#9 rebar, $/cubic yard	116.13
Removal of contaminated heavily rein concrete w/#9 rebar, $/cubic yard	2,640.28
Removal of clean heavily rein concrete w/#18 rebar, $/cubic yard	157.42
Removal of contaminated heavily rein concrete w/#18 rebar, $/cubic yard	3,490.79
Removal heavily rein concrete w/#18 rebar & steel embedments, $/cubic yard	604.94
Removal of below-grade suspended floors, $/cubic yard	220.85
Removal of clean monolithic concrete structures, $/cubic yard	1,248.22
Removal of contaminated monolithic concrete structures, $/cubic yard	2,628.61
Removal of clean foundation concrete, $/cubic yard	978.54
Removal of contaminated foundation concrete, $/cubic yard	2,446.16
Explosive demolition of bulk concrete, $/cubic yard	65.17
Removal of clean hollow masonry block wall, $/cubic yard	27.91
Removal of contaminated hollow masonry block wall, $/cubic yard	65.08
Removal of clean solid masonry block wall, $/cubic yard	27.91
Removal of contaminated solid masonry block wall, $/cubic yard	65.08
Backfill of below-grade voids, $/cubic yard	31.35
Removal of subterranean tunnels/voids, $/linear foot	154.52

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Placement of concrete for below-grade voids, $/cubic yard	154.35
Excavation of clean material, $/cubic yard	3.46
Excavation of contaminated material, $/cubic yard	45.77
Removal of clean concrete rubble (tipping fee included), $/cubic yard	28.37
Removal of contaminated concrete rubble, $/cubic yard	27.70
Removal of building by volume, $/cubic foot	0.38
Removal of clean building metal siding, $/square foot	1.91
Removal of contaminated building metal siding, $/square foot	5.54
Removal of standard asphalt roofing, $/square foot	3.52
Removal of transite panels, $/square foot	2.93
Scarifying contaminated concrete surfaces (drill & spall), $/square foot	14.80
Scabbling contaminated concrete floors, $/square foot	9.47
Scabbling contaminated concrete walls, $/square foot	25.85
Scabbling contaminated ceilings, $/square foot	89.13
Scabbling structural steel, $/square foot	7.83
Removal of clean overhead crane/monorail < 10 ton capacity	966.29
Removal of contaminated overhead crane/monorail < 10 ton capacity	2,376.16
Removal of clean overhead crane/monorail >10-50 ton capacity	2,319.09
Removal of contaminated overhead crane/monorail >10-50 ton capacity	5,699.95
Removal of polar crane > 50 ton capacity	9,689.58
Removal of gantry crane > 50 ton capacity	41,345.84
Removal of structural steel, $/pound	0.27
Removal of clean steel floor grating, $/square foot	6.85
Removal of contaminated steel floor grating, $/square foot	17.22
Removal of clean free standing steel liner, $/square foot	18.76
Removal of contaminated free standing steel liner, $/square foot	47.41
Removal of clean concrete-anchored steel liner, $/square foot	9.38
Removal of contaminated concrete-anchored steel liner, $/square foot	55.05
Placement of scaffolding in clean areas, $/square foot	19.25
Placement of scaffolding in contaminated areas, $/square foot	31.74

APPENDIX B

UNIT COST FACTOR LISTING
(Power Block Structures Only)

Unit Cost Factor	Cost/Unit($)
Landscaping with topsoil, $/acre	24,472.73
Cost of CPC B-88 LSA box & preparation for use	2,071.96
Cost of CPC B-25 LSA box & preparation for use	1,946.29
Cost of CPC B-12V 12 gauge LSA box & preparation for use	1,672.59
Cost of CPC B-144 LSA box & preparation for use	10,319.90
Cost of LSA drum & preparation for use	248.32
Cost of cask liner for CNSI 8 120A cask (resins)	12,389.69
Cost of cask liner for CNSI 8 120A cask (filters)	9,101.60
Decontamination of surfaces with vacuuming, $/square foot	1.12

APPENDIX C

DETAILED COST ANALYSIS

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
PERIOD 0a - Pre-Shutdown Early Planning																					
0a.2.8	PNPS Pre Planning	-	-	-	-	-	-	18,497	-	18,497	18,497	-	-	-	-	-	-	-	-	-	-
0a.2.9	PNPS Transaction Cost	-	-	-	-	-	-	14,000	-	14,000	14,000	-	-	-	-	-	-	-	-	-	-
0a.2	Subtotal Period 0a Additional Costs	-	-	-	-	-	-	32,497	-	32,497	32,497	-	-	-	-	-	-	-	-	-	-
Period 0a Collateral Costs																					
0a.3.1	Dry Fuel Storage (DFS) Project	-	-	-	-	-	-	23,816	3,572	27,388	-	27,388	-	-	-	-	-	-	-	-	-
0a.3	Subtotal Period 0a Collateral Costs	-	-	-	-	-	-	23,816	3,572	27,388	-	27,388	-	-	-	-	-	-	-	-	-
0a.0	TOTAL PERIOD 0a COST	-	-	-	-	-	-	56,313	3,572	59,885	32,497	27,388	-	-	-	-	-	-	-	-	-
PERIOD 0 TOTALS		-	-	-	-	-	-	56,313	3,572	59,885	32,497	27,388	-	-	-	-	-	-	-	-	-
PERIOD 1a - Shutdown through Transition																					
Period 1a Additional Costs																					
1a.2.2	PNPS Spent Fuel Island Modificaitons	-	-	-	-	-	-	419	63	481	481	-	-	-	-	-	-	-	-	-	-
1a.2.3	PNPS System Abandonment Modifications	-	-	-	-	-	-	42	6	48	48	-	-	-	-	-	-	-	-	-	-
1a.2.4	PNPS Instrument Air Modifications	-	-	-	-	-	-	42	6	48	48	-	-	-	-	-	-	-	-	-	-
1a.2.5	PNPS Control Room HVAC Modifications	-	-	-	-	-	-	35	5	40	40	-	-	-	-	-	-	-	-	-	-
1a.2.6	PNPS Security Modifications	-	-	-	-	-	-	349	52	401	401	-	-	-	-	-	-	-	-	-	-
1a.2.7	PNPS IT Modifications	-	-	-	-	-	-	70	10	80	80	-	-	-	-	-	-	-	-	-	-
1a.2.10	PNPS Radwaste System Modifications	-	-	-	-	-	-	70	10	80	80	-	-	-	-	-	-	-	-	-	-
1a.2.12	Corporate A&G	-	-	-	-	-	-	1,995	299	2,294	1,037	1,257	-	-	-	-	-	-	-	-	-
1a.2.20	Defueling Credit	-	-	-	-	-	-	(10,863)	(1,629)	(12,492)	(11,992)	(501)	-	-	-	-	-	-	-	-	-
1a.2	Subtotal Period 1a Additional Costs	-	-	-	-	-	-	(8,349)	(1,328)	(9,678)	(10,435)	757	-	-	-	-	-	-	-	-	-
Period 1a Collateral Costs																					
1a.3.1	Dry Fuel Storage (DFS) Project	-	-	-	-	-	-	4,424	664	5,088	-	5,088	-	-	-	-	-	-	-	-	-
1a.3.2	Legal	-	-	-	-	-	-	167	25	193	193	-	-	-	-	-	-	-	-	-	-
1a.3.4	Site O&M	-	-	-	-	-	-	1,279	192	1,471	1,471	-	-	-	-	-	-	-	-	-	-
1a.3	Subtotal Period 1a Collateral Costs	-	-	-	-	-	-	5,871	881	6,751	1,664	5,088	-	-	-	-	-	-	-	-	-
Period 1a Period-Dependent Costs																					
1a.4.1	Insurance	-	-	-	-	-	-	170	17	187	187	-	-	-	-	-	-	-	-	-	-
1a.4.2	Property taxes	-	-	-	-	-	-	1,115	111	1,226	1,226	-	-	-	-	-	-	-	-	-	-
1a.4.3	Health physics supplies	-	61	-	-	-	-	-	15	76	76	-	-	-	-	-	-	-	-	-	-
1a.4.4	Heavy equipment rental	-	45	-	-	-	-	-	7	52	52	-	-	-	-	-	-	-	-	-	-
1a.4.5	Disposal of DAW generated	-	-	2	1	-	4	-	1	7	7	-	-	-	76	-	-	-	1,527	2	-
1a.4.6	Plant energy budget	-	-	-	-	-	-	197	30	227	227	-	-	-	-	-	-	-	-	-	-
1a.4.7	NRC Fees	-	-	-	-	-	-	94	9	103	103	-	-	-	-	-	-	-	-	-	-
1a.4.8	Emergency Planning Fees	-	-	-	-	-	-	444	44	488	-	488	-	-	-	-	-	-	-	-	-
1a.4.9	Finance & Interest	-	-	-	-	-	-	11	2	12	12	-	-	-	-	-	-	-	-	-	-
1a.4.10	Spent Fuel Pool O&M	-	-	-	-	-	-	67	10	77	-	77	-	-	-	-	-	-	-	-	-
1a.4.11	ISFSI Operating Costs	-	-	-	-	-	-	9	1	10	-	10	-	-	-	-	-	-	-	-	-
1a.4.12	Security Staff Cost	-	-	-	-	-	-	1,173	176	1,349	1,349	-	-	-	-	-	-	-	-	-	23,079
1a.4.13	Utility Staff Cost	-	-	-	-	-	-	6,268	940	7,208	7,208	-	-	-	-	-	-	-	-	-	80,009
1a.4	Subtotal Period 1a Period-Dependent Costs	-	106	2	1	-	4	9,546	1,364	11,022	10,447	575	-	-	76	-	-	-	1,527	2	103,088
1a.0	TOTAL PERIOD 1a COST	-	106	2	1	-	4	7,575	1,068	8,755	2,336	6,419	-	-	76	-	-	-	1,527	2	103,088
PERIOD 1b - SAFSTOR Limited DECON Activities																					
Period 1b Additional Costs																					
1b.2.1	Advanced Site Work (DOC)	-	-	-	-	-	-	17,391	2,609	20,000	20,000	-	-	-	-	-	-	-	-	-	-
1b.2.2	PNPS Spent Fuel Island Modificaitons	-	-	-	-	-	-	2,344	352	2,696	2,696	-	-	-	-	-	-	-	-	-	-
1b.2.3	PNPS System Abandonment Modifications	-	-	-	-	-	-	234	35	270	270	-	-	-	-	-	-	-	-	-	-
1b.2.4	PNPS Instrument Air Modifications	-	-	-	-	-	-	234	35	270	270	-	-	-	-	-	-	-	-	-	-
1b.2.5	PNPS Control Room HVAC Modifications	-	-	-	-	-	-	195	29	225	225	-	-	-	-	-	-	-	-	-	-
1b.2.6	PNPS Security Modifications	-	-	-	-	-	-	1,953	293	2,247	2,247	-	-	-	-	-	-	-	-	-	-
1b.2.7	PNPS IT Modifications	-	-	-	-	-	-	391	59	449	449	-	-	-	-	-	-	-	-	-	-
1b.2.10	PNPS Radwaste System Modifications	-	-	-	-	-	-	391	59	449	449	-	-	-	-	-	-	-	-	-	-
1b.2.12	Corporate A&G	-	-	-	-	-	-	11,558	1,734	13,291	6,008	7,284	-	-	-	-	-	-	-	-	-
1b.2.15	ETR Oversight	-	-	-	-	-	-	3,600	540	4,140	4,140	-	-	-	-	-	-	-	-	-	-
1b.2	Subtotal Period 1b Additional Costs	-	-	-	-	-	-	38,292	5,744	44,036	36,752	7,284	-	-	-	-	-	-	-	-	-
Period 1b Collateral Costs																					
1b.3.2	Process decommissioning liquid waste	76	-	48	147	-	159	-	105	535	535	-	-	-	466	-	-	-	27,963	91	-
1b.3.4	Dry Fuel Storage (DFS) Project	-	-	-	-	-	-	24,775	3,716	28,491	-	28,491	-	-	-	-	-	-	-	-	-
1b.3.5	Legal	-	-	-	-	-	-	938	141	1,078	1,078	-	-	-	-	-	-	-	-	-	-
1b.3.7	Site O&M	-	-	-	-	-	-	5,603	840	6,444	6,444	-	-	-	-	-	-	-	-	-	-
1b.3	Subtotal Period 1b Collateral Costs	76	-	48	147	-	159	31,316	4,802	36,548	8,057	28,491	-	-	466	-	-	-	27,963	91	-
Period 1b Period-Dependent Costs																					
1b.4.1	Decon supplies	33	-	-	-	-	-	-	8	41	41	-	-	-	-	-	-	-	-	-	-
1b.4.2	Insurance	-	-	-	-	-	-	950	95	1,045	1,045	-	-	-	-	-	-	-	-	-	-

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Period 1b Period-Dependent Costs (continued)																					
1b.4.3	Property taxes	-	-	-	-	-	-	6,243	624	6,868	6,868	-	-	-	-	-	-	-	-	-	-
1b.4.4	Health physics supplies	-	227	-	-	-	-	-	57	284	284	-	-	-	-	-	-	-	-	-	-
1b.4.5	Heavy equipment rental	-	251	-	-	-	-	-	38	289	289	-	-	-	-	-	-	-	-	-	-
1b.4.6	Disposal of DAW generated	-	-	6	2	-	13	-	4	25	25	-	-	-	262	-	-	-	5,234	9	-
1b.4.7	Plant energy budget	-	-	-	-	-	-	1,111	167	1,278	1,278	-	-	-	-	-	-	-	-	-	-
1b.4.8	NRC Fees	-	-	-	-	-	-	303	30	333	333	-	-	-	-	-	-	-	-	-	-
1b.4.9	Emergency Planning Fees	-	-	-	-	-	-	2,486	249	2,735	-	2,735	-	-	-	-	-	-	-	-	-
1b.4.10	Finance & Interest	-	-	-	-	-	-	1,059	159	1,218	1,218	-	-	-	-	-	-	-	-	-	-
1b.4.11	Spent Fuel Pool O&M	-	-	-	-	-	-	373	56	429	-	429	-	-	-	-	-	-	-	-	-
1b.4.12	ISFSI Operating Costs	-	-	-	-	-	-	49	7	56	-	56	-	-	-	-	-	-	-	-	-
1b.4.13	Security Staff Cost	-	-	-	-	-	-	6,570	985	7,555	7,555	-	-	-	-	-	-	-	-	-	129,245
1b.4.14	Utility Staff Cost	-	-	-	-	-	-	13,417	2,013	15,430	15,430	-	-	-	-	-	-	-	-	-	161,796
1b.4	Subtotal Period 1b Period-Dependent Costs	33	478	6	2	-	13	32,561	4,492	37,585	34,365	3,220	-	-	262	-	-	-	5,234	9	291,040
1b.0	TOTAL PERIOD 1b COST	109	478	54	149	-	172	102,169	15,038	118,169	79,175	38,994	-	-	728	-	-	-	33,197	99	291,040
PERIOD 1c - Preparations for SAFSTOR Dormancy																					
Period 1c Direct Decommissioning Activities																					
1c.1.1	Prepare support equipment for storage	-	256	-	-	-	-	-	38	294	294	-	-	-	-	-	-	-	-	3,000	-
1c.1.2	Install containment pressure equal. lines	-	60	-	-	-	-	-	9	69	69	-	-	-	-	-	-	-	-	700	-
1c.1.3	Interim survey prior to dormancy	-	-	-	-	-	-	733	220	953	953	-	-	-	-	-	-	-	-	10,252	-
1c.1	Subtotal Period 1c Activity Costs	-	316	-	-	-	-	733	267	1,316	1,316	-	-	-	-	-	-	-	-	13,952	-
Period 1c Additional Costs																					
1c.2.2	PNPS Spent Fuel Island Modificaitons	-	-	-	-	-	-	975	146	1,121	1,121	-	-	-	-	-	-	-	-	-	-
1c.2.3	PNPS System Abandonment Modifications	-	-	-	-	-	-	97	15	112	112	-	-	-	-	-	-	-	-	-	-
1c.2.4	PNPS Instrument Air Modifications	-	-	-	-	-	-	97	15	112	112	-	-	-	-	-	-	-	-	-	-
1c.2.5	PNPS Control Room HVAC Modifications	-	-	-	-	-	-	81	12	93	93	-	-	-	-	-	-	-	-	-	-
1c.2.6	PNPS Security Modifications	-	-	-	-	-	-	812	122	934	934	-	-	-	-	-	-	-	-	-	-
1c.2.7	PNPS IT Modifications	-	-	-	-	-	-	162	24	187	187	-	-	-	-	-	-	-	-	-	-
1c.2.10	PNPS Radwaste System Modifications	-	-	-	-	-	-	162	24	187	187	-	-	-	-	-	-	-	-	-	-
1c.2.12	Corporate A&G	-	-	-	-	-	-	6,002	900	6,902	3,120	3,782	-	-	-	-	-	-	-	-	-
1c.2.16	NDO Contingency	-	-	-	-	-	-	428	64	492	492	-	-	-	-	-	-	-	-	-	-
1c.2.23	Water Processing	-	-	-	-	-	-	615	92	707	707	-	-	-	-	-	-	-	-	-	-
1c.2	Subtotal Period 1c Additional Costs	-	-	-	-	-	-	9,433	1,415	10,848	7,065	3,782	-	-	-	-	-	-	-	-	-
Period 1c Collateral Costs																					
1c.3.1	Process decommissioning liquid waste	130	-	82	252	-	272	-	179	915	915	-	-	-	797	-	-	-	47,837	155	-
1c.3.3	Small tool allowance	-	6	-	-	-	-	-	1	6	6	-	-	-	-	-	-	-	-	-	-
1c.3.4	Dry Fuel Storage (DFS) Project	-	-	-	-	-	-	13,776	2,066	15,842	-	15,842	-	-	-	-	-	-	-	-	-
1c.3.5	Legal	-	-	-	-	-	-	685	103	788	788	-	-	-	-	-	-	-	-	-	-
1c.3.7	Site O&M	-	-	-	-	-	-	2,436	365	2,801	2,801	-	-	-	-	-	-	-	-	-	-
1c.3	Subtotal Period 1c Collateral Costs	130	6	82	252	-	272	16,896	2,714	20,353	4,510	15,842	-	-	797	-	-	-	47,837	155	-
Period 1c Period-Dependent Costs																					
1c.4.1	Insurance	-	-	-	-	-	-	605	61	666	666	-	-	-	-	-	-	-	-	-	-
1c.4.2	Property taxes	-	-	-	-	-	-	2,348	235	2,583	2,583	-	-	-	-	-	-	-	-	-	-
1c.4.3	Health physics supplies	-	212	-	-	-	-	-	53	266	266	-	-	-	-	-	-	-	-	-	-
1c.4.4	Heavy equipment rental	-	160	-	-	-	-	-	24	184	184	-	-	-	-	-	-	-	-	-	-
1c.4.5	Disposal of DAW generated	-	-	4	1	-	8	-	3	16	16	-	-	-	167	-	-	-	3,333	5	-
1c.4.6	Plant energy budget	-	-	-	-	-	-	720	108	828	828	-	-	-	-	-	-	-	-	-	-
1c.4.7	NRC Fees	-	-	-	-	-	-	193	19	212	212	-	-	-	-	-	-	-	-	-	-
1c.4.8	Emergency Planning Fees	-	-	-	-	-	-	1,031	103	1,134	-	1,134	-	-	-	-	-	-	-	-	-
1c.4.9	Finance & Interest	-	-	-	-	-	-	48	7	55	55	-	-	-	-	-	-	-	-	-	-
1c.4.10	Spent Fuel Pool O&M	-	-	-	-	-	-	237	36	273	-	273	-	-	-	-	-	-	-	-	-
1c.4.11	ISFSI Operating Costs	-	-	-	-	-	-	31	5	36	-	36	-	-	-	-	-	-	-	-	-
1c.4.13	Security Staff Cost	-	-	-	-	-	-	2,736	410	3,147	3,147	-	-	-	-	-	-	-	-	-	54,878
1c.4.14	Utility Staff Cost	-	-	-	-	-	-	8,546	1,282	9,827	9,827	-	-	-	-	-	-	-	-	-	103,048
1c.4	Subtotal Period 1c Period-Dependent Costs	-	372	4	1	-	8	16,495	2,345	19,226	17,784	1,442	-	-	167	-	-	-	3,333	5	157,926
1c.0	TOTAL PERIOD 1c COST	130	694	86	253	-	281	43,557	6,742	51,742	30,676	21,067	-	-	964	-	-	-	51,170	14,113	157,926
PERIOD 1 TOTALS		239	1,278	141	403	-	457	153,301	22,848	178,667	112,186	66,480	-	-	1,768	-	-	-	85,894	14,214	552,055
PERIOD 2a - SAFSTOR Dormancy with Wet Spent Fuel Storage																					
Period 2a Additional Costs																					
2a.2.2	PNPS Spent Fuel Island Modificaitons	-	-	-	-	-	-	2,262	339	2,602	2,602	-	-	-	-	-	-	-	-	-	-
2a.2.3	PNPS System Abandonment Modifications	-	-	-	-	-	-	226	34	260	260	-	-	-	-	-	-	-	-	-	-
2a.2.4	PNPS Instrument Air Modifications	-	-	-	-	-	-	226	34	260	260	-	-	-	-	-	-	-	-	-	-
2a.2.5	PNPS Control Room HVAC Modifications	-	-	-	-	-	-	189	28	217	217	-	-	-	-	-	-	-	-	-	-
2a.2.6	PNPS Security Modifications	-	-	-	-	-	-	1,885	283	2,168	2,168	-	-	-	-	-	-	-	-	-	-
2a.2.7	PNPS IT Modifications	-	-	-	-	-	-	377	57	434	434	-	-	-	-	-	-	-	-	-	-

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Period 2a Additional Costs (continued)																					
2a.2.10	PNPS Radwaste System Modifications	-	-	-	-	-	-	377	57	434	434	-	-	-	-	-	-	-	-	-	-
2a.2.11	Fuel Pool Clean up	-	-	-	-	-	-	5,000	750	5,750	5,750	-	-	-	-	-	-	-	-	-	-
2a.2.12	Corporate A&G	-	-	-	-	-	-	43,654	6,548	50,203	22,692	27,511	-	-	-	-	-	-	-	-	-
2a.2.16	NDO Contingency	-	-	-	-	-	-	13,680	1,607	15,287	15,287	-	-	-	-	-	-	-	-	-	-
2a.2.23	Water Processing	-	-	-	-	-	-	4,385	658	5,043	5,043	-	-	-	-	-	-	-	-	-	-
2a.2.24	UST Fuel Oil Tank Remediations	-	35	-	-	-	-	29	10	74	74	-	-	-	-	-	-	-	-	81	400
2a.2.25	Asbestos Remedation	-	1,596	2	261	-	680	-	608	3,147	3,147	-	-	-	13,623	-	-	-	177,093	14,317	-
2a.2	Subtotal Period 2a Additional Costs	-	1,631	2	261	-	680	72,291	11,013	85,878	58,367	27,511	-	-	13,623	-	-	-	177,093	14,398	400
Period 2a Collateral Costs																					
2a.3.1	Small tool allowance	-	23	-	-	-	-	-	3	26	26	-	-	-	-	-	-	-	-	-	-
2a.3.2	Dry Fuel Storage (DFS) Project	-	-	-	-	-	-	77,427	11,614	89,041	-	89,041	-	-	-	-	-	-	-	-	-
2a.3.3	Legal	-	-	-	-	-	-	4,310	646	4,956	4,956	-	-	-	-	-	-	-	-	-	-
2a.3.5	Site O&M	-	-	-	-	-	-	11,608	1,741	13,349	13,349	-	-	-	-	-	-	-	-	-	-
2a.3	Subtotal Period 2a Collateral Costs	-	23	-	-	-	-	93,345	14,005	107,372	18,331	89,041	-	-	-	-	-	-	-	-	-
Period 2a Period-Dependent Costs																					
2a.4.1	Insurance	-	-	-	-	-	-	2,164	216	2,380	2,380	-	-	-	-	-	-	-	-	-	-
2a.4.2	Property taxes	-	-	-	-	-	-	5,264	526	5,790	5,790	-	-	-	-	-	-	-	-	-	-
2a.4.3	Health physics supplies	-	646	-	-	-	-	-	162	808	808	-	-	-	-	-	-	-	-	-	-
2a.4.4	Disposal of DAW generated	-	-	14	6	-	32	-	10	61	61	-	-	-	636	-	-	-	12,716	21	-
2a.4.5	Plant energy budget	-	-	-	-	-	-	2,774	416	3,190	3,190	-	-	-	-	-	-	-	-	-	-
2a.4.6	NRC Fees	-	-	-	-	-	-	723	72	796	796	-	-	-	-	-	-	-	-	-	-
2a.4.7	Emergency Planning Fees	-	-	-	-	-	-	3,413	341	3,754	-	3,754	-	-	-	-	-	-	-	-	-
2a.4.8	Finance & Interest	-	-	-	-	-	-	479	72	551	551	-	-	-	-	-	-	-	-	-	-
2a.4.9	Spent Fuel Pool O&M	-	-	-	-	-	-	2,231	335	2,566	-	2,566	-	-	-	-	-	-	-	-	-
2a.4.10	ISFSI Operating Costs	-	-	-	-	-	-	292	44	336	-	336	-	-	-	-	-	-	-	-	-
2a.4.12	Security Staff Cost	-	-	-	-	-	-	25,728	3,859	29,587	21,243	8,344	-	-	-	-	-	-	-	-	515,954
2a.4.13	Utility Staff Cost	-	-	-	-	-	-	15,295	2,294	17,590	14,371	3,219	-	-	-	-	-	-	-	-	229,313
2a.4	Subtotal Period 2a Period-Dependent Costs	-	646	14	6	-	32	58,362	8,348	67,408	49,190	18,218	-	-	636	-	-	-	12,716	21	745,267
2a.0	TOTAL PERIOD 2a COST	-	2,300	16	266	-	712	223,998	33,366	260,658	125,888	134,770	-	-	14,258	-	-	-	189,808	14,419	745,667
PERIOD 2b - SAFSTOR Dormancy with Dry Spent Fuel Storage																					
Period 2b Additional Costs																					
2b.2.1	NDO Contingency	-	-	-	-	-	-	32,670	3,267	35,937	35,937	-	-	-	-	-	-	-	-	-	-
2b.2	Subtotal Period 2b Additional Costs	-	-	-	-	-	-	32,670	3,267	35,937	35,937	-	-	-	-	-	-	-	-	-	-
Period 2b Collateral Costs																					
2b.3.1	Spent Fuel Transfer (ISFSI to DOE)	-	-	-	-	-	-	9,150	1,373	10,523	-	10,523	-	-	-	-	-	-	-	-	-
2b.3.3	Site O&M	-	-	-	-	-	-	25,917	3,888	29,805	29,805	-	-	-	-	-	-	-	-	-	-
2b.3	Subtotal Period 2b Collateral Costs	-	-	-	-	-	-	35,067	5,260	40,327	29,805	10,523	-	-	-	-	-	-	-	-	-
Period 2b Period-Dependent Costs																					
2b.4.1	Insurance	-	-	-	-	-	-	31,423	3,142	34,565	34,565	-	-	-	-	-	-	-	-	-	-
2b.4.3	Health physics supplies	-	4,090	-	-	-	-	-	1,022	5,112	5,112	-	-	-	-	-	-	-	-	-	-
2b.4.4	Disposal of DAW generated	-	-	97	39	-	225	-	72	432	432	-	-	-	4,472	-	-	-	89,442	146	-
2b.4.5	Plant energy budget	-	-	-	-	-	-	18,241	2,736	20,977	20,977	-	-	-	-	-	-	-	-	-	-
2b.4.6	NRC Fees	-	-	-	-	-	-	9,977	998	10,975	10,975	-	-	-	-	-	-	-	-	-	-
2b.4.7	Finance & Interest	-	-	-	-	-	-	1,780	267	2,047	2,047	-	-	-	-	-	-	-	-	-	-
2b.4.8	ISFSI Operating Costs	-	-	-	-	-	-	4,242	636	4,878	-	4,878	-	-	-	-	-	-	-	-	-
2b.4.9	Corporate A&G	-	-	-	-	-	-	20,117	3,018	23,135	14,562	8,572	-	-	-	-	-	-	-	-	-
2b.4.10	Security Staff Cost	-	-	-	-	-	-	107,015	16,052	123,067	2,092	120,975	-	-	-	-	-	-	-	-	2,580,967
2b.4.11	Utility Staff Cost	-	-	-	-	-	-	117,955	17,693	135,649	88,986	46,663	-	-	-	-	-	-	-	-	1,415,369
2b.4	Subtotal Period 2b Period-Dependent Costs	-	4,090	97	39	-	225	310,749	45,636	360,835	179,747	181,088	-	-	4,472	-	-	-	89,442	146	3,996,336
2b.0	TOTAL PERIOD 2b COST	-	4,090	97	39	-	225	378,486	54,163	437,100	245,489	191,611	-	-	4,472	-	-	-	89,442	146	3,996,336
PERIOD 2c - SAFSTOR Dormancy without Spent Fuel Storage																					
Period 2c Direct Decommissioning Activities																					
2c.1.4	Bituminous roof replacement	-	-	-	-	-	-	477	72	549	549	-	-	-	-	-	-	-	-	-	-
2c.1.5	Maintenance supplies	-	-	-	-	-	-	1,392	348	1,740	1,740	-	-	-	-	-	-	-	-	-	-
2c.1	Subtotal Period 2c Activity Costs	-	-	-	-	-	-	1,870	420	2,289	2,289	-	-	-	-	-	-	-	-	-	-
Period 2c Collateral Costs																					
2c.3.1	NDO Contingency	-	-	-	-	-	-	7,823	782	8,605	8,605	-	-	-	-	-	-	-	-	-	-
2c.3.2	Site O&M	-	-	-	-	-	-	3,202	480	3,682	3,682	-	-	-	-	-	-	-	-	-	-
2c.3	Subtotal Period 2c Collateral Costs	-	-	-	-	-	-	11,024	1,263	12,287	12,287	-	-	-	-	-	-	-	-	-	-
Period 2c Period-Dependent Costs																					
2c.4.1	Insurance	-	-	-	-	-	-	8,091	809	8,900	8,900	-	-	-	-	-	-	-	-	-	-
2c.4.3	Health physics supplies	-	980	-	-	-	-	-	245	1,225	1,225	-	-	-	-	-	-	-	-	-	-
2c.4.4	Disposal of DAW generated	-	-	22	9	-	52	-	17	100	100	-	-	-	1,041	-	-	-	20,810	34	-
2c.4.5	Plant energy budget	-	-	-	-	-	-	1,961	294	2,256	2,256	-	-	-	-	-	-	-	-	-	-

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Period 2c Period-Dependent Costs (continued)																					
2c.4.6	NRC Fees	-	-	-	-	-	-	2,372	237	2,610	2,610	-	-	-	-	-	-	-	-	-	-
2c.4.7	Finance & Interest	-	-	-	-	-	-	313	47	360	360	-	-	-	-	-	-	-	-	-	-
2c.4.8	Corporate A&G	-	-	-	-	-	-	1,742	261	2,004	2,004	-	-	-	-	-	-	-	-	-	-
2c.4.9	Security Staff Cost	-	-	-	-	-	-	2,117	318	2,435	2,435	-	-	-	-	-	-	-	-	-	108,559
2c.4.10	Utility Staff Cost	-	-	-	-	-	-	12,666	1,900	14,566	14,566	-	-	-	-	-	-	-	-	-	151,983
2c.4	Subtotal Period 2c Period-Dependent Costs	-	980	22	9	-	52	29,263	4,128	34,455	34,455	-	-	-	1,041	-	-	-	20,810	34	260,541
2c.0	TOTAL PERIOD 2c COST	-	980	22	9	-	52	42,157	5,810	49,031	49,031	-	-	-	1,041	-	-	-	20,810	34	260,541
PERIOD 2 TOTALS		-	7,369	135	314	-	988	644,642	93,339	746,789	420,408	326,381	-	-	19,771	-	-	-	300,061	14,599	5,002,544
PERIOD 3a - Reactivate Site Following SAFSTOR Dormancy																					
Period 3a Direct Decommissioning Activities																					
3a.1.1	Prepare preliminary decommissioning cost	-	-	-	-	-	-	163	24	187	187	-	-	-	-	-	-	-	-	-	1,300
3a.1.2	Review plant dwgs & specs.	-	-	-	-	-	-	576	86	662	662	-	-	-	-	-	-	-	-	-	4,600
3a.1.3	Perform detailed rad survey	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-
3a.1.4	End product description	-	-	-	-	-	-	125	19	144	144	-	-	-	-	-	-	-	-	-	1,000
3a.1.5	Detailed by-product inventory	-	-	-	-	-	-	163	24	187	187	-	-	-	-	-	-	-	-	-	1,300
3a.1.6	Define major work sequence	-	-	-	-	-	-	939	141	1,080	1,080	-	-	-	-	-	-	-	-	-	7,500
3a.1.7	Perform SER and EA	-	-	-	-	-	-	388	58	446	446	-	-	-	-	-	-	-	-	-	3,100
3a.1.8	Perform Site-Specific Cost Study	-	-	-	-	-	-	626	94	720	720	-	-	-	-	-	-	-	-	-	5,000
Activity Specifications																					
3a.1.9.1	Re-activate plant & temporary facilities	-	-	-	-	-	-	922	138	1,061	955	-	106	-	-	-	-	-	-	-	7,370
3a.1.9.2	Plant systems	-	-	-	-	-	-	522	78	600	540	-	60	-	-	-	-	-	-	-	4,167
3a.1.9.3	Reactor internals	-	-	-	-	-	-	889	133	1,022	1,022	-	-	-	-	-	-	-	-	-	7,100
3a.1.9.4	Reactor vessel	-	-	-	-	-	-	814	122	936	936	-	-	-	-	-	-	-	-	-	6,500
3a.1.9.5	Sacrificial shield	-	-	-	-	-	-	63	9	72	72	-	-	-	-	-	-	-	-	-	500
3a.1.9.6	Moisture separators/reheaters	-	-	-	-	-	-	125	19	144	144	-	-	-	-	-	-	-	-	-	1,000
3a.1.9.7	Reinforced concrete	-	-	-	-	-	-	200	30	230	115	-	115	-	-	-	-	-	-	-	1,600
3a.1.9.8	Main Turbine	-	-	-	-	-	-	261	39	301	301	-	-	-	-	-	-	-	-	-	2,088
3a.1.9.9	Main Condensers	-	-	-	-	-	-	261	39	301	301	-	-	-	-	-	-	-	-	-	2,088
3a.1.9.10	Pressure suppression structure	-	-	-	-	-	-	250	38	288	288	-	-	-	-	-	-	-	-	-	2,000
3a.1.9.11	Drywell	-	-	-	-	-	-	200	30	230	230	-	-	-	-	-	-	-	-	-	1,600
3a.1.9.12	Plant structures & buildings	-	-	-	-	-	-	390	59	449	225	-	225	-	-	-	-	-	-	-	3,120
3a.1.9.13	Waste management	-	-	-	-	-	-	576	86	662	662	-	-	-	-	-	-	-	-	-	4,600
3a.1.9.14	Facility & site closeout	-	-	-	-	-	-	113	17	130	65	-	65	-	-	-	-	-	-	-	900
3a.1.9	Total	-	-	-	-	-	-	5,586	838	6,424	5,854	-	571	-	-	-	-	-	-	-	44,633
Planning & Site Preparations																					
3a.1.10	Prepare dismantling sequence	-	-	-	-	-	-	300	45	345	345	-	-	-	-	-	-	-	-	-	2,400
3a.1.11	Plant prep. & temp. svces	-	-	-	-	-	-	3,300	495	3,795	3,795	-	-	-	-	-	-	-	-	-	-
3a.1.12	Design water clean-up system	-	-	-	-	-	-	175	26	202	202	-	-	-	-	-	-	-	-	-	1,400
3a.1.13	Rigging/Cont. Cntrl Envlps/tooling/etc.	-	-	-	-	-	-	2,300	345	2,645	2,645	-	-	-	-	-	-	-	-	-	-
3a.1.14	Procure casks/liners & containers	-	-	-	-	-	-	154	23	177	177	-	-	-	-	-	-	-	-	-	1,230
3a.1	Subtotal Period 3a Activity Costs	-	-	-	-	-	-	14,795	2,219	17,014	16,443	-	571	-	-	-	-	-	-	-	73,463
Period 3a Collateral Costs																					
3a.3.1	NDO Contingency	-	-	-	-	-	-	750	75	825	825	-	-	-	-	-	-	-	-	-	-
3a.3.2	Site O&M	-	-	-	-	-	-	1,861	279	2,140	2,140	-	-	-	-	-	-	-	-	-	-
3a.3	Subtotal Period 3a Collateral Costs	-	-	-	-	-	-	2,611	354	2,965	2,965	-	-	-	-	-	-	-	-	-	-
Period 3a Period-Dependent Costs																					
3a.4.1	Insurance	-	-	-	-	-	-	775	78	853	853	-	-	-	-	-	-	-	-	-	-
3a.4.3	Health physics supplies	-	455	-	-	-	-	-	114	569	569	-	-	-	-	-	-	-	-	-	-
3a.4.4	Heavy equipment rental	-	546	-	-	-	-	-	82	628	628	-	-	-	-	-	-	-	-	-	-
3a.4.5	Disposal of DAW generated	-	-	11	4	-	26	-	8	50	50	-	-	-	514	-	-	-	10,287	17	-
3a.4.6	Plant energy budget	-	-	-	-	-	-	1,879	282	2,161	2,161	-	-	-	-	-	-	-	-	-	-
3a.4.7	NRC Fees	-	-	-	-	-	-	350	35	385	385	-	-	-	-	-	-	-	-	-	-
3a.4.8	Finance & Interest	-	-	-	-	-	-	161	24	185	185	-	-	-	-	-	-	-	-	-	-
3a.4.9	Corporate A&G	-	-	-	-	-	-	167	25	192	192	-	-	-	-	-	-	-	-	-	-
3a.4.10	Security Staff Cost	-	-	-	-	-	-	1,268	190	1,458	1,458	-	-	-	-	-	-	-	-	-	65,000
3a.4.11	Utility Staff Cost	-	-	-	-	-	-	18,098	2,715	20,813	20,813	-	-	-	-	-	-	-	-	-	257,920
3a.4	Subtotal Period 3a Period-Dependent Costs	-	1,001	11	4	-	26	22,698	3,552	27,293	27,293	-	-	-	514	-	-	-	10,287	17	322,920
3a.0	TOTAL PERIOD 3a COST	-	1,001	11	4	-	26	40,103	6,126	47,271	46,701	-	571	-	514	-	-	-	10,287	17	396,383
PERIOD 3b - Decommissioning Preparations																					
Period 3b Direct Decommissioning Activities																					
Detailed Work Procedures																					
3b.1.1.1	Plant systems	-	-	-	-	-	-	592	89	681	613	-	68	-	-	-	-	-	-	-	4,733
3b.1.1.2	Reactor internals	-	-	-	-	-	-	501	75	576	576	-	-	-	-	-	-	-	-	-	4,000
3b.1.1.3	Remaining buildings	-	-	-	-	-	-	169	25	194	49	-	146	-	-	-	-	-	-	-	1,350

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Detailed Work Procedures (continued)																					
3b.1.1.4	CRD housings & NIs	-	-	-	-	-	-	125	19	144	144	-	-	-	-	-	-	-	-	-	1,000
3b.1.1.5	Incore instrumentation	-	-	-	-	-	-	125	19	144	144	-	-	-	-	-	-	-	-	-	1,000
3b.1.1.6	Removal primary containment	-	-	-	-	-	-	250	38	288	288	-	-	-	-	-	-	-	-	-	2,000
3b.1.1.7	Reactor vessel	-	-	-	-	-	-	454	68	522	522	-	-	-	-	-	-	-	-	-	3,630
3b.1.1.8	Facility closeout	-	-	-	-	-	-	150	23	173	86	-	86	-	-	-	-	-	-	-	1,200
3b.1.1.9	Sacrificial shield	-	-	-	-	-	-	150	23	173	173	-	-	-	-	-	-	-	-	-	1,200
3b.1.1.10	Reinforced concrete	-	-	-	-	-	-	125	19	144	72	-	72	-	-	-	-	-	-	-	1,000
3b.1.1.11	Main Turbine	-	-	-	-	-	-	260	39	299	299	-	-	-	-	-	-	-	-	-	2,080
3b.1.1.12	Main Condensers	-	-	-	-	-	-	261	39	301	301	-	-	-	-	-	-	-	-	-	2,088
3b.1.1.13	Moisture separators & reheaters	-	-	-	-	-	-	250	38	288	288	-	-	-	-	-	-	-	-	-	2,000
3b.1.1.14	Radwaste building	-	-	-	-	-	-	342	51	393	354	-	39	-	-	-	-	-	-	-	2,730
3b.1.1.15	Reactor building	-	-	-	-	-	-	342	51	393	354	-	39	-	-	-	-	-	-	-	2,730
3b.1.1	Total	-	-	-	-	-	-	4,098	615	4,713	4,262	-	451	-	-	-	-	-	-	-	32,741
3b.1	Subtotal Period 3b Activity Costs	-	-	-	-	-	-	4,098	615	4,713	4,262	-	451	-	-	-	-	-	-	-	32,741
Period 3b Additional Costs																					
3b.2.1	Site Characterization	-	-	-	-	-	-	3,640	1,092	4,732	4,732	-	-	-	-	-	-	-	-	20,060	8,092
3b.2.2	Asbestos Remedation	-	1,596	2	261	-	680	-	608	3,147	3,147	-	-	-	13,623	-	-	-	177,093	14,317	-
3b.2.3	NDO Contingency	-	-	-	-	-	-	2,274	38	2,311	2,311	-	-	-	-	-	-	-	-	-	-
3b.2	Subtotal Period 3b Additional Costs	-	1,596	2	261	-	680	5,914	1,738	10,191	10,191	-	-	-	13,623	-	-	-	177,093	34,377	8,092
Period 3b Collateral Costs																					
3b.3.1	Decon equipment	999	-	-	-	-	-	-	150	1,148	1,148	-	-	-	-	-	-	-	-	-	-
3b.3.2	DOC staff relocation expenses	-	-	-	-	-	-	1,456	218	1,675	1,675	-	-	-	-	-	-	-	-	-	-
3b.3.3	Small tool allowance	-	23	-	-	-	-	-	3	26	26	-	-	-	-	-	-	-	-	-	-
3b.3.4	Pipe cutting equipment	-	1,200	-	-	-	-	-	180	1,380	1,380	-	-	-	-	-	-	-	-	-	-
3b.3.6	Site O&M	-	-	-	-	-	-	938	141	1,079	1,079	-	-	-	-	-	-	-	-	-	-
3b.3	Subtotal Period 3b Collateral Costs	999	1,223	-	-	-	-	2,395	692	5,308	5,308	-	-	-	-	-	-	-	-	-	-
Period 3b Period-Dependent Costs																					
3b.4.1	Decon supplies	36	-	-	-	-	-	-	9	45	45	-	-	-	-	-	-	-	-	-	-
3b.4.2	Insurance	-	-	-	-	-	-	396	40	435	435	-	-	-	-	-	-	-	-	-	-
3b.4.4	Health physics supplies	-	322	-	-	-	-	-	80	402	402	-	-	-	-	-	-	-	-	-	-
3b.4.5	Heavy equipment rental	-	275	-	-	-	-	-	41	316	316	-	-	-	-	-	-	-	-	-	-
3b.4.6	Disposal of DAW generated	-	-	6	3	-	15	-	5	28	28	-	-	-	293	-	-	-	5,866	10	-
3b.4.7	Plant energy budget	-	-	-	-	-	-	947	142	1,089	1,089	-	-	-	-	-	-	-	-	-	-
3b.4.8	NRC Fees	-	-	-	-	-	-	176	18	194	194	-	-	-	-	-	-	-	-	-	-
3b.4.9	Finance & Interest	-	-	-	-	-	-	104	16	120	120	-	-	-	-	-	-	-	-	-	-
3b.4.10	Corporate A&G	-	-	-	-	-	-	84	13	97	97	-	-	-	-	-	-	-	-	-	-
3b.4.11	Security Staff Cost	-	-	-	-	-	-	639	96	735	735	-	-	-	-	-	-	-	-	-	32,767
3b.4.12	DOC Staff Cost	-	-	-	-	-	-	1,537	230	1,767	1,767	-	-	-	-	-	-	-	-	-	58,719
3b.4.13	Utility Staff Cost	-	-	-	-	-	-	9,123	1,369	10,492	10,492	-	-	-	-	-	-	-	-	-	130,020
3b.4	Subtotal Period 3b Period-Dependent Costs	36	597	6	3	-	15	13,007	2,058	15,721	15,721	-	-	-	293	-	-	-	5,866	10	221,506
3b.0	TOTAL PERIOD 3b COST	1,034	3,416	9	263	-	694	25,413	5,103	35,933	35,482	-	451	-	13,916	-	-	-	182,958	34,386	262,339
PERIOD 3 TOTALS		1,034	4,417	20	268	-	720	65,516	11,229	83,204	82,183	-	1,021	-	14,430	-	-	-	193,246	34,403	658,722
PERIOD 4a - Large Component Removal																					
Period 4a Direct Decommissioning Activities																					
Nuclear Steam Supply System Removal																					
4a.1.1.1	Recirculation System Piping & Valves	27	99	29	43	114	155	-	103	571	571	-	-	682	722	-	-	-	95,829	1,637	-
4a.1.1.2	Recirculation Pumps & Motors	14	64	17	52	167	170	-	100	584	584	-	-	1,075	894	-	-	-	122,005	1,104	-
4a.1.1.3	CRDMs & NIs Removal	54	1,083	471	200	-	783	-	571	3,161	3,161	-	-	-	4,306	-	-	-	254,900	15,023	-
4a.1.1.4	Reactor Vessel Internals	143	5,969	5,605	1,735	-	38,599	289	25,726	78,066	78,066	-	-	-	2,002	1,753	742	-	366,551	23,365	1,093
4a.1.1.5	Vessel & Internals GTCC Disposal	-	-	-	-	-	4,033	-	605	4,638	4,638	-	-	-	-	-	-	817	169,336	-	-
4a.1.1.6	Reactor Vessel	-	8,247	2,042	1,736	-	5,434	289	9,890	27,639	27,639	-	-	-	22,970	-	-	-	1,442,217	23,365	1,093
4a.1.1	Totals	238	15,461	8,165	3,765	281	49,174	579	36,995	114,658	114,658	-	-	1,757	30,894	1,753	742	817	2,450,838	64,494	2,186
Removal of Major Equipment		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4a.1.2	Main Turbine/Generator	-	403	1,732	706	9,057	-	-	1,738	13,636	13,636	-	-	80,183	-	-	-	-	3,608,249	5,035	-
4a.1.3	Main Condensers	-	1,171	672	274	3,514	-	-	928	6,560	6,560	-	-	31,111	-	-	-	-	1,400,000	14,554	-
Cascading Costs from Clean Building Demolition																					
4a.1.4.1	Reactor	-	308	-	-	-	-	-	46	354	354	-	-	-	-	-	-	-	-	2,015	-
4a.1.4.2	AOG Rentention	-	14	-	-	-	-	-	2	16	16	-	-	-	-	-	-	-	-	70	-
4a.1.4.3	Main Stack & Filter	-	3	-	-	-	-	-	0	3	3	-	-	-	-	-	-	-	-	13	-
4a.1.4.4	Turbine	-	147	-	-	-	-	-	22	169	169	-	-	-	-	-	-	-	-	1,278	-
4a.1.4	Totals	-	472	-	-	-	-	-	71	542	542	-	-	-	-	-	-	-	-	3,376	-
Disposal of Plant Systems		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4a.1.5.1	Circulating Water	-	125	-	-	-	-	-	19	144	-	-	144	-	-	-	-	-	-	1,585	-
4a.1.5.2	Circulating Water (RCA)	-	102	7	32	411	-	-	93	645	645	-	-	4,035	-	-	-	-	163,883	1,277	-
4a.1.5.3	Circulating Water - Intake	-	87	-	-	-	-	-	13	100	-	-	100	-	-	-	-	-	-	1,143	-

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Disposal of Plant Systems (continued)																					
4a.1.5.4	Condensate	-	425	11	48	619	-	-	207	1,311	1,311	-	-	6,077	-	-	-	-	246,780	5,315	-
4a.1.5.5	Condensate (RCA)	-	745	34	153	1,969	-	-	508	3,410	3,410	-	-	19,320	-	-	-	-	784,590	9,150	-
4a.1.5.6	Condensate Demineralizer	-	426	7	32	408	-	-	173	1,046	1,046	-	-	4,004	-	-	-	-	162,594	5,256	-
4a.1.5.7	Demineralized Water and Storage	-	33	-	-	-	-	-	5	38	-	-	38	-	-	-	-	-	-	409	-
4a.1.5.8	Demineralized Water and Storage (RCA)	-	278	4	19	239	-	-	109	648	648	-	-	2,348	-	-	-	-	95,351	3,418	-
4a.1.5.9	Extraction Steam	-	279	8	35	453	-	-	144	919	919	-	-	4,447	-	-	-	-	180,590	3,531	-
4a.1.5.10	Feedwater	-	506	22	101	1,292	-	-	337	2,257	2,257	-	-	12,677	-	-	-	-	514,817	6,377	-
4a.1.5.11	Feedwater Heaters	-	408	27	127	1,632	-	-	368	2,562	2,562	-	-	16,006	-	-	-	-	650,000	5,175	-
4a.1.5.12	Generator Gas Control	-	29	0	1	12	-	-	9	51	51	-	-	122	-	-	-	-	4,969	334	-
4a.1.5.13	Heater Drain	-	348	6	28	363	-	-	146	892	892	-	-	3,564	-	-	-	-	144,718	4,336	-
4a.1.5.14	Lube Oil Purification & Transfer	-	286	5	25	325	-	-	125	767	767	-	-	3,193	-	-	-	-	129,653	3,567	-
4a.1.5.15	Main Steam	-	695	14	67	855	-	-	313	1,944	1,944	-	-	8,387	-	-	-	-	340,604	8,682	-
4a.1.5.16	Main Steam Moisture Separators	-	357	13	58	749	-	-	212	1,389	1,389	-	-	7,348	-	-	-	-	298,400	4,555	-
4a.1.5.17	Mechanical Vacuum	-	86	3	12	155	-	-	47	303	303	-	-	1,521	-	-	-	-	61,779	1,072	-
4a.1.5.18	Neutron Monitoring	-	19	0	1	6	3	-	7	36	36	-	-	58	15	-	-	-	3,299	252	-
4a.1.5.19	Offgas & Augmanted Offgas (RCA)	-	807	21	93	1,194	-	-	397	2,511	2,511	-	-	11,713	-	-	-	-	475,661	9,835	-
4a.1.5.20	Offgas & Augmented Offgas	-	570	19	91	1,168	-	-	333	2,183	2,183	-	-	11,460	-	-	-	-	465,379	7,234	-
4a.1.5.21	Post Accident Sampling	-	12	0	0	3	-	-	3	19	19	-	-	34	-	-	-	-	1,366	147	-
4a.1.5.22	Reactor Core Isolation Cooling	-	119	6	12	76	34	-	52	300	300	-	-	748	174	-	-	-	41,550	1,505	-
4a.1.5.23	Salt Service Water	-	47	-	-	-	-	-	7	54	-	-	54	-	-	-	-	-	-	619	-
4a.1.5.24	Seal Oil	-	39	0	2	29	-	-	14	84	84	-	-	280	-	-	-	-	11,370	467	-
4a.1.5.25	Stator Cooling	-	71	1	3	35	-	-	24	134	134	-	-	348	-	-	-	-	14,124	882	-
4a.1.5.26	Turbine Building Closed Cooling Water	-	424	4	18	228	-	-	143	817	817	-	-	2,236	-	-	-	-	90,795	5,245	-
4a.1.5	Totals	-	7,323	212	959	12,224	37	-	3,809	24,564	24,228	-	337	119,924	188	-	-	-	4,882,270	91,369	-
4a.1.6	Scaffolding in support of decommissioning	-	2,640	26	13	125	19	-	688	3,511	3,511	-	-	1,106	98	-	-	-	55,974	22,666	-
4a.1	Subtotal Period 4a Activity Costs	238	27,470	10,808	5,717	25,201	49,230	579	44,230	163,472	163,136	-	337	234,082	31,179	1,753	742	817	12,397,331	201,495	2,186
Period 4a Additional Costs																					
4a.2.1	Remedial Action Surveys	-	-	-	-	-	-	1,495	448	1,943	1,943	-	-	-	-	-	-	-	-	22,210	-
4a.2.2	NDO Contingency	-	-	-	-	-	-	4,193	106	4,299	4,299	-	-	-	-	-	-	-	-	-	-
4a.2	Subtotal Period 4a Additional Costs	-	-	-	-	-	-	5,688	554	6,242	6,242	-	-	-	-	-	-	-	-	22,210	-
Period 4a Collateral Costs																					
4a.3.1	Process decommissioning liquid waste	3	-	4	14	-	15	-	8	43	43	-	-	-	43	-	-	-	2,605	8	-
4a.3.3	Small tool allowance	-	282	-	-	-	-	-	42	324	292	-	32	-	-	-	-	-	-	-	-
4a.3.5	Site O&M	-	-	-	-	-	-	2,647	397	3,044	3,044	-	-	-	-	-	-	-	-	-	-
4a.3.6	On-site survey and release of 437.7 tons clean metallic	-	-	-	-	-	-	455	46	501	501	-	-	-	-	-	-	-	-	-	-
4a.3	Subtotal Period 4a Collateral Costs	3	282	4	14	-	15	3,102	492	3,912	3,880	-	32	-	43	-	-	-	2,605	8	-
Period 4a Period-Dependent Costs																					
4a.4.1	Decon supplies	100	-	-	-	-	-	-	25	126	126	-	-	-	-	-	-	-	-	-	-
4a.4.2	Insurance	-	-	-	-	-	-	1,110	111	1,221	1,221	-	-	-	-	-	-	-	-	-	-
4a.4.4	Health physics supplies	-	1,805	-	-	-	-	-	451	2,256	2,256	-	-	-	-	-	-	-	-	-	-
4a.4.5	Heavy equipment rental	-	3,010	-	-	-	-	-	452	3,462	3,462	-	-	-	-	-	-	-	-	-	-
4a.4.6	Disposal of DAW generated	-	-	100	40	-	232	-	74	446	446	-	-	-	4,622	-	-	-	92,442	151	-
4a.4.7	Plant energy budget	-	-	-	-	-	-	2,524	379	2,902	2,902	-	-	-	-	-	-	-	-	-	-
4a.4.8	NRC Fees	-	-	-	-	-	-	809	81	890	890	-	-	-	-	-	-	-	-	-	-
4a.4.9	Finance & Interest	-	-	-	-	-	-	672	101	773	773	-	-	-	-	-	-	-	-	-	-
4a.4.10	Liquid Radwaste Processing Equipment/Services	-	-	-	-	-	-	576	86	663	663	-	-	-	-	-	-	-	-	-	-
4a.4.11	Corporate A&G	-	-	-	-	-	-	236	35	271	271	-	-	-	-	-	-	-	-	-	-
4a.4.12	Security Staff Cost	-	-	-	-	-	-	1,792	269	2,061	2,061	-	-	-	-	-	-	-	-	-	91,890
4a.4.13	DOC Staff Cost	-	-	-	-	-	-	6,414	962	7,376	7,376	-	-	-	-	-	-	-	-	-	202,894
4a.4.14	Utility Staff Cost	-	-	-	-	-	-	25,817	3,873	29,689	29,689	-	-	-	-	-	-	-	-	-	367,562
4a.4	Subtotal Period 4a Period-Dependent Costs	100	4,815	100	40	-	232	39,950	6,898	52,136	52,136	-	-	-	4,622	-	-	-	92,442	151	662,346
4a.0	TOTAL PERIOD 4a COST	341	32,568	10,912	5,771	25,201	49,477	49,318	52,175	225,763	225,394	-	369	234,082	35,845	1,753	742	817	12,492,378	223,864	664,532
PERIOD 4b - Site Decontamination																					
Period 4b Direct Decommissioning Activities																					
4b.1.1	Remove spent fuel racks	1,156	114	194	437	-	2,575	-	1,335	5,812	5,812	-	-	-	13,202	-	-	-	838,681	1,563	-
Disposal of Plant Systems																					
4b.1.2.1	Containment Atmospheric Control	-	222	7	31	400	-	-	121	781	781	-	-	3,928	-	-	-	-	159,520	2,795	-
4b.1.2.2	Control Rod Drive Hydraulic	-	957	62	83	284	356	-	390	2,132	2,132	-	-	2,788	1,778	-	-	-	229,188	11,231	-
4b.1.2.3	Core Spray	-	204	3	14	174	-	-	79	473	473	-	-	1,707	-	-	-	-	69,328	2,555	-
4b.1.2.4	Diesel Fuel Oil Storage & Transfer	-	49	-	-	-	-	-	7	56	-	-	56	-	-	-	-	-	-	608	-
4b.1.2.5	Diesel Fuel Oil Storage & Transfer RCA	-	21	0	2	21	-	-	9	53	53	-	-	208	-	-	-	-	8,428	259	-
4b.1.2.6	Diesel Generator & Auxiliaries	-	10	-	-	-	-	-	1	11	-	-	11	-	-	-	-	-	-	121	-
4b.1.2.7	Electrical (RCA)	-	5,201	44	207	2,658	-	-	1,734	9,845	9,845	-	-	26,081	-	-	-	-	1,059,160	64,855	-
4b.1.2.8	Electrical Clean	-	587	-	-	-	-	-	88	675	-	-	675	-	-	-	-	-	-	7,450	-
4b.1.2.9	Electrical Contaminated	-	144	1	5	55	4	-	46	255	255	-	-	536	20	-	-	-	23,050	1,755	-
4b.1.2.10	Fire Protection	-	27	-	-	-	-	-	4	31	-	-	31	-	-	-	-	-	-	351	-
4b.1.2.11	Fire Protection (RCA)	-	159	2	10	123	-	-	60	354	354	-	-	1,211	-	-	-	-	49,177	1,897	-

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Disposal of Plant Systems (continued)																					
4b.1.2.12	Fuel Pool Cooling & Demineralizer	-	1,065	20	38	192	138	-	337	1,791	1,791	-	-	1,884	702	-	-	-	121,489	13,684	-
4b.1.2.13	HVAC Diesel Generator	-	5	-	-	-	-	-	1	6	-	-	6	-	-	-	-	-	-	67	-
4b.1.2.14	HVAC Off Gas Retention	-	1,069	60	116	604	406	-	483	2,738	2,738	-	-	5,930	2,062	-	-	-	372,957	13,187	-
4b.1.2.15	HVAC Other	-	2,029	76	353	4,532	-	-	1,248	8,238	8,238	-	-	44,461	-	-	-	-	1,805,597	25,590	-
4b.1.2.16	HVAC Radwaste	-	917	58	86	156	435	-	380	2,031	2,031	-	-	1,528	2,207	-	-	-	203,737	11,321	-
4b.1.2.17	HVAC Reactor	-	6,442	434	887	5,294	2,795	-	3,280	19,133	19,133	-	-	51,939	14,202	-	-	-	3,019,678	79,813	-
4b.1.2.18	HVAC Turbine	-	5,706	128	599	7,689	-	-	2,682	16,805	16,805	-	-	75,429	-	-	-	-	3,063,197	70,705	-
4b.1.2.19	High Pressure Coolant Injection	-	294	9	40	510	-	-	157	1,008	1,008	-	-	4,999	-	-	-	-	203,010	3,708	-
4b.1.2.20	Instrument Air	-	250	2	11	138	-	-	85	486	486	-	-	1,356	-	-	-	-	55,057	2,869	-
4b.1.2.21	Nuclear Boiler	-	220	31	78	620	174	-	206	1,331	1,331	-	-	6,087	888	-	-	-	304,021	2,843	-
4b.1.2.22	Potable Water	-	186	2	12	148	-	-	71	419	419	-	-	1,457	-	-	-	-	59,155	2,258	-
4b.1.2.23	RX Recirc Motor Generator Auxiliaries	-	166	4	18	233	-	-	79	500	500	-	-	2,284	-	-	-	-	92,751	2,098	-
4b.1.2.24	Radwaste Collection	-	6,454	178	321	983	1,441	-	2,187	11,564	11,564	-	-	9,641	7,361	-	-	-	860,803	82,731	-
4b.1.2.25	Reactor Building Closed Cooling Water	-	506	9	40	509	-	-	210	1,273	1,273	-	-	4,996	-	-	-	-	202,908	6,250	-
4b.1.2.26	Reactor Water Cleanup	-	232	19	35	140	142	-	122	689	689	-	-	1,372	727	-	-	-	102,107	2,883	-
4b.1.2.27	Residual Heat Removal	-	751	49	112	728	328	-	401	2,369	2,369	-	-	7,142	1,677	-	-	-	396,889	9,579	-
4b.1.2.28	Roof Drains	-	15	-	-	-	-	-	2	17	-	-	17	-	-	-	-	-	-	190	-
4b.1.2.29	Service Air	-	412	4	19	242	-	-	142	819	819	-	-	2,371	-	-	-	-	96,288	5,003	-
4b.1.2.30	Service Water	-	73	-	-	-	-	-	11	84	-	-	84	-	-	-	-	-	-	938	-
4b.1.2.31	Service Water (RCA)	-	897	22	97	1,242	-	-	427	2,686	2,686	-	-	12,187	-	-	-	-	494,923	10,748	-
4b.1.2.32	Standby Gas Treatment	-	164	3	15	189	-	-	72	443	443	-	-	1,854	-	-	-	-	75,303	2,019	-
4b.1.2.33	Standby Liquid Control	-	87	2	7	93	-	-	37	225	225	-	-	909	-	-	-	-	36,919	1,087	-
4b.1.2.34	Underground Yard Piping	-	1,201	80	184	1,103	574	-	645	3,787	3,787	-	-	10,826	2,940	-	-	-	626,670	14,977	-
4b.1.2	Totals	-	36,720	1,308	3,419	29,062	6,794	-	15,805	93,107	92,226	-	881	285,109	34,564	-	-	-	13,791,309	458,426	-
4b.1.3	Scaffolding in support of decommissioning	-	3,960	39	19	187	29	-	1,032	5,267	5,267	-	-	1,659	146	-	-	-	83,961	34,000	-
Decontamination of Site Buildings																					
4b.1.4.1	Reactor	6,074	3,786	165	534	5,227	499	-	4,989	21,276	21,276	-	-	51,283	5,787	-	-	-	2,391,751	121,194	-
4b.1.4.2	AOG Rentention	69	45	1	8	25	7	-	53	209	209	-	-	247	222	-	-	-	20,526	1,408	-
4b.1.4.3	Main Stack & Filter	20	16	0	4	6	3	-	16	66	66	-	-	60	107	-	-	-	7,444	442	-
4b.1.4.4	Radwaste	290	335	30	206	32	268	-	334	1,495	1,495	-	-	309	6,755	-	-	-	337,147	7,297	-
4b.1.4.5	Trash Compactor	5	31	2	20	-	18	-	18	93	93	-	-	-	655	-	-	-	30,930	392	-
4b.1.4.6	Turbine	679	280	12	89	214	80	-	476	1,830	1,830	-	-	2,102	2,467	-	-	-	203,175	11,710	-
4b.1.4.7	Spent Fuel Pool Area	336	2,029	152	1,619	86	1,442	-	1,307	6,970	6,970	-	-	840	53,351	-	-	-	2,554,876	26,271	-
4b.1.4	Totals	7,474	6,521	363	2,480	5,590	2,317	-	7,193	31,939	31,939	-	-	54,841	69,345	-	-	-	5,545,849	168,711	-
4b.1.5	Prepare/submit License Termination Plan	-	-	-	-	-	-	513	77	590	590	-	-	-	-	-	-	-	-	-	4,096
4b.1.6	Receive NRC approval of termination plan	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-
4b.1	Subtotal Period 4b Activity Costs	8,630	47,315	1,904	6,355	34,839	11,714	513	25,442	136,714	135,833	-	881	341,609	117,257	-	-	-	20,259,799	662,700	4,096
Period 4b Additional Costs																					
4b.2.1	License Termination Survey Planning	-	-	-	-	-	-	1,430	429	1,859	1,859	-	-	-	-	-	-	-	-	-	12,480
4b.2.2	Remedial Action Surveys	-	-	-	-	-	-	3,733	1,120	4,852	4,852	-	-	-	-	-	-	-	-	55,468	-
4b.2.3	Operational Equipment	-	-	-	243	703	-	-	142	1,087	1,087	-	-	15,250	-	-	-	-	280,000	-	-
4b.2.4	Soil Remediation	-	63	6	751	-	700	-	304	1,823	1,823	-	-	-	14,031	-	-	-	1,234,690	359	-
4b.2.5	License Termination ISFSI	-	263	186	1,568	-	2,664	2,855	1,884	9,421	9,421	-	-	-	45,639	-	-	-	2,431,946	11,719	-
4b.2.6	Underground Services Excavation	-	-	1	6	-	104	-	27	138	138	-	-	-	2,025	-	-	-	182,250	-	-
4b.2.7	Water Processing	-	-	-	-	-	-	1,500	225	1,725	1,725	-	-	-	-	-	-	-	-	-	-
4b.2.8	NDO Contingency	-	-	-	-	-	-	6,724	174	6,898	6,898	-	-	-	-	-	-	-	-	-	-
4b.2	Subtotal Period 4b Additional Costs	-	325	193	2,568	703	3,468	16,241	4,305	27,803	27,803	-	-	15,250	61,694	-	-	-	4,128,886	67,547	12,480
Period 4b Collateral Costs																					
4b.3.1	Process decommissioning liquid waste	13	-	22	69	-	74	-	38	216	216	-	-	-	217	-	-	-	13,013	42	-
4b.3.3	Small tool allowance	-	894	-	-	-	-	-	134	1,028	1,028	-	-	-	-	-	-	-	-	-	-
4b.3.4	Decommissioning Equipment Disposition	-	-	142	79	678	103	-	153	1,155	1,155	-	-	6,000	529	-	-	-	303,608	147	-
4b.3.6	Site O&M	-	-	-	-	-	-	4,170	626	4,796	4,796	-	-	-	-	-	-	-	-	-	-
4b.3.7	On-site survey and release of 384.0 tons clean metallic	-	-	-	-	-	-	399	40	439	439	-	-	-	-	-	-	-	-	-	-
4b.3	Subtotal Period 4b Collateral Costs	13	894	164	147	678	177	4,570	991	7,634	7,634	-	-	6,000	746	-	-	-	316,621	189	-
Period 4b Period-Dependent Costs																					
4b.4.1	Decon supplies	1,420	-	-	-	-	-	-	355	1,775	1,775	-	-	-	-	-	-	-	-	-	-
4b.4.2	Insurance	-	-	-	-	-	-	1,826	183	2,009	2,009	-	-	-	-	-	-	-	-	-	-
4b.4.4	Health physics supplies	-	4,701	-	-	-	-	-	1,175	5,876	5,876	-	-	-	-	-	-	-	-	-	-
4b.4.5	Heavy equipment rental	-	5,105	-	-	-	-	-	766	5,871	5,871	-	-	-	-	-	-	-	-	-	-
4b.4.6	Disposal of DAW generated	-	-	232	93	-	539	-	172	1,037	1,037	-	-	-	10,746	-	-	-	214,915	350	-
4b.4.7	Plant energy budget	-	-	-	-	-	-	3,278	492	3,770	3,770	-	-	-	-	-	-	-	-	-	-
4b.4.8	NRC Fees	-	-	-	-	-	-	1,331	133	1,464	1,464	-	-	-	-	-	-	-	-	-	-
4b.4.9	Finance & Interest	-	-	-	-	-	-	836	125	962	962	-	-	-	-	-	-	-	-	-	-
4b.4.10	Liquid Radwaste Processing Equipment/Services	-	-	-	-	-	-	948	142	1,091	1,091	-	-	-	-	-	-	-	-	-	-
4b.4.11	Corporate A&G	-	-	-	-	-	-	388	58	446	446	-	-	-	-	-	-	-	-	-	-
4b.4.12	Security Staff Cost	-	-	-	-	-	-	2,948	442	3,391	3,391	-	-	-	-	-	-	-	-	-	151,192
4b.4.13	DOC Staff Cost	-	-	-	-	-	-	31,288	4,693	35,982	35,982	-	-	-	-	-	-	-	-	-	324,155
4b.4.14	Utility Staff Cost	-	-	-	-	-	-	40,278	6,042	46,320	46,320	-	-	-	-	-	-	-	-	-	570,900
4b.4	Subtotal Period 4b Period-Dependent Costs	1,420	9,806	232	93	-	539	83,122	14,779	109,992	109,992	-	-	-	10,746	-	-	-	214,915	350	1,046,247

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
4b.0	TOTAL PERIOD 4b COST	10,063	58,341	2,494	9,163	36,220	15,899	104,446	45,517	282,143	281,263	-	881	362,859	190,443	-	-	-	24,920,220	730,786	1,062,823
	PERIOD 4f - License Termination																				
	Period 4f Direct Decommissioning Activities																				
4f.1.1	ORISE confirmatory survey	-	-	-	-	-	-	172	51	223	223	-	-	-	-	-	-	-	-	-	-
4f.1.2	Terminate license	-	-	-	-	-	-	-	-	a	-	-	-	-	-	-	-	-	-	-	-
4f.1	Subtotal Period 4f Activity Costs	-	-	-	-	-	-	172	51	223	223	-	-	-	-	-	-	-	-	-	-
	Period 4f Additional Costs																				
4f.2.1	License Termination Survey	-	-	-	-	-	-	9,756	2,927	12,683	12,683	-	-	-	-	-	-	-	-	119,880	6,240
4f.2.2	NDO Contingency	-	-	-	-	-	-	2,140	55	2,195	2,195	-	-	-	-	-	-	-	-	-	-
4f.2	Subtotal Period 4f Additional Costs	-	-	-	-	-	-	11,896	2,982	14,879	14,879	-	-	-	-	-	-	-	-	119,880	6,240
	Period 4f Collateral Costs																				
4f.3.1	DOC staff relocation expenses	-	-	-	-	-	-	1,456	218	1,675	1,675	-	-	-	-	-	-	-	-	-	-
4f.3.3	Site O&M	-	-	-	-	-	-	735	110	845	845	-	-	-	-	-	-	-	-	-	-
4f.3	Subtotal Period 4f Collateral Costs	-	-	-	-	-	-	2,191	329	2,520	2,520	-	-	-	-	-	-	-	-	-	-
	Period 4f Period-Dependent Costs																				
4f.4.1	Insurance	-	-	-	-	-	-	581	58	639	639	-	-	-	-	-	-	-	-	-	-
4f.4.3	Health physics supplies	-	665	-	-	-	-	-	166	831	831	-	-	-	-	-	-	-	-	-	-
4f.4.4	Disposal of DAW generated	-	-	7	3	-	17	-	6	33	33	-	-	-	345	-	-	-	6,897	11	-
4f.4.5	Plant energy budget	-	-	-	-	-	-	278	42	320	320	-	-	-	-	-	-	-	-	-	-
4f.4.6	NRC Fees	-	-	-	-	-	-	424	42	466	466	-	-	-	-	-	-	-	-	-	-
4f.4.7	Finance & Interest	-	-	-	-	-	-	183	28	211	211	-	-	-	-	-	-	-	-	-	-
4f.4.8	Corporate A&G	-	-	-	-	-	-	55	8	63	63	-	-	-	-	-	-	-	-	-	-
4f.4.9	Security Staff Cost	-	-	-	-	-	-	360	54	414	414	-	-	-	-	-	-	-	-	-	18,464
4f.4.10	DOC Staff Cost	-	-	-	-	-	-	5,836	875	6,712	6,712	-	-	-	-	-	-	-	-	-	56,160
4f.4.11	Utility Staff Cost	-	-	-	-	-	-	5,677	852	6,529	6,529	-	-	-	-	-	-	-	-	-	73,085
4f.4	Subtotal Period 4f Period-Dependent Costs	-	665	7	3	-	17	13,395	2,131	16,218	16,218	-	-	-	345	-	-	-	6,897	11	147,709
4f.0	TOTAL PERIOD 4f COST	-	665	7	3	-	17	27,654	5,493	33,840	33,840	-	-	-	345	-	-	-	6,897	119,891	153,949
	PERIOD 4 TOTALS	10,404	91,574	13,413	14,937	61,421	65,393	181,418	103,185	541,746	540,496	-	1,250	596,942	226,633	1,753	742	817	37,419,495	1,074,541	1,881,304
	PERIOD 5b - Site Restoration																				
	Period 5b Direct Decommissioning Activities																				
	Demolition of Remaining Site Buildings																				
5b.1.1.1	Reactor	-	1,883	-	-	-	-	-	282	2,165	-	-	2,165	-	-	-	-	-	-	13,235	-
5b.1.1.2	AOG Rentention	-	132	-	-	-	-	-	20	152	-	-	152	-	-	-	-	-	-	733	-
5b.1.1.3	Contractor Office - Warehouse	-	118	-	-	-	-	-	18	135	-	-	135	-	-	-	-	-	-	827	-
5b.1.1.4	Diesel Generator	-	110	-	-	-	-	-	16	126	-	-	126	-	-	-	-	-	-	620	-
5b.1.1.5	Engineering & Plant Support	-	295	-	-	-	-	-	44	339	-	-	339	-	-	-	-	-	-	2,077	-
5b.1.1.6	Fencing & Pavement	-	1,438	-	-	-	-	-	216	1,654	-	-	1,654	-	-	-	-	-	-	13,386	-
5b.1.1.7	Intake Structure	-	160	-	-	-	-	-	24	184	-	-	184	-	-	-	-	-	-	1,055	-
5b.1.1.8	Main Stack & Filter	-	24	-	-	-	-	-	4	27	-	-	27	-	-	-	-	-	-	119	-
5b.1.1.9	Miscellaneous Site Structures	-	6,540	-	-	-	-	-	981	7,521	-	-	7,521	-	-	-	-	-	-	67,378	-
5b.1.1.10	Protected Area ISFSI	-	127	-	-	-	-	-	19	146	-	-	146	-	-	-	-	-	-	642	-
5b.1.1.11	Radwaste	-	325	-	-	-	-	-	49	374	-	-	374	-	-	-	-	-	-	1,962	-
5b.1.1.12	SSW Pipe Vault	-	4	-	-	-	-	-	1	4	-	-	4	-	-	-	-	-	-	18	-
5b.1.1.13	Transformer Pads	-	22	-	-	-	-	-	3	25	-	-	25	-	-	-	-	-	-	110	-
5b.1.1.14	Trash Compactor	-	140	-	-	-	-	-	21	161	-	-	161	-	-	-	-	-	-	936	-
5b.1.1.15	Turbine	-	1,483	-	-	-	-	-	223	1,706	-	-	1,706	-	-	-	-	-	-	13,501	-
5b.1.1.16	Turbine Pedestal	-	299	-	-	-	-	-	45	343	-	-	343	-	-	-	-	-	-	1,507	-
5b.1.1	Totals	-	13,099	-	-	-	-	-	1,965	15,063	-	-	15,063	-	-	-	-	-	-	118,106	-
	Site Closeout Activities																				
5b.1.2	Remove Rubble	-	90	-	-	-	-	-	14	104	-	-	104	-	-	-	-	-	-	435	-
5b.1.3	Grade & landscape site	-	67	-	-	-	-	-	10	77	-	-	77	-	-	-	-	-	-	185	-
5b.1.4	Final report to NRC	-	-	-	-	-	-	195	29	225	225	-	-	-	-	-	-	-	-	-	1,560
5b.1	Subtotal Period 5b Activity Costs	-	13,256	-	-	-	-	195	2,018	15,469	225	-	15,244	-	-	-	-	-	-	118,726	1,560
	Period 5b Additional Costs																				
5b.2.1	Concrete Crushing	-	476	-	-	-	-	11	73	560	-	-	560	-	-	-	-	-	-	2,128	-
5b.2.2	Site Restoration ISFSI	-	2,123	-	-	-	-	306	364	2,794	-	-	2,794	-	-	-	-	-	-	23,794	160
5b.2.3	Construction Debris	-	-	-	-	-	-	1,606	241	1,846	-	-	1,846	-	-	-	-	-	-	-	-
5b.2.4	Intake cofferdam	-	177	-	-	-	-	-	26	203	-	-	203	-	-	-	-	-	-	1,227	-
5b.2.5	NDO Contingency	-	-	-	-	-	-	3,847	44	3,891	-	-	3,891	-	-	-	-	-	-	-	-
5b.2	Subtotal Period 5b Additional Costs	-	2,775	-	-	-	-	5,770	749	9,294	-	-	9,294	-	-	-	-	-	-	27,148	160
	Period 5b Collateral Costs																				
5b.3.1	Small tool allowance	-	203	-	-	-	-	-	31	234	-	-	234	-	-	-	-	-	-	-	-
5b.3.3	Site O&M	-	-	-	-	-	-	1,018	153	1,171	-	-	1,171	-	-	-	-	-	-	-	-
5b.3	Subtotal Period 5b Collateral Costs	-	203	-	-	-	-	1,018	183	1,405	-	-	1,405	-	-	-	-	-	-	-	-

Table C
Pilgrim Nuclear Power Station
SAFSTOR Decommissioning Cost Estimate
(thousands of 2018 dollars)

Activity Index	Activity Description	Decon Cost	Removal Cost	Packaging Costs	Transport Costs	Off-Site Processing Costs	LLRW Disposal Costs	Other Costs	Total Contingency	Total Costs	NRC Lic. Term. Costs	Spent Fuel Management Costs	Site Restoration Costs	Processed Volume Cu. Feet	Burial Volumes Class A Cu. Feet	Burial Volumes Class B Cu. Feet	Burial Volumes Class C Cu. Feet	Burial Volumes GTCC Cu. Feet	Burial / Processed Wt., Lbs.	Craft Manhours	Utility and Contractor Manhours
Period 5b Period-Dependent Costs																					
5b.4.1	Insurance	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5b.4.3	Heavy equipment rental	-	4,505	-	-	-	-	-	676	5,181	-	-	5,181	-	-	-	-	-	-	-	-
5b.4.4	Plant energy budget	-	-	-	-	-	-	283	42	326	-	-	326	-	-	-	-	-	-	-	-
5b.4.5	Finance & Interest	-	-	-	-	-	-	214	32	246	-	-	246	-	-	-	-	-	-	-	-
5b.4.6	Security Staff Cost	-	-	-	-	-	-	733	110	843	-	-	843	-	-	-	-	-	-	-	37,611
5b.4.7	DOC Staff Cost	-	-	-	-	-	-	11,150	1,672	12,822	-	-	12,822	-	-	-	-	-	-	-	106,564
5b.4.8	Utility Staff Cost	-	-	-	-	-	-	4,679	702	5,381	-	-	5,381	-	-	-	-	-	-	-	61,118
5b.4	Subtotal Period 5b Period-Dependent Costs	-	4,505	-	-	-	-	17,059	3,235	24,799	-	-	24,799	-	-	-	-	-	-	-	205,293
5b.0	TOTAL PERIOD 5b COST	-	20,740	-	-	-	-	24,042	6,185	50,967	225	-	50,743	-	-	-	-	-	-	145,875	207,013
PERIOD 5 TOTALS		-	20,740	-	-	-	-	24,042	6,185	50,967	225	-	50,743	-	-	-	-	-	-	145,875	207,013
TOTAL COST TO DECOMMISSION		11,678	125,378	13,709	15,923	61,421	67,558	1,125,233	240,358	1,661,258	1,187,994	420,250	53,014	596,942	262,602	1,753	742	817	37,998,696	1,283,632	8,301,638

TOTAL COST TO DECOMMISSION WITH 16.92 % CONTINGENCY:	1,661,258	thousands of 2018 dollars
TOTAL NRC LICENSE TERMINATION COST IS 71.51 % OR:	1,187,994	thousands of 2018 dollars
SPENT FUEL MANAGEMENT COST IS 25.3 % OR:	420,250	thousands of 2018 dollars
NON-NUCLEAR DEMOLITION COST IS 3.19 % OR:	53,014	thousands of 2018 dollars
TOTAL LOW-LEVEL RADIOACTIVE WASTE VOLUME BURIED (EXCLUDING GTCC):	265,097	cubic feet
TOTAL GREATER THAN CLASS C RADWASTE VOLUME GENERATED:	817	cubic feet
TOTAL SCRAP METAL REMOVED:	23,958	tons
TOTAL CRAFT LABOR REQUIREMENTS:	1,283,632	man-hours

End Notes:
n/a - indicates that this activity not charged as decommissioning expense
a - indicates that this activity performed by decommissioning staff
0 - indicates that this value is less than 0.5 but is non-zero

APPENDIX D

ISFSI DECOMMISSIONING

Table D
Pilgrim Nuclear Power Station
ISFSI Decommissioning Cost Estimate
SAFSTOR Decommissioning Alternative
(thousands of 2018 dollars)

Activity Description	Removal Costs	Packaging Costs	Transport Costs	LLRW Disposal Costs	Other Costs	Total Costs	Burial Volume Class A (cubic feet)	Craft Hours	Oversight and Contractor Hours
Decommissioning Contractor									
Planning (characterization, specs and procedures)	-	-	-	-	262	262	-	-	1,048
Decontamination (overpack disposition)	263	186	1,568	2,664	25	4,707	45,639	2,669	-
License Termination (radiological surveys)	-	-	-	-	1,186	1,186	-	9,050	-
Subtotal	**263**	**186**	**1,568**	**2,664**	**1,473**	**6,155**	**45,639**	**11,719**	**1,048**
Supporting Costs									
NRC and NRC Contractor Fees and Costs	-	-	-	-	481	481	-	-	1,153
Site O&M	-	-	-	-	222	222	-	-	-
Insurance	-	-	-	-	80	80	-	-	-
Property Taxes	-	-	-	-	96	96	-	-	-
Security Staff Cost	-	-	-	-	231	231	-	-	4,958
Oversight Staff	-	-	-	-	271	271	-	-	3,761
Subtotal	-	-	-	-	1,382	1,382	-	-	9,872
Total (w/o contingency)	**263**	**186**	**1,568**	**2,664**	**2,855**	**7,537**	**45,639**	**11,719**	**10,920**
Total (w/25% contingency)	**329**	**233**	**1,960**	**3,331**	**3,569**	**9,421**			

The application of contingency (25%) is consistent with the evaluation criteria referenced by the NRC in NUREG-1757 ("Consolidated Decommissioning Guidance, Financial Assurance, Recordkeeping, and Timeliness," U.S. NRC's Office of Nuclear Material Safety and Safeguards, NUREG-1757, Vol. 3, Rev. 1, February 2012)