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DECOMMISSIONING COST ANALYSIS

for the

RIVER BEND STATION

prepared for

Entergy Operations, Inc.

prepared by

TLG Services, Inc.
Bridgewater, Connecticut

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APPROVALS

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TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS
(continued)

TABLES

FIGURES

TABLE OF CONTENTS
(continued)

SECTION **PAGE**

APPENDICES

REVISION LOG

No.	Date	Item Revised	Reason for Revision
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EXECUTIVE SUMMARY

This report presents estimates of the cost to decommission the River Bend Station (River Bend) for the selected decommissioning alternative following the scheduled and permanent cessation of plant operations. The estimates are designed to provide the owner[1] with the information to assess their current decommissioning liability, as it relates to River Bend.

The analysis relies upon site-specific, technical information from an evaluation prepared in 2014,[2] updated to reflect current assumptions pertaining to the operating life of the reactor, 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 estimates prepared in advance of the detailed engineering required to carry out the decommissioning of the nuclear unit. It may also not reflect the actual plan to decommission River Bend; the plan may differ from the assumptions made in this analysis based on facts that exist at the time of decommissioning.

The 2014 plant inventory, the basis for the decontamination and dismantling requirements and cost, and the decommissioning waste streams, was reviewed for this analysis. There were no substantive changes made to the plant inventory (that would impact decommissioning).

The costs to decommission River Bend for the alternatives evaluated are tabulated at the end of this section. Costs are reported in 2018 dollars and include monies anticipated to be spent for radiological remediation and operating license termination, spent fuel management, and site restoration activities.

A complete discussion of the assumptions relied upon in this analysis is provided in Section 3, along with schedules of annual expenditures for each scenario. A sequence of significant project activities is provided in Section 4 with a timeline for

1 River Bend is owned by Energy Louisiana, LLC, with Entergy Operations Inc., the licensed operator of the facility. In 2015, Entergy Gulf States Louisiana, L.L.C., River Bend's then-owner, entered into a business combination with Entergy Louisiana, LLC, with the combined company being named Entergy Louisiana, LLC.

2 "Decommissioning Cost Analysis for the River Bend Station," Document E11-1691-001 Rev. 0, TLG Services, Inc., December 2014

each scenario. Detailed cost reports used to generate the summary tables contained within this document are provided in Appendices C and D.

Consistent with the 2014 analysis, the current cost estimates assume that the shutdown of the nuclear unit is a scheduled and pre-planned event (e.g., there is no delay in transitioning the plant and workforce from operations or in obtaining regulatory relief from operating requirements). The estimates include the continued operation of the fuel handling building as an interim wet fuel storage facility for approximately five and one-half years after operations cease. During this time period, it is assumed that the spent fuel residing in the pool that cannot be transferred to the Department of Energy (DOE) will be transferred to an independent spent fuel storage installation (ISFSI) located on the site.

The ISFSI will remain operational until the DOE is able to complete the transfer of the fuel to a federal facility (e.g., a monitored retrievable storage facility).[3] 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.

Alternatives and Regulations

The Nuclear Regulatory Commission (NRC) provided general decommissioning requirements in a rule adopted on June 27, 1988.[4] 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.

[3] Projected expenditures for spent fuel management identified in the cost analyses do not consider the outcome of the litigation with the DOE with regard to the delays incurred by Entergy in the timely removal of spent fuel from the site.

[4] 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

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."[5]

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."[6] 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."[7] 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 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.

5 Ibid. Page FR24022, Column 3

6 Ibid.

7 Ibid. Page FR24023, Column 2

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.[8] 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.[9]

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.[10] 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 E.

Decommissioning Scenarios

Two decommissioning scenarios were evaluated for the River Bend nuclear unit. The scenarios selected are representative of alternatives currently available to the owner and are defined as follows:

1. The first scenario assumes that the unit is promptly decommissioned (DECON 40) upon the expiration of the current operating license in 2025. Following the cessation of operations, spent fuel is relocated from the wet storage pool to the ISFSI for interim storage so as to facilitate decontamination and dismantling activities within the fuel building. Once the spent fuel has been removed from the fuel building, the fuel building and remaining portions of the power block are decommissioned, non-essential structures dismantled and the site, exclusive of the ISFSI, remediated and dismantled. The ISFSI remains operational until the transfer of the spent fuel to the DOE is complete. Once completed, the ISFSI is decommissioned and the pad demolished.

8 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

9 “Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors,” Regulatory Guide 1.202, Nuclear Regulatory Commission, February 2005

10 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

2. Entergy filed an application for license renewal for River Bend with the NRC on May 31, 2017. The application is currently under review. The second scenario assumes that the unit is promptly decommissioned (DECON 60) upon the expiration of an extended operating license in 2045. Spent fuel that cannot be transferred directly from the pool to the DOE, is transferred to the ISFSI for interim storage. ISFSI operations continue at the site until the transfer of the spent fuel to the DOE is complete. Decommissioning operations (radiological remediation and site restoration activities) are similar to those in the DECON 40.

Methodology

The methodology used to develop the estimates follows the basic approach originally presented in the cost estimating guidelines[11] developed by the Atomic Industrial Forum (now Nuclear Energy Institute). This reference describes a unit cost factor method for estimating decommissioning activity costs. The unit cost factors used in this analysis incorporate site-specific costs and the latest available information about 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

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

unforeseeable events which will increase costs are likely to occur."[12] 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 price escalation and inflation in the cost of decommissioning over the remaining operating life of the station.

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.

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,[13] 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[14]) can be sent to Energy*Solutions*' facility in Clive, Utah. Therefore, disposal costs for Class A waste were based upon Entergy's *Life of Plant Agreement* and other service agreements with Energy*Solutions*. This facility is not licensed to receive the higher activity portion (Classes B and C) of the decommissioning waste stream.

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

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

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

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 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 either stored on site or shipped directly to a federal facility as it is generated (depending upon the timing of the decommissioning and whether the spent fuel 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.

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.[15] Entergy's current spent fuel management plan for the River Bend 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 River Bend 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, [16] the removal of spent fuel from the site could be completed in 2065 for a 2025 shutdown or 2077 for a 2045 shutdown. Different DOE acceptance schedules may result in different completion dates.

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."[17] 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."[18]

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

15 In 2008, the DOE issued a report to Congress in which it concluded that it did not have authority, 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 River Bend, 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.

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

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

18 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"[19]
- "[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."[20]

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..."[21]

"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."[22]

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

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

20 Ibid., p.27

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

22 Ibid., p.2

August 2013)[23] 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.

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.[24] Interim storage of the fuel, until the DOE has completed the transfer, will be in the fuel handling 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[25]), has been constructed to support continued plant operations. The facility is assumed to be available to support future decommissioning operations. As such, the fuel that cannot be transferred directly to the DOE from the wet pool is packaged for interim storage at the ISFSI. Once the spent fuel storage pool is emptied the fuel handling building can be either decontaminated and dismantled or prepared for long term storage.

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

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

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

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

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 estimates to decommission River Bend assume 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 alternatives evaluated in this analysis are 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 Appendices C and D. The major cost components are also identified in the cost summary provided at the end of this section.

The cost elements in the estimates for the DECON 40 and DECON 60 alternatives 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). The cost reported for this subcategory is generally sufficient to terminate the unit'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). Section 3.4.1 provides the basis for the ISFSI decommissioning cost delineated in Appendix E.

The "Spent Fuel Management" subcategory contains costs associated with the containerization and transfer of spent fuel from the wet storage pool to the DOE or to the ISFSI for interim storage, as well as the transfer of the spent fuel in storage at the ISFSI to the DOE. Costs are included for the operation of the storage pool and the management of the ISFSI until such time that the transfer is complete. It does not include any spent fuel management expenses incurred prior to the cessation of plant operations, nor does it 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 removed to a 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., Asset Retirement Obligation 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 estimates were developed and costs are presented in 2018 dollars. As such, the estimates do not reflect the escalation of costs (due to inflationary and market forces) over the remaining operating life of the plant or during the decommissioning period.

DECON 40 COST SUMMARY
DECOMMISSIONING COST ELEMENTS
(thousands of 2018 dollars)

Cost Element	Cost
Decontamination	21,368
Removal	165,811
Packaging	32,609
Transportation	18,184
Waste Disposal	109,142
Off-site Waste Processing	56,625
Program Management [1]	364,966
Site Security	194,880
Spent Fuel Pool Isolation	13,800
Spent Fuel (Direct Expenditures) [2]	169,580
Insurance and Regulatory Fees	42,604
Energy	9,876
Characterization and Licensing Surveys	29,794
Property Taxes	2,091
Site O&M (Non-Labor Overhead)	6,690
Corporate A&G	47,273
Miscellaneous Equipment / Site Services	8,328
Severance	6,000
Total [3]	1,299,619

Cost Category	Cost
License Termination	864,794
Spent Fuel Management	356,403
Site Restoration	78,422
Total [3]	1,299,619

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

DECON 60 COST SUMMARY
DECOMMISSIONING COST ELEMENTS
(thousands of 2018 dollars)

Cost Element	Cost
Decontamination	21,368
Removal	165,613
Packaging	32,609
Transportation	18,127
Waste Disposal	120,227
Off-site Waste Processing	56,625
Program Management [1]	354,670
Site Security	169,896
Spent Fuel Pool Isolation	13,800
Spent Fuel (Direct Expenditures) [2]	125,080
Insurance and Regulatory Fees	36,524
Energy	9,876
Characterization and Licensing Surveys	29,794
Property Taxes	1,682
Site O&M (Non-Labor Overhead)	6,690
Corporate A&G	44,515
Miscellaneous Equipment / Site Services	8,328
Severance	6,000
Total [3]	1,221,421

Cost Category	Cost
License Termination	875,743
Spent Fuel Management	267,482
Site Restoration	78,196
Total [3]	1,221,421

[1] Includes engineering costs
[2] Direct costs only, excludes program management costs (staffing) but includes costs for spent fuel loading/transfer/spent fuel pool O&M and EP fees
[3] Columns may not add due to rounding

1. INTRODUCTION

This report presents estimates of the cost to decommission the River Bend Station (River Bend) for the selected decommissioning alternatives following the scheduled and permanent cessation of plant operations. The estimates are designed to provide the owner with the information to assess their current decommissioning liability, as it relates to River Bend.

The analysis relies upon site-specific, technical information from an earlier evaluation prepared in 2014,[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 estimates prepared in advance of the detailed engineering required to carry out the decommissioning of the nuclear unit. It may also not reflect the actual plan to decommission River Bend; the plan may differ from the assumptions made in this analysis based on facts that exist at the time of decommissioning.

The 2014 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).

1.1 OBJECTIVES OF STUDY

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

The plant was issued its operating license in August 1985 which is currently scheduled to expire in 2025. Entergy Operations, Inc. (Entergy Operations or Entergy) filed an application for license renewal for River Bend with the NRC on May 31, 2017. The application is currently under review. For purposes of this analysis, two scenarios are evaluated: with and without license renewal.

* References are provided in Section 7 of the document

1.2 SITE DESCRIPTION

River Bend is located on a site in West Feliciana Parish, approximately 2 miles east of the Mississippi River and 2.7 miles southeast of St. Francisville, Louisiana. The nuclear unit is operated by Entergy Operations, a nuclear management company, subject to the owner oversight of Entergy Louisiana, LLC. In 2015, Entergy Gulf States Louisiana, L.L.C., River Bend's then-owner, entered into a business combination with Entergy Louisiana, LLC, with the combined company being named Entergy Louisiana, LLC.

The nuclear steam supply system (NSSS), which consists of the boiling water reactor and two-loop recirculation system, was designed and supplied by General Electric Company (GE). Each loop contains one reactor recirculation pump and associated piping connected to the reactor vessel. The licensed thermal power limit is 3,091 MWt with a corresponding net electric generating capacity of 967 MWe.

The NSSS is located within the "primary containment structure" consisting of the drywell and suppression system. The containment is a steel structure in the form of a right cylinder with a torispherical dome and flat bottom. Surrounding the containment is a reinforced concrete shield building. The shield building geometry is also a right cylinder with a constant radius dome. The lower portion of the annulus, between the steel containment and shield building, is filled with structural concrete that acts as a connecting element to tie the containment vessel and shield building wall together to form a composite section. Above the concrete fill, the shield building is separated from the containment. This separation provides an annular space between the two structures. Internal structures include a reinforced concrete drywell and suppression pool of the GE Mark III concept. The containment, including all internal structures, and the shield building were designed by the Stone & Webster Engineering Corporation.

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 in the reactor vessel into mechanical shaft power and then into electrical energy. The unit's turbine-generator is a tandem compound, four-flow, single-stage reheat unit, consisting of one double-flow high-pressure turbine and two double-flow low pressure turbines driving a direct-coupled generator at 1800 rpm. The turbine is operated in a closed feedwater cycle, which condenses the steam; the condensate/feedwater is returned to the reactor recirculation system to complete the loop.

Heat rejected in the main condenser is removed by the circulating water system. The system is designed to circulate the flow of water required to remove the heat load from the main condenser and other auxiliary equipment and to discharge it to the atmosphere through four mechanical draft cooling towers.

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.[2] 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,"[3] 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,[4] 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.[6] 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. Within two years of submitting notice of permanent cessation of operations, the licensee is required to submit a Post-Shutdown Decommissioning Activities Report (PSDAR) to the NRC. 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.[7] 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 E.

1.3.1 High-Level Radioactive Waste Management

Congress passed the "Nuclear Waste Policy Act"[8] (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.

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. Entergy's current spent fuel management plan for the River Bend 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 River Bend 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),[9] the removal of spent fuel from the site is completed in 2065 for a 2025 shutdown and 2077 for a 2045 shutdown. Different DOE acceptance schedules may result in different completion dates.

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.

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.[14] Interim storage of the fuel, until the DOE has completed the transfer, will be in the fuel handing building's spent fuel storage pool, as well as at an on-site ISFSI. 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.

An ISFSI, operated under a Part 50 General License (in accordance with 10 CFR 72, Subpart K[15]), has been constructed to support continued plant operations. The facility is assumed to be available to support future decommissioning operations. As such, the fuel that cannot be transferred directly to the DOE from the wet pool is packaged for interim storage at the ISFSI. Once the fuel handling building's spent fuel storage pool is emptied, the building can be either decontaminated and dismantled or prepared for long-term storage.

Entergy's position is that the DOE has a contractual obligation to accept River Bend'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.

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,[16] and its Amendments of 1985,[17] 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[18]) can be sent to

Energy*Solutions*' facility in Clive, Utah. Therefore, disposal costs for Class A waste were based upon Entergy's *Life of Plant Agreement* and other service agreements 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 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 either stored on site or shipped directly to a federal facility as it is generated (depending upon the timing of the decommissioning and whether the spent fuel 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,"[19] 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 River Bend 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).[20] An additional and separate limit of 4 millirem per year, as defined in 40 CFR §141.66, is applied to drinking water.[21]

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)[22] 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. DECON DECOMMISSIONING ALTERNATIVE

Detailed cost estimates were developed to decommission River Bend based upon the NRC approved DECON decommissioning alternative.

Two decommissioning scenarios were evaluated for the River Bend nuclear unit. The scenarios selected are representative of alternatives available to the owner and are defined as follows:

1. The first scenario assumes that the unit is promptly decommissioned (DECON 40) upon the expiration of the current operating license in 2025. Following the cessation of operations, spent fuel is relocated from the wet storage pool to the ISFSI for interim storage so as to facilitate decontamination and dismantling activities within the fuel building. Once the spent fuel has been removed from the fuel building, the fuel building and remaining portions of the power block are decommissioned, non-essential structures dismantled and the site, exclusive of the ISFSI, remediated and dismantled. The ISFSI remains operational until the transfer of the spent fuel to the DOE is complete. Once completed, the ISFSI is decommissioned and the pad demolished.

2. Entergy filed an application for license renewal for River Bend with the NRC on May 31, 2017. The application is currently under review. The second scenario assumes that the unit is promptly decommissioned (DECON 60) upon the expiration of an extended operating license in 2045. Spent fuel that cannot be transferred directly from the pool to the DOE, is transferred to the ISFSI for interim storage. ISFSI operations continue at the site until the transfer of the spent fuel to the DOE is complete. Decommissioning operations (radiological remediation and site restoration activities) are similar to those in the DECON 40.

The following sections describe the basic activities associated with each 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 estimates developed for River Bend are 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

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, a characterization of the facility and major components, and the development of the PSDAR.

2.1.1 Engineering and Planning

The PSDAR, required prior to or within two years of permanent cessation of operations, provides a description of the licensee's planned decommissioning activities, a timetable, a site-specific decommissioning cost estimate, and the associated financial requirements of the intended decommissioning program. Upon receipt of the PSDAR, the NRC will make the document available to the public for comment in a local hearing to be held in the vicinity of the reactor site. Ninety days following submittal and NRC receipt of the PSDAR, the licensee may begin to perform major decommissioning activities under a modified 10 CFR §50.59 procedure (10 CFR §50.59 establishes the conditions under which licensees may make changes to the facility or procedures and conduct test or experiments without prior NRC approval). Major activities are defined as 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 GTCC, as defined by 10 CFR §61.55. Major components are further defined as comprising the reactor vessel and internals, large bore reactor coolant system piping, and other large components that are radioactive. The NRC includes the following additional criteria for use of the §50.59 process in decommissioning. The proposed activity must not:

- foreclose release of the site for possible unrestricted use,

- significantly increase decommissioning costs,
- cause any significant environmental impact, or
- violate the terms of the licensee's existing license.

Existing operational technical specifications are reviewed and modified to reflect plant conditions and the safety concerns associated with permanent cessation of operations. The environmental impact associated with the planned decommissioning activities is also considered. Typically, a licensee will not be allowed to proceed if the consequences of a particular decommissioning activity are greater than that bounded by previously evaluated environmental assessments or impact statements. In this instance, the licensee would have to submit a license amendment for the specific activity and update the environmental report.

The decommissioning program outlined in the PSDAR will be designed to accomplish the required tasks within the ALARA guidelines (as defined in 10 CFR Part 20) for protection of personnel from exposure to radiation hazards. It will also address the continued protection of the health and safety of the public and the environment during the dismantling activity. Consequently, with the development of the PSDAR, activity specifications, cost-benefit and safety analyses, work packages, and procedures, would be assembled to support the proposed decontamination and dismantling activities.

2.1.2 Site Preparations

Following final plant shutdown, and in preparation for actual decommissioning activities, the following activities are initiated:

- Characterization of the site and surrounding environs. This includes radiation surveys of work areas, major components (including the reactor vessel and its internals), internal piping, and primary shield cores.
- Isolation of the spent fuel storage pool and fuel handling systems, such that decommissioning operations can commence on the balance of the plant. The pool will remain operational for approximately five and one-half years following the cessation of operations. During this time period, it is assumed that the spent fuel residing in the pool that cannot be directly transferred to the DOE will be moved to an ISFSI for interim storage.

- Specification of transport and disposal requirements for activated materials and/or hazardous materials, including shielding and waste stabilization.
- Development of procedures for occupational exposure control, control and release of liquid and gaseous effluent, processing of radwaste (including dry-active waste, resins, filter media, metallic and non-metallic components generated in decommissioning), site security and emergency programs, and industrial safety.

2.2 PERIOD 2 - DECOMMISSIONING OPERATIONS

This period includes the physical decommissioning activities associated with the removal and disposal of contaminated and activated components and structures, including the successful release of the site from the 10 CFR Part 50 operating license, exclusive of the ISFSI. Significant decommissioning activities in this phase include:

- Construction of temporary facilities and/or modification of existing facilities to support dismantling activities. For example, this will include a centralized processing area to facilitate equipment removal and component preparations for off-site disposal.
- Reconfiguration and modification of site structures and facilities as needed to support decommissioning operations. This will include the upgrading of roads (on- and off-site) as required to facilitate hauling and transport. Modifications will be required to the containment structure to facilitate access of large/heavy equipment. Modifications will also be required to the refueling area of the building to support the segmentation of the reactor vessel internals and component extraction.
- Transfer of the spent fuel from the storage pool to the ISFSI pad.
- Design and fabrication of temporary and permanent shielding to support removal and transportation activities, construction of contamination control envelopes, and the procurement of specialty tooling.
- Procurement (lease or purchase) of shipping canisters, cask liners, and industrial packages.
- Decontamination of components and piping systems as required to control (minimize) worker exposure.
- Removal of piping and components no longer essential to support decommissioning operations.
- Disconnection of the control blades from the drives on the vessel lower head. Blades are transferred to the spent fuel pool.

- Removal and segmentation of the steam separator and dryer assemblies. Segmentation will maximize the loading of the shielded transport casks, i.e., by weight and activity. The operations are conducted under water using remotely operated tooling and contamination controls.
- Disassembly and segmentation of the remaining reactor internals, including the core shroud and in-core guide tubes. Some material is expected to exceed Class C disposal requirements. As such, and to the extent required, the segments are packaged in modified fuel storage canisters for geologic disposal.
- Segmentation of the reactor vessel. A shielded platform is installed for segmentation as cutting operations are performed in-air using remotely operated equipment within a contamination control envelope. The water level is maintained just below the cut to minimize the working area dose rates. Segments are transferred in-air to containers that are stored under water, for example, in the dryer-separator pool.
- Disconnection of the control rod drives and instrumentation tubes from reactor vessel lower head. The lower reactor head and vessel supporting structure are then segmented.
- Removal of the reactor recirculation pumps. Exterior surfaces are decontaminated and openings covered. Components can serve as their own burial containers provided that all penetrations are properly sealed.
- Demolition of the primary shield activated concrete by controlled demolition.

At least two years prior to the anticipated date of license termination, an LTP is required. Submitted as a supplement to the Updated Safety Analysis Report (USAR) or its equivalent, the plan must include: a site characterization, description of the remaining dismantling activities, plans for site remediation, procedures for the final radiation survey, designation of the end use of the site, an updated cost estimate to complete the decommissioning, and any associated environmental concerns. The NRC will notice the receipt of the plan, make the plan available for public comment, and schedule a local hearing. LTP approval will be subject to any conditions and limitations as deemed appropriate by the Commission. The licensee may then commence with the final remediation of site facilities and services, including:

- Removal of remaining plant systems and associated components as they become nonessential to the decommissioning program or worker health and safety (e.g., waste collection and treatment systems, electrical power and ventilation systems).

- Removal of the steel liners from the drywell, disposing of the activated and contaminated sections as radioactive waste. Removal of any activated/contaminated concrete.
- Removal of the steel liners from the dryer-separator pool and the reactor well.
- Surveys of the decontaminated areas of the containment structure.
- Removal of the contaminated equipment and material from the turbine, fuel handling, radwaste and auxiliary buildings, and any other contaminated facility. Use of radiation and contamination control techniques until radiation surveys indicate that the structures can be released for unrestricted access and conventional demolition. This activity may necessitate the dismantling and disposition of most of the systems and components (both clean and contaminated) located within these buildings. This activity will facilitate surface decontamination and subsequent verification surveys required prior to obtaining release for demolition.
- Routing of material removed in the decontamination and dismantling to a central processing area. Material certified to be free of contamination is released for unrestricted disposition, e.g., as scrap, recycle, or general disposal. Contaminated material is characterized and segregated for additional off-site processing (disassembly, chemical cleaning, volume reduction, and waste treatment), and/or packaged for controlled disposal at a low-level radioactive waste disposal facility.

Incorporated into the LTP is the Final Survey Plan. This plan identifies the radiological surveys to be performed once the decontamination activities are completed and is developed using the guidance provided in the "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)."[23] This document incorporates the statistical approaches to survey design and data interpretation used by the EPA. It also identifies 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 survey is complete, the results are provided to the NRC in a format that can be verified. The NRC then reviews and evaluates the information, performs an independent confirmation of radiological site conditions, and makes a determination on the requested change to the operating license (that would release the property, exclusive of the ISFSI, for unrestricted use).

The NRC will amend the operating license if it determines that site remediation has been performed in accordance with the LTP, and that the terminal radiation survey and associated documentation demonstrate that the property (exclusive of the ISFSI) is suitable for release.

2.3 PERIOD 3 – SITE RESTORATION

Following completion of decommissioning operations, site restoration activities can begin. Efficient removal of the contaminated materials and verification that residual radionuclide concentrations are below the NRC limits will result in substantial damage to many of the structures. Although performed in a controlled, safe manner, blasting, coring, drilling, scarification (surface removal), and the other decontamination activities will substantially degrade power block structures including the reactor, turbine, fuel handling, radwaste and auxiliary buildings. Under certain circumstances, verifying that subsurface radionuclide concentrations meet NRC site release requirements will require removal of grade slabs and lower floors, potentially weakening footings and structural supports. This removal activity will be necessary for those facilities and plant areas where historical records, when available, indicate the potential for radionuclides having been present in the soil, where system failures have been recorded, or where it is required to confirm that subsurface process and drain lines were not breached over the operating life of the station.

It is not currently anticipated that these structures would be repaired and preserved after the radiological contamination is removed. The cost to dismantle site structures, once remediation is complete, with a work force already mobilized on site is more efficient than if the process is deferred.

This cost study presumes that non-essential structures and site facilities are dismantled as a continuation of the decommissioning activity. Foundations and exterior walls are removed to a nominal depth of three feet below grade. The three-foot depth allows for the placement of gravel for drainage, as well as topsoil, so that vegetation can be established for erosion control. Site areas affected by the dismantling activities are restored and the plant area graded as required to prevent ponding and inhibit the refloating of subsurface materials.

Non-contaminated concrete rubble produced by demolition activities is processed to remove reinforcing steel and miscellaneous embedments. The processed material is then used on site to backfill foundation voids. Excess non-contaminated materials are trucked to an off-site area for disposal as construction debris.

2.4 ISFSI OPERATIONS AND DECOMMISSIONING

For purposes only of this estimate, transfer of spent fuel to a DOE repository or interim facility is assumed to be exclusively from the ISFSI once the fuel pool has been emptied and the fuel handling building released for decommissioning. If this assumption is incorrect, it is assumed that DOE will have liability for costs incurred to transfer the fuel to DOE-supplied containers and to dispose of existing containers. The ISFSI will continue to operate under a general license (10 CFR Part 50) following the amendment of the operating license to release the adjacent (power block) property.

Assuming the DOE starts accepting fuel from River Bend in 2037, transfer of spent fuel from the ISFSI is anticipated to continue through the year 2065 or 2077, depending upon the shutdown date. This assumption is made for purposes of this estimate, although it is acknowledged that the plant owner will seek the most expeditious means of removing fuel from the site when DOE commences performance.

At the conclusion of the spent fuel transfer process, the ISFSI will be decommissioned. The Commission will terminate the Part 50 license if it determines that the remediation of the ISFSI has been performed in accordance with an ISFSI license termination plan and that the final radiation survey and associated documentation demonstrate that the facility is suitable for release. Once the requirements are satisfied, the NRC can terminate the license for the ISFSI.

The design of the ISFSI is based upon the use of a multi-purpose canister and a vertical concrete module/overpack for pad storage. It is assumed that once the inner canisters containing the spent fuel assemblies have been removed, any required decontamination is performed on the storage modules (some minor neutron activation is assumed), and the license for the facility terminated, the modules can be dismantled using conventional techniques for the demolition of reinforced concrete. The concrete storage pad is then removed and the area regraded to minimize ponding.

3. COST ESTIMATES

The cost estimates prepared for decommissioning River Bend 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 estimates, 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 estimates were developed using the site-specific, technical information relied upon in the decommissioning analysis prepared in 2014. 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,"[24] and the DOE "Decommissioning Handbook."[25] 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.[26]

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 [27] 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,[28] 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.

<u>Work Difficulty Factors</u>

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 37%
- 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.

<u>Scheduling Program Durations</u>

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. In the DECON alternative, dismantling of the fuel handing building systems and decontamination of the spent fuel pool is also dependent upon the timetable for the transfer of the spent fuel assemblies from the pool to the ISFSI.

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"[29] 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 each detailed estimate (as provided in Appendix C and D). 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 River Bend. 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, requires 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.[30]

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. The ISFSI will be expected to operate throughout decommissioning, and beyond the conclusion of the remediation phase in the DECON decommissioning scenario, until such time that the transfer of spent fuel to the DOE can be completed. Assuming that DOE begins accepting commercial spent fuel from the industry in 2030, River Bend fuel is projected to be removed from the site beginning in 2037. The process is expected to continue through and beyond the cessation of plant operations. It could be completed by the year 2065 or 2077, depending upon the shutdown date, although 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 DOE and/or 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 DOE and/or 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 five and one-half years after the cessation of operations. It is assumed that the five and one-half years 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).

ISFSI Decommissioning

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, 10 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., 624 offloaded assemblies, 68 assemblies per cask) which results in 10 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 E.

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 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 River Bend site. It is acknowledged, however, that the plant owners 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 the River Bend plant ceases operation. 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 DECON scenario, the reactor recirculation system components are assumed to be decontaminated using chemical agents prior to the start of dismantling operations. This type of decontamination can be expected to have a significant ALARA impact, since in this scenario the removal work is done within the first few years of shutdown. Disposal of the decontamination solution effluent is included within the estimate as a "process liquid waste" charge.

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.[31] 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.[32]

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 Appendices C and D, 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 the current cost for disposal at Energy*Solutions* facility in Clive, Utah. Disposal costs for the higher activity waste (Class B and C) were based upon Entergy's current agreement with WCS for the Andrews County facility.

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 four 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 River Bend is decommissioned in support of the regional transmission and distribution system. 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 estimates do not assume the remediation of any significant volume of contaminated soil. Costs are included, however, for the remediation of the firing range, i.e., removal of soil containing lead residue.

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. Costs provided as input to the decommissioning cost model in dollars other than 2018 dollars were escalated to 2018 dollars.

The estimates rely upon the physical plant inventory that was the basis for the 2014 analysis.

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

Entergy will manage the decontamination and dismantling of the station, in addition to maintaining site security, radiological health and safety, quality assurance and overall site administration during the decommissioning (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 Entergy. 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 engineering, planning, and licensing efforts for the station, 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 Figures 3.1 and 3.2 for the DECON scenarios. Utility staffing levels will gradually decrease after completing the removal of physical systems. 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 2065 or 2077, the security organization will be reduced to Part 37 requirements.

3.5.3 Design Conditions

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 NSSS components to be shipped under current transportation regulations and disposal requirements.

The curie contents of the vessel and internals at final shutdown are derived from those listed in NUREG/CR-3474.[33] Actual estimates are derived from the curie/gram values contained therein and adjusted for the different mass of the River Bend components, projected operating life, and different periods of decay. Additional short-lived isotopes were derived from NUREG/CR-0130[34] and NUREG/CR-0672,[35] and benchmarked to the long-lived values from NUREG/CR-3474.

The disposal cost for the control blades removed from the vessel with the final core load is included within the estimates. Disposition of any blades stored in the pools from operations is considered an operating expense and therefore not accounted for in the estimates. The estimate does include the disposition of 131 irradiated fuel channels that are current stored in the spent fuel pool.

Neutron activation of the reactor building structure is assumed to be confined to the primary shield wall.

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

FEMA and state fees associated with emergency planning are assumed to continue for approximately 12 months following the cessation of operations. At this time, the fees are discontinued. The timing is based upon the anticipated condition of the spent fuel (i.e., the hottest spent fuel assemblies are assumed to be cool enough that no substantial Zircaloy oxidation and off-site event would occur with the loss of spent fuel pool water). Local fees continue until all fuel has been moved from the pool into dry storage (approximately five and one-half years following the cessation of operations).

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."[36] The NRC's financial protection requirements are based on various reactor (and spent fuel) configurations.

Taxes

Property taxes are included within the estimates. However, the tax is based upon the land, without any consideration of any ongoing site operations and property assets.

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

Schedules of expenditures are provided in Tables 3.1 and 3.2. The tables delineate the cost contributors by year of expenditures as well as cost contributor (e.g., labor, materials, and waste disposal).

The tables in Appendices C and D provide additional detail. The cost elements in these tables 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. Costs are included for approximately one year prior to the permanent cessation of operations for pre-planning and decommissioning preparations. 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 that is included in both Appendices C and D is provided in Appendix E.

The "Spent Fuel Management" subcategory contains costs associated with the containerization and transfer of spent fuel from the wet storage pool to the ISFSI for interim storage, as well as the transfer of the spent fuel in storage at 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 removed to a depth of three feet and backfilled.

As discussed in Section 3.4.1, it is assumed that the DOE will not accept the GTCC waste prior to completing the transfer of spent fuel. Therefore, the cost of GTCC disposal is shown in the final year of ISFSI operation (for the DECON alternative). While designated for disposal at a federal facility 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 Appendices C and D, along with the timelines presented in Section 4.

TABLE 3.1
DECON 40 ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2024	1,545	0	0	0	4,638	6,183
2025	27,243	665	559	15	18,231	46,713
2026	75,023	8,342	2,191	1,194	35,309	122,058
2027	78,128	36,890	1,832	41,513	25,025	183,388
2028	77,388	40,198	1,555	49,144	20,006	188,291
2029	81,827	43,802	1,263	26,345	17,540	170,778
2030	82,465	44,311	1,224	23,238	17,209	168,448
2031	46,767	14,706	650	12,052	9,106	83,280
2032	28,453	7,542	239	15	5,131	41,381
2033	19,386	10,816	163	0	5,504	35,869
2034	14,950	7,696	114	0	4,351	27,111
2035	4,530	368	0	0	1,643	6,541
2036	4,542	369	0	0	1,648	6,559
2037	4,530	368	0	0	1,643	6,541
2038	4,530	368	0	0	1,643	6,541
2039	4,530	368	0	0	1,643	6,541
2040	4,542	369	0	0	1,648	6,559
2041	4,530	368	0	0	1,643	6,541
2042	4,530	368	0	0	1,643	6,541
2043	4,530	368	0	0	1,643	6,541
2044	4,542	369	0	0	1,648	6,559
2045	4,530	368	0	0	1,643	6,541
2046	4,530	368	0	0	1,643	6,541
2047	4,530	368	0	0	1,643	6,541
2048	4,542	369	0	0	1,648	6,559
2049	4,530	368	0	0	1,643	6,541
2050	4,530	368	0	0	1,643	6,541
2051	4,530	368	0	0	1,643	6,541
2052	4,542	369	0	0	1,648	6,559
2053	4,530	368	0	0	1,643	6,541

TABLE 3.1 (continued)
DECON 40 ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2054	4,530	368	0	0	1,643	6,541
2055	4,530	368	0	0	1,643	6,541
2056	4,542	369	0	0	1,648	6,559
2057	4,530	368	0	0	1,643	6,541
2058	4,530	368	0	0	1,643	6,541
2059	4,530	368	0	0	1,643	6,541
2060	4,542	369	0	0	1,648	6,559
2061	4,530	368	0	0	1,643	6,541
2062	4,530	368	0	0	1,643	6,541
2063	4,530	368	0	0	1,643	6,541
2064	4,542	369	0	0	1,648	6,559
2065	4,525	1,104	0	0	9,151	14,780
2066	3,880	1,323	86	4,742	4,935	14,966
Total	677,571	228,446	9,876	158,258	225,468	1,299,619

TABLE 3.1a
DECON 40 ALTERNATIVE
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2024	1,545	0	0	0	4,638	6,183
2025	27,075	665	559	15	17,384	45,697
2026	74,134	7,479	2,191	1,194	33,240	118,238
2027	73,801	24,895	1,832	41,513	23,736	165,777
2028	72,522	26,301	1,555	49,144	18,713	168,235
2029	70,098	14,837	1,263	26,345	16,251	128,794
2030	69,793	13,275	1,224	23,238	15,920	123,451
2031	40,131	7,021	650	12,052	8,799	68,653
2032	15,756	969	151	15	2,514	19,405
2033	92	0	0	0	760	851
2034	64	0	0	0	533	597
2035-64	0	0	0	0	0	0
2065	169	750	0	0	7,553	8,472
2066	976	277	59	4,742	4,387	10,441
Total	446,157	96,468	9,483	158,258	154,427	864,794

TABLE 3.1b
DECON 40 ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2024	0	0	0	0	0	0
2025	0	0	0	0	848	848
2026	287	862	0	0	2,069	3,219
2027	3,989	11,966	0	0	1,289	17,244
2028	4,621	13,863	0	0	1,293	19,776
2029	9,621	28,863	0	0	1,289	39,773
2030	10,308	30,924	0	0	1,289	42,521
2031	6,260	7,667	0	0	307	14,234
2032	4,664	736	0	0	344	5,744
2033	4,410	0	0	0	532	4,942
2034	4,446	110	0	0	864	5,420
2035	4,530	368	0	0	1,643	6,541
2036	4,542	369	0	0	1,648	6,559
2037	4,530	368	0	0	1,643	6,541
2038	4,530	368	0	0	1,643	6,541
2039	4,530	368	0	0	1,643	6,541
2040	4,542	369	0	0	1,648	6,559
2041	4,530	368	0	0	1,643	6,541
2042	4,530	368	0	0	1,643	6,541
2043	4,530	368	0	0	1,643	6,541
2044	4,542	369	0	0	1,648	6,559
2045	4,530	368	0	0	1,643	6,541
2046	4,530	368	0	0	1,643	6,541
2047	4,530	368	0	0	1,643	6,541
2048	4,542	369	0	0	1,648	6,559
2049	4,530	368	0	0	1,643	6,541
2050	4,530	368	0	0	1,643	6,541
2051	4,530	368	0	0	1,643	6,541
2052	4,542	369	0	0	1,648	6,559
2053	4,530	368	0	0	1,643	6,541

TABLE 3.1b (continued)
DECON 40 ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2054	4,530	368	0	0	1,643	6,541
2055	4,530	368	0	0	1,643	6,541
2056	4,542	369	0	0	1,648	6,559
2057	4,530	368	0	0	1,643	6,541
2058	4,530	368	0	0	1,643	6,541
2059	4,530	368	0	0	1,643	6,541
2060	4,542	369	0	0	1,648	6,559
2061	4,530	368	0	0	1,643	6,541
2062	4,530	368	0	0	1,643	6,541
2063	4,530	368	0	0	1,643	6,541
2064	4,542	369	0	0	1,648	6,559
2065	4,356	354	0	0	1,599	6,309
Total	188,954	106,395	0	0	61,054	356,403

TABLE 3.1c
DECON 40 ALTERNATIVE
SITE RESTORATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2024	0	0	0	0	0	0
2025	168	0	0	0	0	168
2026	601	0	0	0	0	601
2027	338	29	0	0	0	367
2028	245	35	0	0	0	280
2029	2,108	103	0	0	0	2,211
2030	2,363	112	0	0	0	2,476
2031	376	18	0	0	0	393
2032	8,033	5,838	88	0	2,273	16,232
2033	14,884	10,816	163	0	4,212	30,075
2034	10,439	7,586	114	0	2,954	21,094
2035-65	0	0	0	0	0	0
2066	2,903	1,047	27	0	548	4,525
Total	42,460	25,583	393	0	9,987	78,422

TABLE 3.2
DECON 60 ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2044	1,545	0	0	0	4,638	6,183
2045	27,631	1,830	559	15	18,231	48,266
2046	76,008	11,297	2,191	1,194	35,309	126,000
2047	75,250	28,256	1,832	46,242	25,001	176,581
2048	73,796	29,424	1,555	54,819	19,977	179,570
2049	79,248	36,066	1,263	27,027	17,536	161,141
2050	80,023	36,987	1,224	23,238	17,209	158,682
2051	46,897	15,096	650	12,052	9,106	83,801
2052	28,692	8,260	239	15	5,131	42,337
2053	19,515	11,204	163	0	5,504	36,386
2054	15,045	7,982	114	0	4,351	27,493
2055	4,546	416	0	0	1,646	6,607
2056	4,558	417	0	0	1,650	6,625
2057	4,546	416	0	0	1,646	6,607
2058	4,546	416	0	0	1,646	6,607
2059	4,546	416	0	0	1,646	6,607
2060	4,558	417	0	0	1,650	6,625
2061	4,546	416	0	0	1,646	6,607
2062	4,546	416	0	0	1,646	6,607
2063	4,546	416	0	0	1,646	6,607
2064	4,558	417	0	0	1,650	6,625
2065	4,546	416	0	0	1,646	6,607
2066	4,546	416	0	0	1,646	6,607
2067	4,546	416	0	0	1,646	6,607
2068	4,558	417	0	0	1,650	6,625
2069	4,546	416	0	0	1,646	6,607
2070	4,546	416	0	0	1,646	6,607
2071	4,546	416	0	0	1,646	6,607
2072	4,558	417	0	0	1,650	6,625
2073	4,546	416	0	0	1,646	6,607

TABLE 3.2 (continued)
DECON 60 ALTERNATIVE
TOTAL ANNUAL EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2074	4,546	416	0	0	1,646	6,607
2075	4,546	416	0	0	1,646	6,607
2076	4,558	417	0	0	1,650	6,625
2077	4,544	1,160	0	0	9,153	14,857
2078	3,716	1,288	86	4,742	4,829	14,661
Total	631,991	198,005	9,876	169,344	212,204	1,221,421

TABLE 3.2a
DECON 60 ALTERNATIVE
LICENSE TERMINATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2044	1,545	0	0	0	4,638	6,183
2045	27,075	665	559	15	17,384	45,697
2046	74,134	7,479	2,191	1,194	33,240	118,238
2047	73,801	24,895	1,832	46,242	23,712	170,481
2048	72,522	26,301	1,555	54,819	18,684	173,880
2049	70,098	14,837	1,263	27,027	16,247	129,473
2050	69,793	13,275	1,224	23,238	15,920	123,451
2051	40,131	7,021	650	12,052	8,799	68,653
2052	15,756	969	151	15	2,514	19,405
2053	92	0	0	0	760	851
2054	64	0	0	0	533	597
2055-76	0	0	0	0	0	0
2077	169	750	0	0	7,553	8,472
2078	976	277	59	4,742	4,308	10,362
Total	446,157	96,468	9,483	169,344	154,290	875,743

TABLE 3.2b
DECON 60 ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2044	0	0	0	0	0	0
2045	388	1,165	0	0	848	2,401
2046	1,273	3,818	0	0	2,069	7,160
2047	1,111	3,332	0	0	1,289	5,732
2048	1,029	3,088	0	0	1,293	5,410
2049	7,042	21,126	0	0	1,289	29,457
2050	7,867	23,600	0	0	1,289	32,755
2051	6,390	8,057	0	0	307	14,755
2052	4,903	1,453	0	0	344	6,700
2053	4,540	388	0	0	532	5,460
2054	4,541	396	0	0	865	5,802
2055	4,546	416	0	0	1,646	6,607
2056	4,558	417	0	0	1,650	6,625
2057	4,546	416	0	0	1,646	6,607
2058	4,546	416	0	0	1,646	6,607
2059	4,546	416	0	0	1,646	6,607
2060	4,558	417	0	0	1,650	6,625
2061	4,546	416	0	0	1,646	6,607
2062	4,546	416	0	0	1,646	6,607
2063	4,546	416	0	0	1,646	6,607
2064	4,558	417	0	0	1,650	6,625
2065	4,546	416	0	0	1,646	6,607
2066	4,546	416	0	0	1,646	6,607
2067	4,546	416	0	0	1,646	6,607
2068	4,558	417	0	0	1,650	6,625
2069	4,546	416	0	0	1,646	6,607
2070	4,546	416	0	0	1,646	6,607
2071	4,546	416	0	0	1,646	6,607
2072	4,558	417	0	0	1,650	6,625
2073	4,546	416	0	0	1,646	6,607

TABLE 3.2b (continued)
DECON 60 ALTERNATIVE
SPENT FUEL MANAGEMENT EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2074	4,546	416	0	0	1,646	6,607
2075	4,546	416	0	0	1,646	6,607
2076	4,558	417	0	0	1,650	6,625
2077	4,375	410	0	0	1,601	6,385
Total	143,538	75,989	0	0	47,954	267,482

TABLE 3.2c
DECON 60 ALTERNATIVE
SITE RESTORATION EXPENDITURES
(thousands, 2018 dollars)

Year	Labor	Equipment & Materials	Energy	Burial	Other	Total
2044	0	0	0	0	0	0
2045	168	0	0	0	0	168
2046	601	0	0	0	0	601
2047	338	29	0	0	0	367
2048	245	35	0	0	0	280
2049	2,108	103	0	0	0	2,211
2050	2,363	112	0	0	0	2,476
2051	376	18	0	0	0	393
2052	8,033	5,838	88	0	2,273	16,232
2053	14,884	10,816	163	0	4,212	30,075
2054	10,439	7,586	114	0	2,954	21,094
2055-77	0	0	0	0	0	0
2078	2,740	1,012	27	0	521	4,299
Total	42,296	25,548	393	0	9,960	78,196