PLANNING FOR THE EARLY RETIREMENT OF THE OYSTER CREEK NUCLEAR GENERATING STATION –ENGINEERING ISSUES

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This paper provides the status of planning and preparation for the possible early retirement of the Oyster Creek Nuclear Generating Station (OCNGS) with particular focus on engineering issues. In April 1997, GPU Nuclear announced that early retirement and decommissioning of the plant was an option because of projections that the plant could not operate economically in a deregulated market. At that time, GPU Nuclear selected the "DECON" option for decommissioning. Although many of the issues that apply to other decommissioning projects apply to OCNGS, there are unique issues associated with decommissioning this BWR-2 with its MARK I containment. Further, the desire to continue running OCNGS until Fall 2000, while simultaneously planning for decommissioning, presents unique challenges to the organization.

INTRODUCTION

General Public Utilities Nuclear (GPU Nuclear) Corporation has announced that shutdown of the Oyster Creek Nuclear Generating Station (OCNGS) in 2000, nine years before the end of its license, is an option due to the onset of deregulation in New Jersey. Planning bases and issues associated with continued operation for an extended period after announcement of the early shutdown option have been presented previously(1). This paper provides an update of progress made in the preparation for early shutdown and reports on results of analyses supporting those preparations.

BACKGROUND

The Oyster Creek Nuclear Generating Station (OCNGS) is a 1930 MW_{th} (approximately 620 MW_e) boiling water reactor which became operational in 1969. It is an early generation General Electric design, specifically a BWR-2, which employs the Mark I containment used in many later generation plants. The license capacity of its fuel pool will be expanded to include approximately 3000 spent fuel elements by the year 2000. Fig. 1 illustrates the reactor building which contains the reactor, primary containment or "drywell", and the spent fuel storage pool. If GPU Nuclear elects to shutdown the plant in 2000, corporate direction is to proceed with prompt dismantlement, or "DECON". Planning for this option began in mid-1997 with the formation of a small team of people with engineering, radiological, spent fuel management and environmental expertise. This paper will summarize the results of planning to date, with focus on various scenarios for decommissioning, reactor pressure vessel removal, design of engineered systems, accident analysis**,** and low level waste disposition. These issues are common to other commercial nuclear power plants undergoing decommissioning. However, the nature of the plant design and uncertainty regarding management of spent fuel introduce some unique challenges to the Oyster Creek project. The Oyster Creek situation also differs from other nuclear plants in that resources must be given to the highest priority, safe operation of the facility, for the next two years.

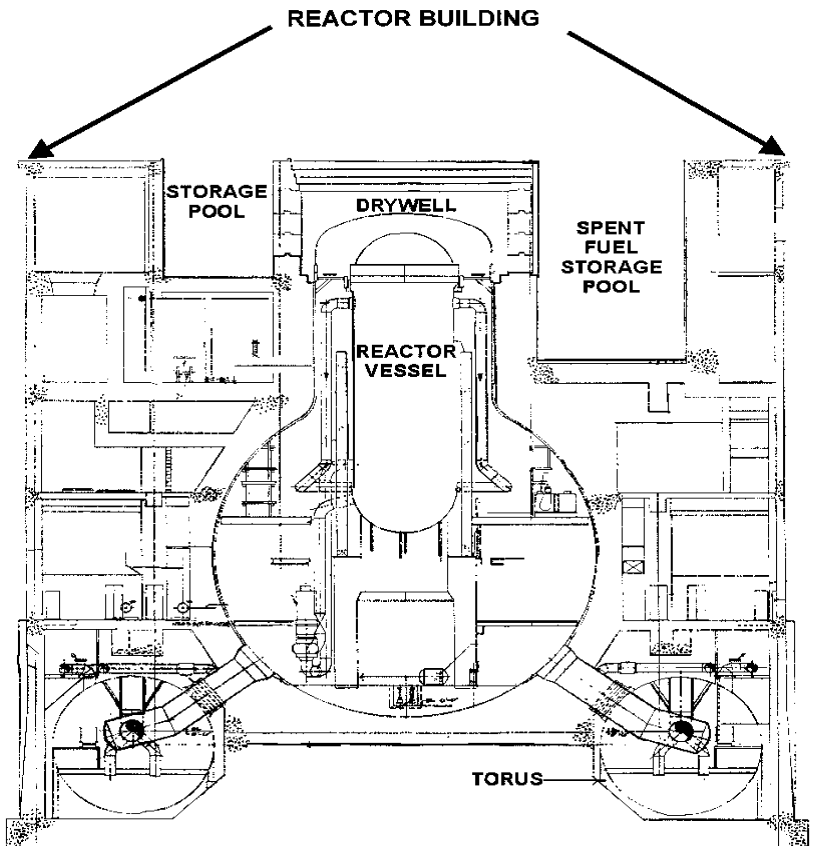

Fig. 1: Simplified illustration of OCNGS reactor building

SUMMARY OF DECOMMISSIONING SCENARIOS

Assuming shutdown in Fall 2000, a number of scenarios are being reviewed to determine which is optimum within the corporate guidance of prompt dismantlement. The dominant considerations in defining the decommissioning time line for Oyster Creek are (i) the length of time that fuel will be stored on-site after shutdown and (ii) its storage location. A license amendment will be submitted to the NRC to increase the licensed capacity of the fuel pool to accommodate approximately 3000 fuel elements, the capacity needed to store all of the spent fuel used since plant startup in 1969. There is currently no licensed on-site dry storage capacity at Oyster Creek. There is also considerable uncertainty about the potential for licensing such a facility due, in part, to local regulations.

Our current planning assumption is that transfer of fuel to DOE would occur in a ten-year window ending in 2020. However, there is uncertainty in that assumption as well. (For cost estimation (2), we have assumed fuel transfer completion dates of 2014, 2024 and 2037.) Therefore, two broad planning scenarios emerge. One scenario assumes that a full-capacity on-site ISFSI is constructed and fuel transfer from the fuel pool is completed by 2007. The second scenario assumes that fuel is maintained in the pool until transfer to DOE. The second scenario results in a period of decommissioning dormancy while awaiting transfer of all fuel from the pool with the net effect being that site release is delayed by three years. Fig 2 provides key dates for each of these scenarios.

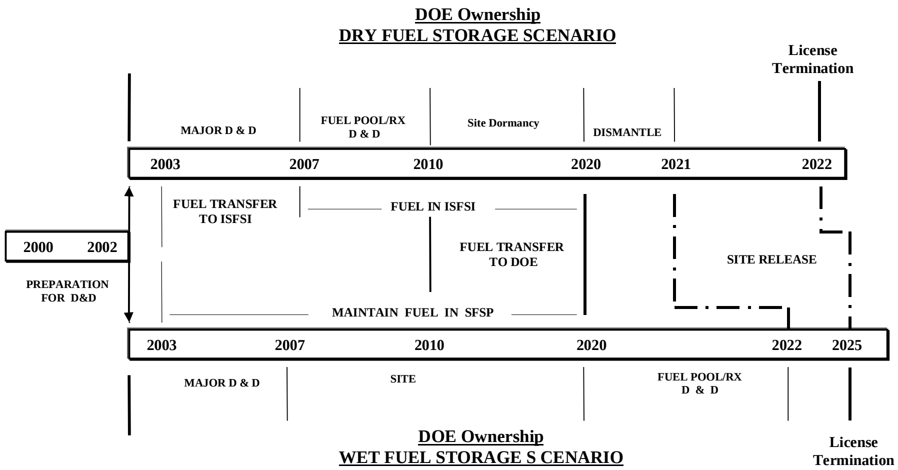

Fig 2: Potential OCNGS Decommissioning Time Line for “Wet” and “Dry” Fuel Storage Scenarios

An important variation on the scenarios indicated in Fig. 2 is available for Oyster Creek. GPU, in conjunction with several other utilities is funding a private fuel storage facility in Utah. This facility, which is not yet licensed, may provide the opportunity to move fuel from the Oyster Creek site earlier than is projected for DOE acceptance of fuel. The decommissioning cost estimate, currently being completed will evaluate this scenario in addition to those illustrated in Fig. 2.

REACTOR PRESSURE VESSEL REMOVAL

Removal and shipment of the reactor pressure vessel represents a significant engineering challenge under any circumstance. Given the potential for long term storage of fuel in the fuel pool and the desire to proceed with prompt dismantlement, the option of removing the RPV with nearby fuel storage (as can be seen from Fig. 1) represents the most significant engineering challenge of the OCNGS decommissioning project.

The OCNGS reactor pressure vessel and its internal components are illustrated in Fig. 3.

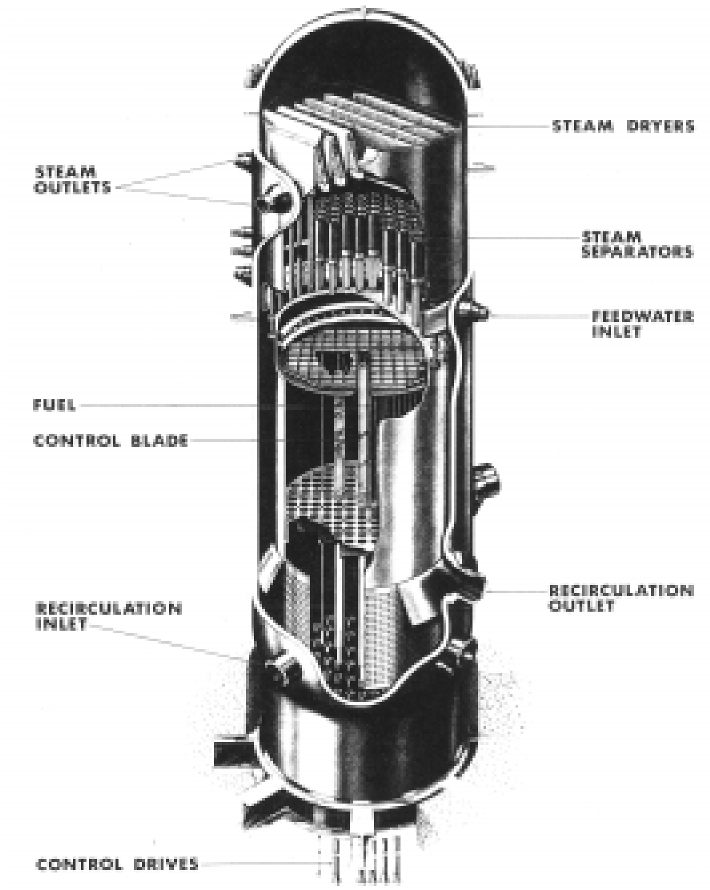

Fig. 3 RPV cut-out illustrating internal components

Table I summarizes key characteristics of the vessel and its internals.

Table I. Key Characteristics of OCNGS Reactor Pressure Vessel and Internals

Component	Size	Weight	Material / Max.Thickness	Estimated Curies of Activated Metal (3)
RPV with internals and head	6.1m (o.d) x 20.4m (20 ft x 67 ft)	717 tonnes (790 tons)	carbon steel 17.8 cm	1.7×10^6
RPV without internals or head	6.1m (o.d) x 17.4m (20 ft x 57 ft)	525 tonnes (577 tons)	carbon steel 17.8 cm	< 2000
RPV Head	6.1m (o.d.) x 3.1m (20 ft x 10 ft)	68 tonnes (75 tons)	carbon steel 17.8 cm	small
Steam Dryer	5.21m (o.d.) x 3.1m (17.1 ft x 10 ft)	22.7 tonnes (25 tons)	stainless steel 2.5 cm	small
Steam Separator	5.21m (o.d.) x 3.7m (17.1 ft x 12 ft)	44.6 tonnes (49 tons)	stainless steel 2.5 cm	1,471
Core Shroud	4.55m (o.d.) x 5.5m (14.9 ft x 17.9 ft)	28.2 tonnes (31 tons)	stainless steel 3.8 cm	211,000
Control Rod Guide Tubes	0.46m (o.d.) x 3.9m (1.5 ft x 13.0 ft)	17.4 tonnes (19.2 tons)	stainless steel 1.3 cm	132,600
Lower Core Plate	4.4m (o.d.) x 0.51m (14.4 ft x 1.7 ft)	7.6 tonnes (8.3 tons)	stainless steel 5.1 cm	921,900
Top Guide Assembly	4.6m (o.d.) x 0.46m (14.9 ft x 1.5 ft)	5.1 tonnes (5.6 tons)	stainless steel 5.1 cm	368,600

As can be seen from Table I, the OCNGS reactor vessel is a very large and heavy component; if internals are included, the "package" becomes that much heavier. From the most general perspective, a spectrum of options is being evaluated for the Oyster Creek vessel. The vessel itself may be removed intact or it may be segmented. Internal components of the vessel may also be removed with the vessel or separated from the vessel and dispositioned separately. For simplicity, this discussion will focus on four general options (ignoring variations such as removing the vessel head separately):

Option I. Intact RPV removal with internals

This option is essentially the approach planned for removing the Trojan nuclear plant reactor vessel. An advantage of this option is the elimination of personnel radiation exposure associated with segmenting the vessel and internals. Load handling and packaging of multiple components is also minimized. Further, if internals that individually would be considered GTCC were included with the vessel, the resulting package could be less that Class C (4).

A disadvantage, as seen from Table I, is that the OCNGS package of vessel and internals would weigh 700 metric tons, exclusive of grouting. The physical dimensions of this package require specialized removal equipment and extensive safety evaluations. Based in the latest activation analysis, the total curie content of the package would be on the order of 1.7 E6 curies which far exceeds the curie limits for the Chem-Nuclear facility in South Carolina.

Option IA: Intact reactor vessel removal without internal components

This option is a variant of Option I except that the internals are removed prior to removing the vessel intact. This approach was used for the Yankee Rowe reactor vessel. Costs and personnel exposure associated with RPV segmentation are avoided. For the OCNGS vessel, the total activated curie content of the package would be reduced to less than 2000 Ci if no internal components were included, thus, facilitating burial in currently licensed facilities. The major disadvantage of this option is that separating highly activated internal components mandates their treatment as GTCC waste.

Option II: Cutting reactor vessel into large pieces.

This option reflects the possibility of cutting the reactor vessel into large pieces. Increased personnel radiation exposure would be incurred with the cutting and handling operations. However, the package size would be reduced which may facilitate removal from the reactor building and subsequent shipping. Separate disposition of the GTCC internals components would be required.

Option IV: Cutting reactor vessel into small pieces

This option assumes that the reactor vessel is segmented into small enough pieces to fit into existing licensed shipping containers. Thus, regulatory approvals, complex removal analyses, and detailed shipping analyses can be minimized. Obviously, personnel radiation exposures and the number of load handling operations would be expected to increase over the prior options. For example, the Japan Power Demonstration Reactor, a small demonstration BWR, and Shoreham, which ran for only two EFPD, were segmented. Again, separate disposition of the GTCC internals components would be required.

To address the options for removal and shipment GPU Nuclear has commissioned two feasibility studies. An RPV removal feasibility study is being performed by Bechtel Power Corporation with final results expected in Spring 1999.(5) A wide spectrum of removal options are being considered with the intent that the results of the feasibility study will determine which options should be considered for more detailed engineering analysis. In addition to vessel segmentation, options for lifting and lowering an intact RPV from the reactor building are being examined.

Similarly, an RPV shipment feasibility study is underway with Stone & Webster Engineering Corporation performing the analysis.(6) Again, the desire is to broadly consider a spectrum of options and identify those that should be considered for more detailed analysis. The study will identify controlling limits to transport, e.g., clearances, weight limitations, and is also scheduled to be completed in Spring 1999.

DECOMMISSIONING ACCIDENT ANALYSIS

GPU Nuclear is currently drafting the PSDAR for the Oyster Creek project. To support the environmental impact conclusions necessary for the PSDAR, and as a basis for developing the Technical Specifications (and other licensing documents), a decommissioning accident analysis is underway. Raytheon Nuclear, Inc has been contracted to perform the analysis for GPU Nuclear.(7) Our approach was to develop a wide spectrum of potential accidents to assure that future choices in decommissioning scenarios and activities are encompassed by the analysis. We also believe that a broad, decommissioning-specific accident spectrum will facilitate application of the safety review process by minimizing questions regarding type, probability, and consequences of accidents. Finally, the accident analysis provides a basis for simpler engineered systems whose design is consistent with the hazards associated with decommissioning activities.

For the Oyster Creek decommissioning, a three-pronged approach was used to develop the credible accident spectrum. The first task was to review applicable regulations to understand requirements for accident type and analysis methodology. Various regulations address spent fuel storage, spent fuel transportation, and offsite dose limitations. The second task to review what other plants undergoing decommissioning considered to be credible accidents; examples include the Yankee Rowe, Big Rock Point, Shoreham, Connecticut Yankee, Maine Yankee, Trojan, Ft. St. Vrain, and Rancho Seco commercial nuclear plants. In addition, the postulated accident spectrum for the General Electric fuel storage facility at Morris Il was reviewed for applicability to the Oyster Creek project. The third task in establishing the credible accident spectrum was to analyze the planned activities for the Oyster Creek project to identify potentially unique conditions that would not be identified by the first two tasks.

From this approach, six general categories of accidents were identified. Within each of these categories, specific types of accidents were defined and used for consequence analysis. The resultant credible accident spectrum is summarized in Table II.

Table II. Summary of postulated accidents for OCNGS decommissioning

Accident category	Examples of specific types
Decontamination, dismantlement & material handling	1. Decontamination, e.g., sprays, leaks, vacuum bag ruptures, high pressure cleaning incidents 2. Dismantlement, e.g., component segmentation, oxyacetylene explosion 3. Material handling, e.g., dropped resin vessel, large component drops, 4. Loss of support systems, e.g., compressed air, HVAC
Accidents associated with storage of fuel in on-site fuel pool	1. Loss of spent fuel pool cooling 2. Loss of spent fuel pool water 3. Fuel handling accidents
Accidents associated with storage of fuel in on-site dry storage facility	1. Loss of cooling (e.g, due to blockage of air circulation) 2. Loading accidents (e.g., loading of newly discharged assembly)
"Common mode" events on-site	1. Fires 2. Loss of electrical power 3. External events (e.g. flood, freezing, aircraft impact)
Fuel transportation	1. As defined by transportation regulations
Others	1. Liquid waste storage tank release

The postulated non-mechanistic loss-of-fuel pool inventory was analyzed to establish the duration of the zirconium (Zr) fire potential. While the argument must be made that the accident is not credible given the design basis of the pool, the minimum duration of the Zr fire "window" was found to be relatively short (less than four months) using current analytical tools.(8) The reason for the short window, in comparison to the average BWR duration, is largely due to the age of the stored Oyster Creek fuel. Hence, the impact on decommissioning costs and schedule, by including the Zr fire in the accident spectrum, is expected to be small.

An important accident analysis insight, that may not be applicable to all plants, is associated with the design temperature of the Oyster Creek fuel pool. Although many pools are designed to withstand boiling, the OCNGS pool limit is 140 °F due to potential structural deflections if large temperature differentials across the pool floor occur. Thus, the large heat removal associated with pool boiling cannot be credited as a method of mitigating a loss-of-cooling accident. This result affects the design of post-shutdown pool cooling systems and the duration of their use.

Preliminary results of the accident analysis indicate that the offsite consequences of postulated credible accidents are within the limits defined by 10 CFR 100 and EPA protective action guidelines. It is anticipated that the analysis will also provided guidance on applicable administrative controls. Examples include arrangement of spent fuel in the fuel pool, control of heavy loads, and fuel pool chemistry control.

ENGINEERED SYSTEMS TO SUPPORT DECOMMISSIONING

To accommodate changed conditions after final shutdown, numerous plant system redesigns are planned. These new designs are required to (i) support decommissioning activities, (ii) facilitate removal of systems designed to support plant operation, and (iii) prevent or mitigate potential decommissioning accidents.

Table III summarizes engineered systems currently planned for Oyster Creek after shutdown and their design criteria.

Table III. Engineered systems for decommissioning vs. design criteria

Engineered System	Design Criteria
Electrical Power	1. New system reduces personnel electrical hazards by eliminating need to identify and terminate leads of existing system prior to dismantlement activities 2. Reduced decommissioning loads allow reduction in site power requirements 3. Reduced credible accident spectrum allows reduction in redundancy and other "safety grade" characteristics
Radwaste Processing	1. New system allows dismantlement of operating plant systems which may include extensive piping and support systems 2. New system designed to be dismantled
Spent Fuel Pool Cooling	1. New system allows dismantlement of operating plant systems which may include extensive piping and support systems 2. New system sized to reduced heat loads. 3. New system can be localized to fuel pool area
Heating, Ventilation, and Air Conditioning (HVAC)	1. New or modified systems designed to support dismantlement activities. 2. Potential for localizing key components to fuel pool area to supply accident mitigation requirements
Fire protection	1. Modifications consistent with dismantlement activities (e.g., industrial safety requirements may predominate)
Radiation and Environmental Monitoring	1. Modifications consistent with dismantlement activities (e.g., changing radiological control envelope)
Plant "monitoring" station	1. Monitoring station replaces control room of operating plant due to reduced operator action requirements after shutdown 2. Monitoring station may be collocated with security station

As described in the Introduction, the decommissioning project will compete for resources necessary to support plant operation until Fall 2000. To most efficiently identify the amount and skill sets needed to initiate engineering for decommissioning, dates and associated resources for each project have been estimated. These schedules were independently reviewed by Asta Engineering to develop a baseline for 1999 and 2000 engineering needs. This baseline was used to establish the decommissioning budget for engineering support. After extensive discussion regarding the optimum approach to managing this resource, management elected to form a dedicated decommissioning modifications group. This group has the responsibility to develop the modifications in Table III using processes that may differ from those that apply to the operating plant. Additionally, the modifications group will determine the final disposition of the systems used to support the operating plant, e.g., abandoned, useful for decommissioning.

LOW LEVEL RADWASTE (LLW) DISPOSITION

The volume of LLW associated with the Oyster Creek decommissioning project is estimated as 5 E 6 ft^3 exclusive of contaminated soil**.** This estimate is based on an area-by-area walk-down as part of our latest estimate of the cost of decommissioning; this estimate was performed by TLG Inc. Fig. 4 provides more detail of the sources of this waste volume and illustrates our current assumptions regarding its disposition.

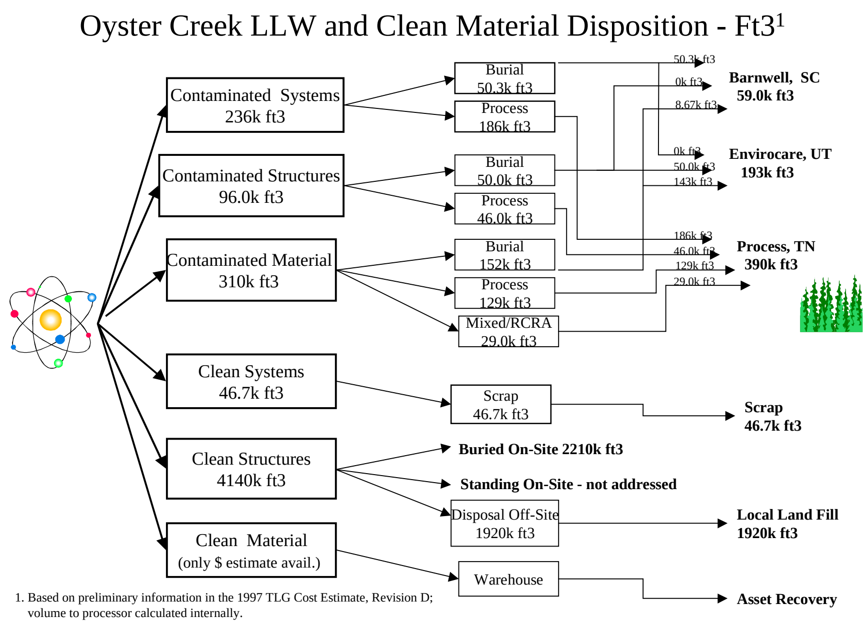

Fig. 4: Projected OCNGS Decommissioning LLW Flow Paths

Because of differences in costs at the currently licensed sites, the constantly changing outlook for closure of existing sites and uncertainty of licensing new sites, developing the optimum strategy for cost-effective disposition of LLW is difficult. For the Oyster Creek project, we are evaluating the most cost-effective solution for addressing the projected LLW volume. To assist in this evaluation, WMG Associates is preparing a report to support GPU Nuclear's development of an overall low level waste strategy for OCNGS decommissioning. Strategies for issues such as on-site vs. off-site decontamination, overboard vs. evaporative discharge, and the unavailability of the Chem-Nuclear facility are being developed.

ADDITIONAL FOCUS AREAS IN 1999

There are several additional focus areas for 1999. The first is preparation and submittal of the licensing bases documents, e.g., Technical Specifications, Decommissioning SAR, QA Plan, Emergency Plan. A key question in this regard is whether entire plans should be submitted or a combination of exemption requests and internal evaluations used to change the licensing bases documents most efficiently. Our plan is to complete the required submittals in 1999. The NRC recently agreed to meet regularly with GPU Nuclear as a means to maximize the effectiveness of the regulatory interface.

We anticipate markedly increased staff hours associated with developing initial system designs as described earlier in this paper. A project team assigned to develop all decommissioning modifications and to determine closeout of operating-plant systems was assigned in early 1999. We decided to have an integrated team rather than specific but separate task assignments to facilitate interface requirements of the shutdown systems.

Timely decision-making is important to cost management. We have recently defined a project management group that will be charged with defining key decisions associated with decommissioning and facilitating their resolution. The group, tentatively referred to as Decommissioning Project Integration Team, is intended to help timely decision-making. A matrix of the key decisions for the decommissioning option has been drafted. The decisions can be sorted by organizational element. At the highest level are those decisions considered "project guidance", e.g., commitment to long-term wet storage. Decisions at lower levels include those associated with engineered-system design, cost-estimation, and low-level waste management.

We intend to modify our work processes consistent with the risk associated with decommissioning activities. This task will be challenging because it requires a major shift in the nuclear mentality. But, if we can successfully define and implement changes, cost savings are anticipated. Very recently, teams were formed to address design criteria, engineering processes, and fieldwork processes.

The sequence for dismantling the Oyster Creek class of plant has not previously been defined. GPU Nuclear does intend to dismantle the facility using an "area-by-area" approach. To assist in dismantlement planning, a request-for-proposal has been issued to companies with major construction experience in the nuclear field. The product of this work is intended to be a "Level 1" schedule which sequences plant areas for decontamination and dismantlement based on a constructors experience and knowledge of boiling water reactor issues. We plan to award a contract by 2nd quarter 1999.

CONCLUSIONS

Planning for the potential early retirement of Oyster Creek is well underway. The engineering work scope has been broadly defined and internal resources have been allocated to initiate design modification work. Work has begun on long-lead time items whose resolution is expected to require significant engineering and/or policy decisions, e.g., accident analysis, options for removal of the RPV, and optimum low level radwaste management strategy. A good understanding of contractor and consultant capabilities has been developed and working relationships with several contract organizations are in place.

Additionally, in 1999, there will be significant focus on developing licensing bases documents including a defueled safety analysis report, technical specifications, and associated plans. Work will also begin on processes to be applied to decommissioning work and developing the initial draft of the OCNGS dismantlement sequence.

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