December 9, 2005

LICENSEE: U.S. Maritime Administration (MARAD)

FACILITY: N.S. Savannah

SUBJECT: SUMMARY OF MEETING BETWEEN MARAD AND NRC STAFFS

On November 2, 2005, representatives of the NRC staff met at NRC Headquarters with representatives of the MARAD, the licensee for the N.S. Savannah. Representatives of the licensee's contractors also attended the meeting. Attachment one is a list of meeting attendees.

The purpose of the meeting was to discuss potential plans for decommissioning the N.S. Savannah. The N.S. Savannah was the only U.S. operational nuclear-powered commercial cargo/passenger vessel. The ship was taken out of service in 1970. Some initial decommissioning work was performed in the 1970s which included removing fuel and resins from the ship and draining coolant from the primary system. The fuel was returned to the Atomic Energy Commission. The N.S. Savannah is currently located in the James River, Virginia at the James River Reserve Fleet.

Unique aspects of the N.S. Savannah design (e.g., the shipboard reactor can be moved to another location for decommissioning, the compact reactor compartment limits the extent of the ship that will be impacted by decommissioning activities and the site is the ship) will affect decommissioning activities.

Topics discussed at the meeting were: reactor pressure vessel characterization, N.S. Savannah technical staff, the radiation safety officer, technical specifications, upcoming requests for proposal, and drydocking the Savannah in 2006. Attachment two is a listing of the discussion topics with additional detail. Attachment three is a overview of the N.S. Savannah technical staff. Attachment four is an excerpt from the pressure vessel characterization study.

In the area of pressure vessel characterization, the licensee reported that calculations based on measurements made on the pressure vessel indicate that the pressure vessel is Class A waste. This is a change from earlier calculations that did not include the data from the measurements. The NRC staff pointed out that it would be the licensees of the potential waste disposal sites and their regulators who would review and make a determination on MARAD's waste classification calculations.

The licensee discussed a potential license amendment to change the organizational structure to reflect the change in the ship's status from possession only to decommissioning. This license amendment may be submitted in 2006.

The licensee discussed the continued use of a Radiation Safety Officer under contract to MARAD. The NRC staff had no objections to the licensee’s plan.

The license for the Savannah has a condition that prohibits decommissioning without approval of the NRC. The removal of this restriction and the modification of the facility technical specifications from possession only to active decommissioning was discussed. The licensee is developing decommissioning technical specifications for submission to NRC.

The licensee discussed the planned drydocking of the ship in 2006 and the possible removal of the buffer seal charge pumps. After some discussion, it was determined that it would be best to conduct this activity after the license condition that prohibits decommissioning is removed from the license.

The licensee will keep the NRC informed of its plans as they are developed.

/RA/

Alexander Adams, Jr., Senior Project Manager
Research and Test Reactors Branch
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Docket No. 50-238

Attachments: As stated

cc w/attachments: Please see next page

Contact: Alexander Adams
301-415-1127

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Contact: Alexander Adams
301-415-1127

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Test, Research, and Training
  Reactor Newsletter
University of Florida
202 Nuclear Sciences Center
Gainesville, FL 32611

MEETING BETWEEN THE NRC STAFF AND
U.S. MARITIME ADMINISTRATION

November 2, 2005

NAME	TITLE	ORGANIZATION
Al Adams	Project Mgr	USNRC
Jon Stouky	Project Manager	MARAD/WPI
GARRICK SOLONEY		MARAD / WPI
Gene Simmons	Contracting Officer	MARAD
Erhard Koehler	Sr. Tech'l Advisor	MARAD
John Wiegand	NSS ~~Program~~ Decommission Program Manager	MARAD
Eric Crane	Attorney	MARAD
JOHN OSBORNE	Regulatory Analyst Sayres →	Sayres + Assoc MARAD
Charles Mahon	Director	SAYRES and Associates Corp.

Attachment 1

MEETING BETWEEN THE NRC STAFF AND
U.S. MARITIME ADMINISTRATION

November 2, 2005

NAME	TITLE	ORGANIZATION
John Buckley	Proj. Manager	DWMEP
Bob Nelson	Chief Licensing Section	SFPO
Kevin Witt	General Engineer	NRR
Jessie Quichocho	Health Physicist	NRC
Robert Moody	Sr. Emergency Prep. Spec.	NRC
Jeff Bell	D&D Program Manager	British Nuclear Group

Attachment 1

MEETING BETWEEN THE NRC STAFF AND
U.S. MARITIME ADMINISTRATION

November 2, 2005

NAME	TITLE	ORGANIZATION
Michael Buonopane	Project Engineer	USDOT/RITA/Volpe Center
JOHN B DAVIS	RSO	General Health Physics Contractor
WILLIAM HALLORAN	PROJECT ENGINEER	USDOT/VOLPE CENTER
Greg Thornton	ENGINEER	USDOT MARAD
John Bowen	Chief Engineer	WPI
John Millacci	Director	WPI
Jim Kennedy	Sr. Project Mgr. ~~USNRC~~	NMSS/NRC
CHRISTEPHER MCKENNEY	Sr. Systems Performance ANALYST	NMSS/DWMEP
Jim Shaffner	PM	NMSS/DWMEP

Attachment 1

Discussion Topics for November 2, 2005 Meeting

Nuclear Regulatory Commission and Maritime Administration

Regarding Nuclear Ship SAVANNAH Decommissioning

License NS-1, Docket 50-238

- **Reactor Pressure Vessel characterization & classification and implications on decomm location & time frame**

    - See Excerpt from Project Report.
    - 2004 Characterization and Historical Assessment found RPV to be Class B.
    - 2005, RPV was direct sampled, reanalyzed, and found to be Class A.
    - MARAD will meet with UT and SC next week to discuss disposal sites.
    - Pending resolution, MARAD cannot determine decommissioning site.

1. **SAVANNAH Technical Staff implementation and organizational license amendment**

    - See handout.
    - MARAD is developing a license amendment to implement the change.

- **RSO - contract vs. "direct" employee**

    1. Resolved. MARAD will continue to provide RSO via inter-agency agreement and subcontract to U.S. Army Corps of Engineers.

- **Tech Spec / QA Plan / UFSAR requirements vs. Saxton experience**

    2. MARAD and contractor have a number of questions regarding form and content for developing new and updated documents.

- **Plans for upcoming Request For Proposals (Engineering & Management Oversight Services)**

    3. Acquisition website: <voa.marad.dot.gov>
    4. Draft RFP released for comment in September 2005; Comments have been reviewed and acquisition strategy/plans are being updated accordingly.

- **06 drydock and possibilities for on-dock removal of buffer seal charge pumps**

    1. Planned routine maintenance drydocking and topside preservation package for May – June 2006
    2. Buffer Seal Charge Pumps are accessible from outside the hull and significant advantages are offered for removal while on drydock.

Attachment 2

Overview – SAVANNAH Technical Staff (STS)

The SAVANNAH Technical Staff (STS) is a staff organization within the Office of Ship Operations dedicated to managing the radiological decommissioning of the nuclear facilities housed onboard the N.S. SAVANNAH. The STS was re-established in May 2005 as a consequence of Congressional appropriations action to commence the radiological decommissioning program. The current-day STS follows historic MARAD management practices and organizations that supported the N.S. SAVANNAH during her development and operations from 1956 to 1976.

Functions

The SAVANNAH Technical Staff assumed responsibility for all activities associated with the N.S. SAVANNAH. These activities can be broadly grouped into three categories:

1. Routine Radiological Monitoring, Surveillance and Ship Husbanding.
2. Radiological Decommissioning.
3. Historic Preservation.

Organization

The SAVANNAH Technical Staff is under the supervision and direction of the Manager, N.S. SAVANNAH Programs, who also functions as the Director, STS. The Manager, N.S. SAVANNAH Programs serves on the immediate staff of, and is supervised by, the Director, Office of Ship Operations (MAR-610).

The Manager, N.S. SAVANNAH Programs also serves as the "Senior Technical Advisor, N.S. SAVANNAH." This designated official is responsible for all matters pertaining to the ship's nuclear reactor and related systems, and manages all licensing activities and matters before the U.S. Nuclear Regulatory Commission.

The STS includes three full time employees other than the Director. These include:

1. Decommissioning Program Manager
2. Facility Site Manager / Nuclear Engineering
3. Documentation and Administrative Manager

In addition, the STS includes a Radiological Safety Officer (RSO), provided under interagency agreement and subcontract by the United States Army Corps of Engineers (ACOE). The ACOE provides routine radiological monitoring and surveillance of the SAVANNAH at the James River Reserve Fleet.

The STS is designed on the Integrated Procurement Team concept, and includes a dedicated Contracting Officer, Contracting Specialist, and Attorney-Advisor.

Relationship with other Organizational Units within the Maritime Administration

On an as-needed and required basis, collateral support to the STS is provided from within other functional areas of MARAD, including but not necessarily limited to the following disciplines:

- Acquisitions (MAR-380)
- Quality Assurance (MAR-610.3)
- Environmental Consulting and Oversight (MAR-820)
- Legal (MAR-220)
- Non-nuclear Engineering (MAR-760)
- Financial Management (MAR-320/600/613)
- Ship Custody & Husbanding (MRG-7100/7700)

The Director, STS provides technical direction and oversight to other participating organizational units within MARAD with respect to the radiological decommissioning program.

Partnering Organizations

MARAD has established agreements with several external organizations to provide depth and experience to the STS. Among these are:

- The United States Merchant Marine Academy, Engineering Department
- The Volpe Center of the DOT Research and Innovative Technologies Administration

MARAD is developing an inter-agency agreement with the *Department of Energy's Argonne National Laboratory* to provide decommissioning-specific technical expertise and advice. MARAD has a standing agreement with *DOE's Thomas Jefferson National Accelerator Facility* to provide on-site radiological support to the SAVANNAH while she remains at the James River Reserve Fleet.

Points of Contact

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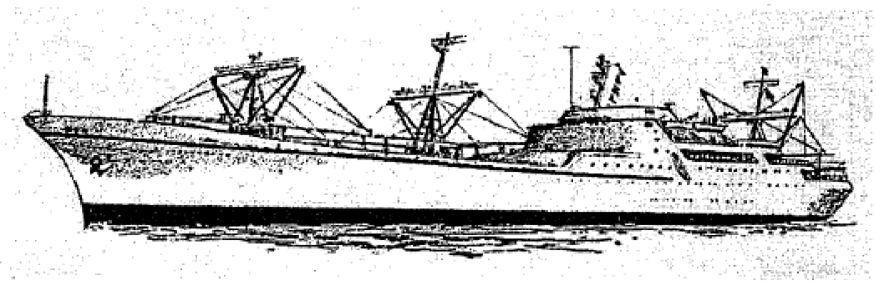


EXCERPT
FROM
NS SAVANNAH REACTOR PRESSURE VESSEL DRILLING, SAMPLING and RADIOCHEMICAL ANALYSIS PROJECT REPORT

OBJECTIVE & RESULTS

The objective of this project, conducted on the NS SAVANNAH between August 25, 2005 and September 1, 2005, was to refine the 2004 analysis and obtain a more accurate set of activation measurements. These measurements are based on current Reactor Pressure Vessel (RPV) and internals conditions as observed from actual metal sampling deep in the reactor internals. The 2004 analysis was performed using the same version of Origen-ARP with data from past analyses and original reactor design. All earlier analyses dating back to the late 1950's were based on theoretical design values which were very conservative. This

recent 2005 analysis will provide a highly reliable baseline in the decision-making process associated with various disposal options for the NS SAVANNAH RPV.

The specific effort was to determine the curie content, waste classification and radio isotopic inventory of the NS SAVANNAH RPV, Internals and Neutron Shield Tank (NST) by extracting metal samples at selected locations in the RPV and internals, and subsequent radiochemical analysis. Refined calculations were performed based on the integrated actual reactor power history, actual radiochemical data from reactor components and realistic neutron flux values. Comparison of the current calculations with the conservative analysis performed in 2004 is shown in Table 1 below.

The result of the analysis using a current computer code and isotopic discrete sample radiochemical analysis is that the NS SAVANNAH's RPV and internals package meets the radiological requirements of the US NRC and the States of Utah and South Carolina for a Class A waste package.

It is important to note that MARAD intends to remove, package, ship and dispose of the RPV and internals package without opening the RPV or further sampling of the RPV/internals by drilling more holes. Further sampling will require more time, exposure and expense, and the value of additional data is marginal. Opening the RPV (the ambient dose rate by measurement in the internals is approximately 16 R/Hr) would require equipment and systems activation far exceeding the value of any additional data and would not be consistent with ALARA principles.

TABLE 1

Comparison of 2004 & 2005 Analytical Results

Nuclide	ORIGEN (April 2004)	WAC Class/ Ratio*	ORIGEN (October2005)	WAC Class/ Ratio*
Ni-63	2902	B/0.324	361	A/0.81
Co-60	1108	A/0.124	81	A/0.12
Ni-59	30.6	A/0.109	4.0	A/0.14
Fe-55	17.8	A/0.002	0.9	A/1.3E-4
Nb-94	0.100	A/0.391	<0.0001	---
C-14	7.32	A/0.072	<0.0001	---
Total	4066		447	

* Ratio of Curie concentration from metal sample analysis to Class A limit.

APPROACH

Using a heavy metal drilling system, a 4" access hole was drilled through the external lead shield, the inner annuli of the neutron shield tank, and the thermal insulation layer adjacent to the RPV wall. The 4" bore was sleeved with PVC pipe. A 1.0625" hole was bored in the center through the carbon steel RPV wall and SS clad layer, and through the outer thermal shield. A 0.5" hole was drilled through the middle thermal shield.

All metal samples were taken in the form of chips by extending a drill bit with an extension shaft, operating inside of a sleeve, through the metal to be sampled. The sleeve forced the chips up the drill bit flute. A new drill bit and sleeve was used for each sample to eliminate cross-sample contamination. Each sample was packaged separately and marked to preserve a chain of custody.

The methodology for drilling of holes for sampling and other reasons in reactor and other pressure vessels is not new. As an example, the Shoreham reactor vessel, which was the same wall thickness and experienced comparable dose rates (due to significantly less decay time before samples were obtained) to that of the NS SAVANNAH, was drilled in a similar manner to render the vessel forever inoperable. The drilling or boring of heavy wall vessels and castings is a common field machining practice. This physical drilling process was mocked-up and demonstrated at the subcontractor's (Wachs Technical Services) facilities in Charlotte NC prior to deployment.

A total of eight metal samples, one insulation sample, and two liquid samples from the secondary steam generator loops were collected, bagged, packaged for

transportation and transported by private carrier to General Engineering Laboratory (GEL), a QA certified laboratory in Charleston, SC. A 10 CFR Part 61 analysis of six metal samples was performed. The lead shield and thermal insulation were analyzed by gamma scan only.

The sample locations included:

1. NST-Lead (Neutron Shield Tank)
2. NST- Outer Diameter (OD) Inner Wall (Neutron Shield Tank)
3. NST – Inner Diameter (ID) (Neutron Shield Tank)
4. RPV Insulation (Reactor Pressure Vessel)
5. RPV OD (Reactor Pressure Vessel)
6. RPV ID (Reactor Pressure Vessel)
7. OTS ID/OD (Outer Thermal Shield)
8. MTS OD (Middle Thermal Shield)
9. MTS ID (Middle Thermal Shield)
10. Starboard Steam Generator secondary side (water)
11. Port Steam Generator secondary side (water)

ANALYTICAL METHODOLOGIES

- **Radiochemical Data**

Sample data was reviewed and discussed with GEL personnel involved in the NSS radiochemical analysis. Data anomalies were satisfactorily resolved. Activation levels at statistically significant levels above MDA (Minimum Detectable Activity) were reported in uCi/gm, which were converted to uCi/cm³ for direct comparison with South Carolina DHEC (Department of Health and Environmental Control) Waste Acceptance Criteria. All GEL data was decay-

adjusted to October 2008, the date considered to be the earliest feasible date for RPV disposal.

At Chem-Nuclear and Envirocare of Utah (EOU), averaging is permitted per their state issued license and waste facility procedures. The quality and packaging requirements are described in Envirocare procedure titled, "Bulk Waste Disposal and Treatment Facilities Waste Acceptance Criteria", Revision 5; and Chem-Nuclear Systems Document S20-AD-010, "Barnwell Waste Management Facility Site Disposal Criteria", Revision 20.

For each of the isotopes of interest, activity concentration levels were scaled to the core centerline in conformance to reactor flux profiles developed as part of the initial reactor physics calculations. Though the 1956 design basis peak flux for the NSS core has been shown to be an over-estimate, the general shape of the thermal flux curve is considered to be an adequate representation of NSS reactor's neutron distribution. Using the middle thermal shield data as a benchmark, ID and OD activation levels were extrapolated to components in higher flux regions of the core including the core basket – an internal component with the highest expected Curie content in the vessel. This flux ratio approach enabled the use of relative flux differences without arbitrarily selecting a baseline peak flux value.

All RPV/internal samples were extracted at an access hole with an elevation equal to mid-height of the core, where maximum axial flux would be expected to occur. Based on flux profiles used in design of the NSS reactor (*Nuclear Merchant Ship Reactor*, April 1958, W.R.Smith & M.A.Turner), a peak to average axial flux ratio of 1.48 was calculated. This is a typical ratio for pressurized water reactors. The reciprocal of the 1.48 ratio corresponds to a 68% reduction in Curie concentrations derived from metal sample data obtained at the core mid-height.

Niobium (Nb-94), a 10CFR part 61 reportable isotope with low concentration limits for all waste classification categories, was not found in any samples at levels above the minimum detectable activity (MDA). To approximate Nb-94 Curie concentrations, the MDA level for Nb-94 was assumed to be the actual concentration and was extrapolated to the peak flux region of the core. This conservative approach still yielded activation levels three orders of magnitude below the State of South Carolina Waste Acceptance Class A limit of 0.02 Curies/meter^3.

The same methodology was used for Carbon (C-14), another reportable isotope in 10CFR part 61. Peak concentration levels were calculated to be more than two orders of magnitude below Waste Acceptance Class A limits of 8 Curies/meter^3.

Dosimetry Measurements

An independent confirmation of the credibility of the radiochemistry data is supported through actual dose measurements taken aboard ship in 2005. Dosimeter readings were taken at two locations – one external to the NST Inner Diameter (7 mR/hr at contact, taken April 2005), the other in the annular space between the outer and middle thermal shields (16 R/hr, taken September 2005). The reading at the thermal shield was taken with a small diameter Teletector extension instrument on a shaft that was inserted through the vessel drill hole. The face of the detector was extended 50 inches (127 cm) from the outer diameter of the lead shield surrounding the NST to the annular space between the outer and middle thermal shields as shown in Figure ES-1. The detector was used with a closed plastic shield to block beta radiation and low energy gammas; therefore, the readings are attributable primarily to the energetic gamma radiation from Cobalt (Co-60). Using conventional gamma dosimetry calculations, the

laboratory-derived activity concentrations for Co-60 at the two locations were compared to the dosimetry readings. This activation scaling approach yielded agreement within a factor of 6 over a dose range of almost four orders of magnitude. This was well within acceptable correlation limits.

- **ORIGEN Computer Code**

ORIGEN-ARP, Version 2.0 performs isotopic activation and depletion/decay calculations for pressurized and boiling water reactors. Oak Ridge National Laboratory developed ORIGEN-ARP (and its predecessors) for the Nuclear Regulatory Commission and the Department of Energy to satisfy the need for a standardized method of isotope depletion/decay analysis of spent fuel, fissile material and radioactive material. It can be used for spent fuel characterization, isotopic inventory, radiation source terms and decay heat.

The reactor operated from 1962 to 1970 at an average plant capacity factor of 30% resulting in 2.423 years of effective full power operation. A realistic fuel irradiation profile was inputted to the ORIGEN code in the 2005 analysis which was the same code used in the 2004 analysis. Consistent with the complete operational history of NS SAVANNAH's reactor, a total of 2.423 effective full power years of operation was utilized, but was apportioned in accordance with NS SAVANNAH'S actual operating history.

The eight-year operating period and extended interim shutdown resulted in significant decay of Co-60 and Iron (Fe-55) and minor decay of Nickel (Ni-63). Because the NS SAVANNAH seldom operated at full power for extended periods, peak neutron flux was rarely experienced. The 38-year decay mode results in only trace quantities of Fe-55 currently in the RPV (decay factor =

2.1×10^{-6}), considerable reduction in Co-60 (decay factor = 6.8×10^{-3}) and modest reduction in Ni-63 (decay factor = 0.77).

As with the radiochemical analysis, a peak to average axial neutron flux ratio of 1.48 was calculated to realistically account for average neutron flux levels axially across the reactor internals and pressure vessel wall. The reduction from 4066 to 447 curies (Table 1) was due to the reactor power history, actual radiochemical data from the reactor components, and more accurate neutron flux approximations.

Regulatory Conditions

The regulatory conditions, limitations and allowances are such that the NS SAVANNAH RPV and Internals package is a Class A package per 10 CFR Part 61 at both Envirocare of Utah and Chem-Nuclear in Barnwell, SC.

Extra Control Blade

There was an extra used (irradiated) NS SAVANNAH cruciform control blade that required disposal. This control blade was either damaged during the fuel shuffle or was destructively tested at the shipyard. The control blade was placed vertically and rotated 45 degrees in an empty fuel element space in the core region before insertion of the upper internals package when the reactor vessel was sealed in 1976. It is now impractical from a cost, safety, or ALARA standpoint to take this control blade out of the RPV. If that was done it would be buried with the RPV in its own cask or container.

The effects of the (22^{nd}) control blade are minimal. In the analysis the blade was assumed to be among the most highly irradiated blades and the curie content

assigned to it was 150% of the average control blade activity from the most current ORIGEN-ARP analysis. The 150% value was the highest value for all the control blades.

FINDINGS

Nuclide Activation

Table 2 below presents the results of total RPV nuclide activation levels based on actual radiochemistry data from the samples and analysis using the ORIGEN code for the part 61 analyses. The concentration of each radionuclide was averaged over the entire volume of metal in the RPV and internals. As shown, all nuclides are within the Waste Classification Class A limit both individually per isotope and when combined using the sum of the fractions for Class A Waste, which is 0.89. These results satisfy the WAC and averaging methodology for burial at Chem-Nuclear Systems and Envirocare of Utah (EOU).

TABLE 2

Nuclide	Metal Sample Analysis		ORIGEN		WAC Class A Limit / Ratio*
	Curies	Curies/m^3	Curies	Curies/m^3	Curies/m^3
Ni-63	391	30.6	361	28.3	35 / 0.87
Co-60	63	4.9	81	6.3	700 / 0.007
Ni-59	4.1	0.3	4.0	0.3	22 / 0.014
Fe-55	1.1	0.09	0.9	0.07	700 / 1.3E-4
Nb-94	< MDA	--	<0.0001	--	--
C-14	<0.01	--	<0.0001	--	--
Total	459.2	35.9	446.9	35.0	Sum of Fractions = 0.89

* Ratio of Curie concentration from metal sample analysis to Class A limit.

Water/Insulation Sample Analysis

Water samples taken from the port and starboard secondary loop and the insulation sample had no detectable levels of activity based on the gamma scan results. This result is consistent with the operating history of the steam generators, which experienced no significant leakage in the secondary system.

Gamma Scans

The lead shield external to the NST outer diameter had no activation above MDA. Trace amounts of Eu-152 and Eu-154 were detected in the insulation between the inner diameter of the NST and outer diameter of the RPV. The Eu isotopes (Eu-152 and Eu-154) were most likely impurities inherent in the insulation. Europium isotopes are not reportable nuclides in a 10CFR part 61 analysis. Reported trace amounts of Co-60 in the insulation are not readily explainable from the history. However they could have resulted from slight cross contamination of the samples during the drilling process. These concentrations have negligible effect on total Co-60 content of the RPV. The two water samples were below MDA levels.

CONCLUSIONS

The following conclusions are drawn from this project:

- These results are consistent with previous analyses and are based upon a conservative methodology and assumptions.
- This project approach has been proven and accepted for similar projects, such as one completed at Shoreham Nuclear Power Station.

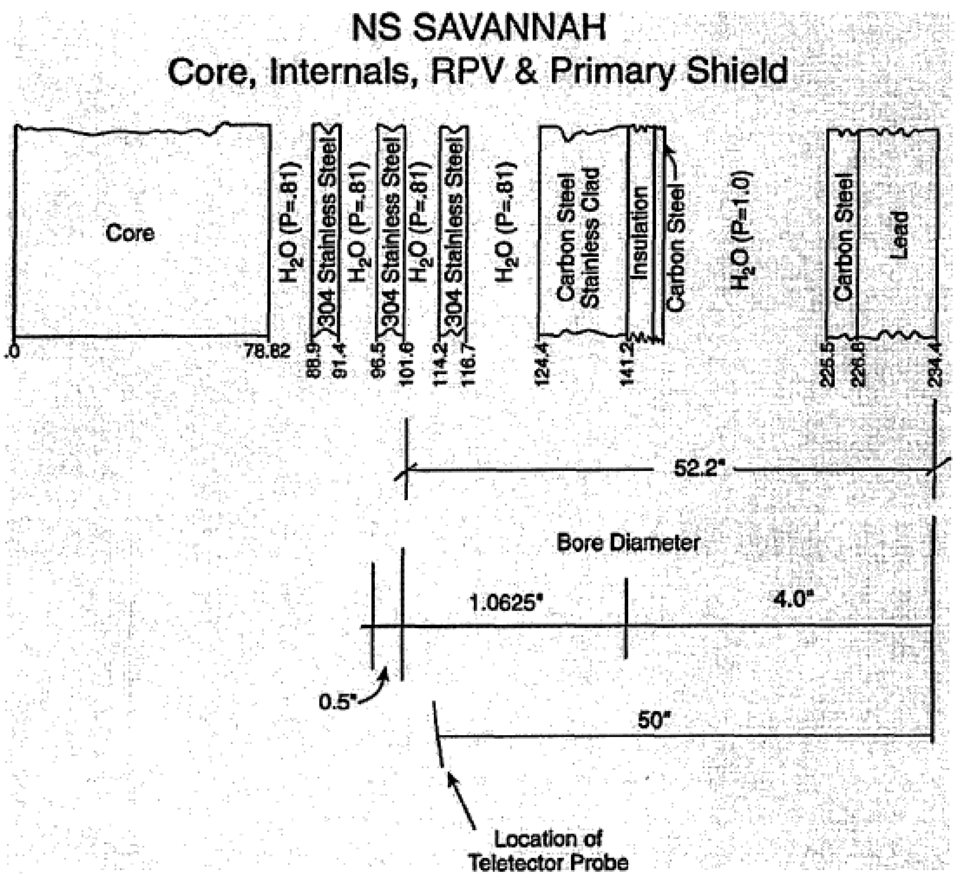
- The analytical data and results also correlate with actual field dosimetry measurements taken during the project.

- The computer code used for this analysis (ORIGEN-ARP Version 2.0) is the state-of-the-art code used by the nuclear industry and government for analyses of this type.

- The radionuclide concentration for the NS SAVANNAH RPV and internals package is clearly shown to be within Class A disposal limits. The specific waste classification criteria and allowable limits comply with the written requirements set forth by the federal government, state governments, and waste management facilities.

- Further intrusive sampling or opening of the RPV and/or internals will be expensive, will require additional personnel radiation exposure, and will not yield data that will change this waste classification conclusion.

FIGURE ES-1


NS SAVANNAH
Core, Internals, RPV & Primary Shield
Core
H2O (P=.81)
304 Stainless Steel
H2O (P=.81)
304 Stainless Steel
H2O (P=.81)
304 Stainless Steel
H2O (P=.81)
Carbon Steel
Stainless Clad
Insulation
Carbon Steel
H2O (P=1.0)
Carbon Steel
Lead
.0
78.82
88.9
91.4
96.5
101.6
114.2
116.7
124.4
141.2
225.5
226.8
234.4
52.2"
Bore Diameter
1.0625"
4.0"
0.5"
50"
Location of
Teletector Probe