1. EXECUTIVE SUMMARY

1.1 CHARACTERIZATION OF RADIONUCLIDES IN THE BACK RIVER AND INTERTIDAL ZONE AROUND THE FORMER MAINE YANKEE NUCLEAR POWER PLANT SITE.

As a result of the closure and decommissioning of the Maine Yankee Nuclear Power Plant, and the 1999 Federal Energy Regulatory Commission (FERC) settlement, Maine Yankee agreed with Raymond Shadis, Executive Director of Friends of the Coast (FOTC), to fund and conduct an environmental field survey of marine sediments in the Back River. The purpose of the study was to determine how licensed liquid radioactive effluent discharges from Maine Yankee are distributed in the environment. In the 2001 License Termination Plan (LTP) settlement, Maine Yankee further agreed to conduct a similar study in the intertidal zone surrounding selected portions of Maine Yankee property. .By separate agreement, the State of Maine, subject to approval of FOTC, specified various aspects of the sampling program.

Researchers from the University of Maine, the Woods Hole Oceanographic Institute, and Normandeau Associates performed the study. The majority of samples were taken during the summer of 2004 after the final discharge of the plant's spent fuel pool. This report characterizes radionuclides in the marine environment around Maine Yankee and describes the methodologies used in the study. Four sets of sampling were accomplished to complete this study. The results of each type of sampling are provided and are compared with a model of radionuclide distribution from licensed discharges. Additionally, the results are compared to previous work done in the area both pre and post plant operation. The results are also used to calculate an incremental intertidal zone dose, which is compared to the limiting "resident farmer dose calculations in the License Termination Plan for Bailey Point post-decommissioning." Maine Yankee operated from 1972-1996. Plant decommissioning is scheduled to be complete in late spring of 2005.

This sampling effort included a search for areas high in nuclear radiation (hot particle search), samples from the surface of the tidal region, core samples from the tidal region, and samples of biota including seaweed, lobsters, mussels, and fish. The results are discussed in this order. In all, about 600 samples from 147 locations were collected and analyzed. To ensure that the sampling effort was as comprehensive and efficient as possible, a model was used to determine the best locations. The results of this effort are summarized here.

Before any sample collection, a model of the bay was developed to determine the effect of tidal influences on releases of radioisotopes. The model takes into account the action of the tides, the flow of water, and the discharges from various points. The work was necessary due to the changes made over time to the plant. In particular, three different discharge points were used as well as the removal of a causeway over the lifetime of the plant. A theoretical model was developed to determine the location of the hottest zones for radioisotopes. This model was tested using floats to validate the results. The predictions of the model became the points for the first sampling effort. After measuring this first set and refining the model, a second sampling effort was accomplished based on the results of the first set. In this manner, a coordinated study was possible.

The first results to discuss involve the search for localized areas high in radiation. To accomplish this goal, an instrument which measures radiation exposure called a High Pressure Ion Chamber (HPIC) was used. The HPIC was placed on a sled and dragged across the mud flats at low tide. Three sets of measurements were taken. These sets were placed so that the HPIC system would pass close to the discharge points. If a single measurement of three times background was found, the HPIC would signal the researchers that a hot spot was found. No such measurement was found. In fact, the exposure seen away from shore was, in general, less than the background seen on shore. We feel this is due to the mixing of the sediment due to the action of tides and the turnover of sediment due to digging (clam or worm digging).

The next set of results involves the analysis of the samples taken from the surface of the intertidal zone. These samples were analyzed for certain radioisotopes associated with nuclear fission including ^{137}Cs and ^{60}Co. As expected, these were the predominate radioisotopes seen. The results were compared to measurements taken earlier. In general, the values seen are lower than before the plant was brought on line. We feel that the reason the values are so low is due to a mixing within the tidal flat, lowering the amount of radiation seen on the surface. The distribution of the Cesium and Cobalt is also consistent with the history of discharges. The Cobalt is highest near the recently used diffuser. Since Cobalt has a relatively short half-life, we expected to see very low levels at locations where discharges were stopped and highest where discharges were done more recently. Cesium, with a longer half-life, should be higher at locations that had more discharges. Overall the greatest concentration of plant derived radionuclides is in Bailey Cove and the area of the diffuser. Bailey Cove was the original plant discharge location prior to installation of the diffuser. The distribution is consistent with these assumptions.

As well as surface samples, cores were also taken, sectioned, and counted. The results show that the overall radiation is low. An individual core was sectioned and counted to determine how far into the soil the highest level of radiation exists. Most radiation was found below the surface, which is consistent with results from surface samples. Again, the data indicates that a mixing of the soil is occurring so that radioisotopes are distributed and do not remain localized.

In comparison, naturally occurring radionuclides such as ^{40}K are found at higher levels in the marine environment than either Cesium or Cobalt. The average naturally occurring Potassium concentration was about 10 pCi/g, which results in an exposure rate of approximately 8 mrem/yr. The average Cesium or Cobalt concentration was about 0.073 pCi/g or 0.019 pCi/g which results in an exposure rate approximately 0.17 mrem/yr or 0.13 mrem/yr, respectively using NRC approved soil screening values.

Last, several biota samples were taken and analyzed. These samples included lobsters, clams, mussels, seaweed and fish. The samples were crushed and analyzed for the same radioisotopes as above. For the shellfish, the shells were counted separately from the meat. Additionally, these samples were sent to another laboratory to search for radioisotopes, such as Beta emitters and Plutonium, which are difficult to measure (hard to detects). The results show that all levels are very low, including the hard to detect values.

As a final calculation, the results of the above samples were used to calculate the average and peak doses that an individual would receive if they stood on the tidal flat went swimming, went fishing, harvested seaweed, or ingested the biota. The results range between 3 mrem/yr for land reclamation to 2.6×10^{-3} mrem/yr for swimming. Such exposures are a small fraction of normal exposures received naturally through a year. The low exposures are indicative of the low values seen in the data sets.