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January 1973

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January 1973

*This invited paper will be presented at the American Nuclear Society and Marine Technology Society National Topical Meeting "The Ocean, Nuclear Energy and Man" on April 25-27, 1973 at West Palm Beach, Florida.

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Because many of our major population and industrial centers with large electrical power needs are located along our coastal regions, consideration is being given to siting nuclear power plants offshore either on man-made islands or barges surrounded by breakwaters. Two incentives for siting offshore are that the ocean provides essentially an unlimited supply of cooling water and scarce coastal land is left free for other priority uses.

Waste discharges from an offshore or coastal nuclear power plant can have local effects on the environment of the receiving waters. These effects consist mainly of an increase in temperature of the coolant water over ambient as well as the effect of the addition of materials added to the water in its passage through the plant. To determine how these discharges affect the ecology of the receiving waters the engineer is faced with the task of first estimating how they will be transported throughout the surrounding water. With the advent of high speed computers it is now possible under certain conditions to predict with great accuracy how this transport will take place.

At Rand we have developed a water-quality simulation model for use in well-mixed estuaries and coastal seas.[1-3] The model is based on the numerical solution by finite difference techniques of the two-dimensional vertically integrated equations of motion and continuity for a fluid. First, the water velocities and levels are computed, taking into account the bottom roughness, surface winds, effect of earth rotation, and the time variation of the area and shape of the bay due to the rise and fall of the tides. Predictions can be made of the changes in current patterns caused by the introduction of large man-made structures, such as offshore power plant sites, into coastal areas. Once the flow characteristics are established, the transport of constituents in the waters of the bay is then determined using the computed velocities and levels. These constituents can be either

conservative, salinity, or non-conservative, coliform bacteria or radioactive materials. The interaction and die-away of constituents is accounted for by a reaction model which describes the various biological, chemical, and physical processes, as well as their interactions, which occur between constituents.

The simulation model is currently being used in water-quality studies of several areas throughout the world, including: Jamaica Bay, Long Island, New York; Tampa Bay, Florida; and several estuaries in the Netherlands. Each of these studies have been accompanied by an extensive field investigation of the area under investigation. The model can accurately predict water levels and currents throughout the waters of a bay using a real tide as input. As an example, in Jamaica Bay the standard deviations between computed and field-measured water levels and velocities at five locations in the bay varied between .03 and .06 ft. and between 0.15 and 0.30 ft./sec.[4] respectively, for a five foot tide. Similar comparisons of measured and computed constituent concentrations such as dissolved oxygen, biochemical oxygen demand, coliform bacteria and salinity show good agreement.[3] In addition, the model has been used to predict the effect of the addition of a new auxiliary water-pollution control facility for combined sewer overflow on the coliform-bacteria densities in Jamaica Bay.[5]

The application of environmental simulation models of the type being developed by Rand can help to assist in estimating the effects of waste discharges from electrical power plants on the environment of the receiving waters if sufficient field data is available. In this way, quantitative rather than qualitative answers can be given to the questions of environmental effects of power plant siting as related to liquid waste discharges under normal and postulated accident conditions.

REFERENCES

1. Leendertse, J. J., "A Water-Quality Simulation Model for Well-Mixed Estuaries and Coastal Seas: Volume I, Principles of Computation," The Rand Corporation, RM-6230-RC, February 1970.

2. Leendertse, J. J., and E. C. Gritton, "A Water-Quality Simulation Model for Well-Mixed Estuaries and Coastal Seas: Volume II, Computation Procedures," The Rand Corporation, R-708-NYC, July 1971.

3. Leendertse, J. J., and E. C. Gritton, "A Water-Quality Simulation Model for Well-Mixed Estuaries and Coastal Seas: Volume III, Jamaica Bay Simulation ," The Rand Corporation, R-709-NYC, July 1971.

4. Leendertse, J. J., "A Water-Quality Simulation Model for Well-Mixed Estuaries and Coastal Seas: Volume IV, Jamaica Bay Tidal Flows," The Rand Corporation, R-1009-NYC, July 1972.

5. Gritton, E. C., "A Water-Quality Simulation Model for Well-Mixed Estuaries and Coastal Seas: Volume V, Jamaica Bay Rainstorms," The Rand Corporation, R-1010-NYC, July 1972.

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