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The Strategy for Assessing the Technical, Environmental, and Engineering Feasibility of Subseabed Disposal

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This report presents the strategy and management techniques used in the development of the U.S. Subseabed Disposal Program (SDP) for possible disposal of both high-level waste and spent fuel. These have been developed through joint efforts of the Department of Energy (DOE), Division of Waste Isolation, the Sandia Technical Program Manager, the Technical Program Coordinators, the Advisory Group, and the Principal Investigators.

Three subsections of this paper address the various components which make up the SDP strategy and management techniques. The first section summarizes the U.S. DOE high-level waste and spent-fuel disposal program and the position that the SDP occupies within that program. The second section, the Subseabed Program Plan, addresses the technical and administrative tools which are employed to facilitate the day-to-day operation of the SDP. The third section addresses the current studies and future plans for addressing the local, political, and international uncertainties that must be resolved before the SDP reaches the final engineering phases.

Interpretation

CONTENTS

	<u>Page</u>
Introduction	7
Nuclear Waste Management Strategy	8
Subseabed Program Plan: Strategy and Management Methods	12
Subseabed Strategy and Management Methods	20
Management Methods	22
References	27

ILLUSTRATIONS

Figure

1	NWTS Program Management Chart	11
2	Programmatic Activity Chart	19
3	SDP Research Approach	21

THE STRATEGY FOR ASSESSING THE TECHNICAL, ENVIRONMENTAL, AND ENGINEERING FEASIBILITY OF SUBSEABED DISPOSAL

Introduction

The assessment of geologic disposal of radioactive waste beneath the seabed is part of the Department of Energy (DOE) National Waste Terminal Storage (NWTs) Program. The overall goal of the NWTs Program is to identify and develop technologies that will provide a high degree of assurance that existing and future radioactive wastes can be isolated from the biosphere in a safe, environmentally acceptable manner and to provide necessary facilities to achieve this isolation.

The major thrust of the DOE NWTs Program is toward the isolation of waste in stable geologic formations within the contiguous United States, at depths reachable by conventional mining methods. The geological formations of primary interest are rock salt, basalt, granite, shale, and volcanic tuffs. A prime alternative is seabed formations. A systematic assessment of seabed formations has identified vast areas of deep ocean sediments which are considered to be some of the more stable formations on the earth.

The Seabed Disposal Program is investigating the feasibility of disposal within these sediments. The near-term objectives are to (1) assess the technical feasibility of the concept of engineered emplacement of appropriately solidified and packaged high-level wastes within the stable deep sea sediments and (2) develop and maintain the capability to evaluate and cooperate with other nations' ocean disposal programs.

Nuclear Waste Management Strategy

In the late 1950s, waste management strategies turned from short-term solutions to an increasing emphasis on the development of waste disposal methods which would provide isolation from the biosphere for very long periods of time with minimum requirements for maintenance and surveillance beyond. At the same time, commercialization of nuclear technology began with the use of radioisotopes in medicine and industry and with the construction of large nuclear power plants for the generation of electricity.

Increasing concerns with long-term environmental problems and the expanding role of nuclear technology have resulted in an evolving strategy for waste management which has received new emphasis in recent years and is becoming increasingly broad-based. U.S. government waste management strategies continue to evolve, and major initiatives are under consideration.

Recently, the recommendations of the DOE task force¹ on waste management and the Interagency Review Group (IRG) Report to the President² on nuclear waste management contain specific recommendations which are being used as a basis for the current programs.

The Interagency Review Group on Nuclear Waste Management was formed by the President's direction in March 1978. The final IRG report was submitted in March 1979. This report delineates some of the major objectives, strategies, and policy options of waste management.

On February 14, 1980 the President issued a statement on a comprehensive national radioactive waste management program. The national program is based on key characteristics of a strategy for high-level radioactive waste disposal as recommended by the IRG and is being followed generally.

- Mixed repositories in geologic formations should be the first approach to disposal in the U.S.
- Technology is adequate to proceed with geologic exploration for sites.
- A broad range of geologic media and environments should be explored during the site selection process in order to

have available several sites which are geographically distributed

- Deep ocean sediments should be evaluated as potential alternatives
- Technical conservatism should be used for the repository
- A systems approach should be used to select the geologic environment, repository site, and waste/package form
- Program flexibility and timing should consider the important role played by away-from-reactor storage of spent fuel

The DOE cannot unilaterally decide on and implement a long-term waste disposal program. The Energy Reorganization Act of 1974 requires that facilities for the long-term storage of high-level waste be licensed by the Nuclear Regulatory Commission. The National Environmental Policy Act of 1969 requires that appropriate Environmental Impact Statements be prepared as part of the decision-making process by the public state, special interest groups, and Federal agencies.

A Draft Generic Environmental Impact Statement³ (GEIS) on the management of commercially generated radioactive waste was issued in April 1979. A series of public hearings airing this document was held in 1979. Comments from these public hearings and other written comments are currently being considered, and a final GEIS is being prepared. The GEIS focuses on high-level wastes in the form of either discarded spent-fuel elements or canisters of waste from the reprocessing of such elements. Nine alternative concepts for disposal of long-lived radioactive waste are addressed:

- Geologic disposal using conventional mining techniques
- Very deep hole disposal
- Rock Melting
- Island disposal
- Subseabed disposal
- In-shaft disposal

- Reverse well disposal
- Treatment by transmutation
- Disposal in space

These concepts constitute a comprehensive set of waste management technologies. It is presently thought that additional disposal modes that could be identified as potential alternatives would merely be variations of one or more of these concepts. As part of the repository selection process, site-specific Environmental Impact Statements will be prepared.

The National Waste Terminal Storage (NWTs) Program encompasses the work breakdown structures and strategies to investigate and develop the technologies for selection, design, construction, and operation of Federal repositories. The NWTs program is comprised of four subprograms, each investigating isolation systems centered on different host media and specific related technologies:

1. The Office of Nuclear Waste Isolation (ONWI) Program thus far has concentrated on systems associated with rock salt formations with some work on granite and shale. The investigation into other hard rock formations is being expanded.
2. The Basalt Waste Isolation Program (BWIP) is investigating the basalt formations found within the DOE Hanford Reservation.
3. The Nevada Nuclear Waste Storage Investigation Program is investigating potential systems involving primarily granite, shale, and tuffs at the DOE Nevada Test Site. It is currently focusing on volcanic tuffs.
4. The Subseabed Disposal Program is investigating the deep ocean clay sediments.

The primary goal of the composite NWTs program is to identify specific candidate locations that might qualify as repository sites. The acceptance of these sites and associated systems will be gaged through comparison with criteria, guidelines, and regulations currently being formulated by the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Environmental Protection Agency. In the case of subseabed disposal,

criteria, guidelines, and regulations of appropriate international regulatory bodies and international treaties will also have to be considered. In the meantime, DOE is developing its own criteria to provide direction for the NWTS program efforts by establishing general performance criteria for the waste isolation system and general functional criteria for the site, repository, and waste package components of the system. The relationship among the NWTS Program participants is shown in Figure 1.

Figure 1. NWTS Program Management Chart

For the first repositories, only mined caverns in geologic formations within the continental United States are being considered. An alternative waste disposal concept study recently has been completed by Bechtel National, Inc. for ONWI.⁴ This study concludes that the subseabed alternative is the most promising alternative to mined geologic repositories, and recommends that the deep ocean sediments warrant further study as a waste isolation media.

The Subseabed Program is managed by Sandia National Laboratories. A committee of technical experts from oceanographic and academic institutions provide project guidance and review. Periodic peer reviews provide additional interaction with uninvolved technical experts and continuing assessment of the program goals and investigations. An international Seabed Working Group under the auspices of the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) provides a forum for discussions, assessment of programs, and planning of future efforts; coordination of research and joint research cruises and experiments; exchange of information; and the opportunity to maintain cognizance of international policies and issues which could affect the concept of seabed disposal.

A multiyear Subseabed Program Plan⁵ was issued in January 1980. It outlines in some detail the current and planned activities. It is governed by the consciousness that, even though our understanding of deep ocean sedimentary geologic formations indicates that they are repository candidates, much additional specific research and development is needed before the feasibility of the concept can be considered as having been demonstrated.

Subseabed Program Plan: Strategy and Management Methods

Program Plan

The primary objective of the Subseabed Disposal Program (SDP) is to assess the technical, environmental, and engineering feasibility of disposal of processed and packaged high-level nuclear waste or repackaged spent reactor fuel (SF), or both, in geologic formations beneath the world oceans. High-level waste (HLW) and SF are considered the most difficult of radioactive wastes to dispose of in oceanic geologic formations because of their heat and radiation outputs. From a scientific standpoint, disposal of other nuclear wastes, such as transuranic (TRU) and low-level wastes, and materials from decommissioned facilities are a subset of this program. If seabed disposal is found feasible for the most difficult

wastes, then other factors such as cost will become dominant in determining the use of the oceanic regime for other nuclear wastes. A secondary objective is to develop and maintain a capability to assess the seabed nuclear waste disposal programs of other nations.

The SDP is divided into four phases:

- Phase 1: Estimation of technical and environmental feasibility on the basis of historical data. Completed: 1976.
- Phase 2: Determination of technical and environmental feasibility from newly acquired oceanographic and effects data. Estimated completion date: 1985-87.
- Phase 3: Determination of engineering feasibility and legal and political acceptability. Estimated completion date: 1993-95.
- Phase 4: Demonstration of disposal facilities. Estimated completion date: 2000.

At the end of each phase of the program, a review is made and concept feasibility is assessed. This assessment requires both internal and external review. At each of these reviews (go/no-go gates), a comprehensive report will be prepared summarizing the results of that phase. If results indicate that the concept is unacceptable, the program will be terminated and emphasis thereafter will be placed on demonstrating this unacceptability to other nations which are considering using the seabed for HLW disposal. The main tasks to be accomplished before completion of each remaining phase are discussed in detail below.

Phase 2: Technical and Environmental Feasibility

- All units of a systems model must be operational. A model containing all parts of the system that address technical and environmental feasibility (biological transport, physical oceanographic transport, ion transport through sediments, thermal effects on sediments, canister responses, etc) will be made operational but not fully verified through laboratory or field experiments.
- All properties must be bracketed but not necessarily verified. Each unit of the model described above will require certain input properties. During this phase,

maximum and minimum estimates of all properties will be made (bracketed), and sensitivity analyses completed to identify properties that are critical. Certain of the identified critical properties will be acquired through laboratory and field measurements, but these will not be site-specific.

- Verification tests will be completed on certain property model units. Depending on resources available and the completion dates for sections of the system model, certain sections will be validated through both laboratory and field testing. As an example, the model unit nearest completion at this time addresses thermal transport through the sediments. It is hoped that an in-situ transfer heat experiment (ISHTe), currently in development and planned for deployment in 1982, will provide verification data for this section of the model.
- At least one site in each of the northern Atlantic and Pacific oceans will be identified and initially characterized. Although the geologic formations of interest are expected to be stable, uniform, and homogeneous over large areas, many areas have not yet been completely mapped. To be considered acceptable, sites should be topographically mapped and a detailed three-dimensional understanding of the sedimentary geologic formation developed. This task will be accomplished through a combination of sediment sampling and ocean-surface and near-bottom acoustic profiling of the sediments.
- A technical and environmental feasibility document will make an estimation of impacts on both man and the environment, using the total system model and the acquired properties. From this and other studies identified in this section, an assessment of technical and environmental feasibility will be made and the conclusions reviewed and published.

Phase 3: Engineering Feasibility

- All units of the system model must be developed and verified. All units of the system model will be developed, coupled, and verified for both technical and environmental feasibility through appropriate laboratory and/or field testing.
- All properties will be verified. Each unit of the system described above requires input properties. During this phase, the maximum-minimum estimates made in Phase 2 will be reviewed, and when required, the property information refined through additional laboratory and field experiments and measurements.

- Long-term (15-yr) in-situ experiments will be initiated. Several long-term thermal experiments using real waste and appropriately designed containers will be initiated to help validate the system models and to allow testing in real time through the peak heat and radiation period.
- A conceptual design of the total system (from spent-fuel discharge to the repository) will be completed.
- An Engineering Feasibility document will be completed and reviewed. A summary report of the studies in this section which contribute to the assessment of engineering feasibility will be compiled and the conclusions reviewed and published.
- Several sites in the Atlantic and Pacific oceans will be identified and characterized. Within the oceanic regime, large areas will be mapped in detail, and a three-dimensional understanding of sedimentary geologic formations developed. At the end of this phase several acceptable sites should have been identified in each ocean.
- National and international legal and political positions will be clarified. Since the legal and political implications of the disposal of HLW or spent fuel in geologic formations under the oceans are unclear, these must be resolved during this phase of the program.
- A Draft Environmental Impact Statement (DEIS) will be written and reviewed and a license application submitted. The DEIS will contain all the information and understanding developed in Phases 2 and 3, as well as results from long-term experiments and site selection studies.

Phase 4: Demonstration of Disposal Capability

- Conceptual Design and detailed designs for the total system will be completed.
- The license application or permit requested in Phase 3 will be received.
- After the license or permit has been received and the conceptual and detailed designs are complete, the dock and ship system will be built and tested.
- After receipt of the license and completion of the detailed designs, the land transportation network will be developed.
- A long-term monitoring network will be developed.

Two key questions must be answered in order to demonstrate both technical and engineering feasibility of seabed disposal:

- Is there a barrier or set of barriers, natural or manmade,* that will offer satisfactory containment of radionuclides? The barriers under consideration are

<u>Natural</u>	<u>Man-Made</u>
Sediments	Canister
Basement rock	Waste form
Ocean	Sacrificial layers (overpacks)

- Will these barriers still be adequate after introduction of waste containers?

These key questions must address:

- Hole closure following physical disruption of sediments
- Effects of heat
- Effects of radiation

The multibarrier concept, developed by the SDP in 1974, assumes a continuously wet environment in which solidified and packaged radionuclides are placed. The seabed sediments, together with any modifications to them, are the primary barriers to radionuclide migration. The canister is considered very important during the initial heat generation period until the geologic formation has returned to essentially ambient temperatures (~300 yr). The waste form and the water column are supplemental barriers.

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* A barrier is a quantifiable passive mechanism that will delay the movement of radionuclides, allowing time for radioactive decay to make the waste less harmful or ultimately harmless.

A reference disposal system has been established for purposes of assessment and programmatic planning, even though that system may have to be altered as additional information is required. The reference system was chosen on the basis of simplicity, completeness of emplacement technology, and estimated cost. The reference subseabed geological disposal system involved the placement of appropriately treated wastes or spent reactor fuel in a container which will be placed into clayey sediments away from the edges of oceanic tectonic plates (to avoid volcanic and seismic activity), and away from the edges of major circular surface currents (to avoid subsurface agitation and resource exploitation associated with these currents). The abyssal-hill areas of the ocean bottom covered by this definition are designated mid-plate/mid-gyre (MPG) areas.

Several emplacement methods appear feasible, though none have been developed in detail. We are conceptually considering penetrators, winch-controlled injectors, trenching or drilling to emplace wastes at a substantial depth beneath the sediment surface.

Program Structure

The program has been subdivided into seven major activities, which have been further divided into tasks and subtasks for the purpose of organization, planning, and reporting accomplishments in a logical and consistent manner. The abbreviated program outline follows.

Activity A: Site Studies -- To find areas in the oceans that satisfy the site selection criteria; to select one or more sites from each area, and to survey them. At present, because of limited funds, only areas in the North Atlantic and North Pacific are being assessed.

Activity B: Environmental Studies -- To supply data and information for the Risk/Safety Analysis, transportation, and Site Studies activities of the program. These studies include the physical and biological sections of the Subseabed Disposal Program.

Activity C: Multibarrier Identification and Quantification -- To identify and quantify both natural and man-made barriers that could be interposed between buried wastes and mankind; to evaluate ways in which these barriers might be breached; and to develop methods of preventing or counteracting such breachment.

Activity D: Emplacement of Wastes in Sediments -- To develop technical understanding of the benefits of the various emplacement methods (e.g., penetrometer, injector, trench, and drill), make cost estimates, and demonstrate the concept.

Activity E: Transportation -- To develop the necessary technology to move suitably packaged wastes or spent fuel from the originator plant to the dock facility, thence by ship to the disposal area, and to emplace the waste package in the submarine geologic formation.

Activity F: Social-Scientific Issues -- To maintain an ongoing evaluation of legal and institutional structures in the U.S. and other countries relating to seabed disposal; to similarly survey local political attitudes; to furnish information by which any nation can form institutional structures for the proper use and control of seabed disposal; and to insure that data needed to support legal, social, and political discussions are collected and evaluated as a basis for decision.

Activity G: Risk/Safety Analyses -- Use all available information to predict the degree of risk and the amount of environmental impact expected from all phases of the Subseabed Disposal Program.

Figure 2 shows the current schedule for the total program. This schedule is tightly interrelated to program funding.

Figure 1. Project Schedule, 1980-2000

Sub seabed Strategy and Management Methods

In order to most productively use the limited resources available for assessment of the waste disposal potential of the geologic formations beneath the world oceans, effective site selection and management strategies must be employed. These strategies for the program can be broken down into two parts. The first addresses the process for selection of acceptable geologic formations. The second addresses the process which assesses the technical, environmental, and engineering feasibility of geologic disposal beneath the oceans.

Strategy for Site Studies

Since the geologic formations beneath the oceans are so vast (covering about 70% of the surface of the globe) and the resources available to study them so small, a cost- and manpower-effective method was developed to focus the site studies. A group of leading U.S. oceanographers was given the task of developing a methodology which would allow, after the appropriate research was completed, acceptable sites to be identified. The approach being implemented involves

- Development of a list of exclusion criteria through which the global area under consideration could be decreased to a somewhat more manageable size
- Ranking of the areas not excluded in Step 1 using all available historical data
- Acquisition of additional generic information for the smaller areas of interest
- Acquisition of site-specific ranking data
- Selection of one or more sites in each ocean from those still considered acceptable for long-term engineering assessment studies. The site selection process is described in more detail in a paper by Laine, et al.

Strategy for Barrier Assessment

Since the processes within some of the more promising oceanographic geologic formations are very slow, and since the decay times of some of the radionuclides are very long, it was apparent that the most efficient

and possibly the only method of assessing the feasibility of oceanographic geologic disposal would be through the development and use of predictive models and computer codes. Models and codes alone, however, are ineffective if not supported by sound research and field data. The approach being taken by the Subseabed Disposal Program to give credence to the predictions made by the codes and models is shown in Figure 3. The first step is to incorporate the best existing science expressed in mathematical terms in a set of models and codes which describe a function or process occurring in subseabed disposal. Second, it will be necessary to acquire from the historical literature or through laboratory measurements necessary properties to use the codes and models correctly. Third, complete sensitivity studies must be made of each section of the model, identifying properties that critically affect the outputs. Fourth, verifiable predictions must be made based on the models, codes, and property estimates. Fifth, complete lab or field experiments must be performed which can be used to validate the models, codes, and properties. If the predictions from a section of the model and codes agree with the field experiments, then that section will be coupled with other sections to yield an overall systems-predictive model. If the predictions and validation experiments do not agree, then the model will be refined and the property data improved.

Figure 3. SDP Research Approach

Management Methods

In order to manage the SDP and move most rapidly toward the goal of assessment of the feasibility of subseabed high-level waste and spent-fuel disposal, a number of management methods were developed. These methods are covered in this section.

Scientist Participation

At the very beginning of the SDP it was decided that a major part of the geologic research would be carried out in U.S. universities and research institutions. Top scientists in each of the critical fields of geology have been recruited to work with Sandia researchers and scientists from other government laboratories and industry as a subseabed disposal program. All the researchers are involved in the planning and execution of the program, even though in some cases the specific expertise of a scientist and some aspects of the research will not be needed for several years. For such scientists, a maintenance level budget is being used to keep them involved in the program. Conversely, university scientists whose research has been identified as critical in the first phases of the SDP are funded to a maximum of 30% of their total annual research costs. This approach produces two benefits for the SDP: first, since a maximum of only 30% of an individual's support comes from the SDP, the scientists are more likely to remain independent and to identify possible problem areas which might disqualify the concept; second, if the scientist and research task are chosen judiciously, the other 70% of the scientist's research funded by other programs or agencies will also benefit the SDP. These interactions, as well as by direct and continuous exchange between different government agencies (EPA, NRC, NSF, USN, NOAA, etc.), much additional information is available for use by the SDP. A formal advisory committee to help with the long-range planning, development of strategy, and the expansion of the management methods for the subseabed Disposal Program has been chosen from the list of participating scientists.

Periodic Review of the Program

The program has been designed with predetermined times for technical and peer review. These reviews are considered at each go/no-go decision point at the end of the technical and environmental feasibility, the engineering feasibility, and the pilot production phases. In addition to these major reviews, a yearly publication of all data is prepared and widely distributed for review. An annual meeting is held with all SDP principal investigators, at which the past year's research is discussed and reviewed by the other scientists within the Subseabed Program. When a piece of research has been completed, the program strongly encourages the investigators involved to publish their data and results in the open literature where they can be reviewed by the public and the scientific community at large.

At the end of each major section identified above, an additional outside review of the program and of the individual tasks will be made by an eminent group assembled by the National Academy of Science or a comparable organization. This review will accomplish two things: first, the reviewers will be asked to identify any problem areas which have been overlooked by the Subseabed Program; second, and more importantly, they will be asked to make an independent assessment of the validity and acceptability of the Subseabed Disposal Program at that phase of its development.

In addition to the participants mentioned above, an international Subseabed Working Group was established under the Nuclear Energy Agency/OECD has been developed. In addition to exchanging information on specific research topics of interest, this group reviews, on a yearly basis, the research of the six countries involved in the assessment of geologic disposal beneath the oceans. This review has as one of its goals, the identification of any uncertainties which might make the concept unacceptable.

Activity Chart and Program Plan Development

Early in the development of the program, the Technical Advisory Committee (TAC) decided that a program plan and an activity time line

chart identifying individual research tasks was necessary. The program plan was prepared in two parts: Volume I is a description of a multiyear plan for the program; Volume II contains a detailed breakdown of the individual activities for any single year, and identifies the principal investigators, tasks, and funds available to accomplish those tasks. Each year a new Volume II will be compiled so that, over the years, Volume I and several Volume IIs will show how the program is progressing toward its stated goals. The activity chart is a tool which allows the program managers and the TAC to monitor the progress of the program in a logical, step-wise fashion. It also allows for the rapid identification and marshalling of assistance in areas in which unforeseen problems might arise.

Since the evaluation of the technological, environmental, and economic feasibility of subseabed emplacement is the central purpose of the SDP, and since no definite conclusions as to these aspects have yet been reached, a definitive and complete delineation of the political, legal, and regulatory aspects of this emplacement option must of necessity await further progress within the overall program plan. However, the engineered emplacement of radioactive wastes within the subseabed geologic formation is at present considered to be a viable disposal option on a tentative, preliminary basis. Accordingly, the SDP incorporates a multidisciplinary effort to identify in an ongoing fashion institutional, legal, and regulatory problems on a national and an international basis.

A primary concern is, of course, to ensure that the conduct of the program and the proposed subseabed emplacement mode be in full and ongoing compliance with applicable laws and regulations of the United States. To ensure compliance with the provisions of the National Environmental Policy Act (NEPA), the SDP maintains an ongoing action to establish and maintain full and accurate documentation. Those evaluations required by law are therefore being anticipated and a documentary basis is being provided to facilitate their being performed with the optimum intellectual rigor.

The public participation and response requirements under NEPA are being provided for. The SDP has initiated long-term planning in this respect so as to identify public concerns at an early date in order to

address them in a forthright manner, within an educational context, within the parameters of our political processes, and within a "feedback" process which might effect further scientific, technical, and environmental investigation. An ongoing series of interviews is presently planned with concerned citizens in this field in order to initiate the public participation process.

The SDP recognizes that political acceptance of the overall concept, should it prove ultimately feasible, is of the utmost importance; for this reason, in addition to the general public education efforts, we will attempt to maintain liaison with interested legislators to provide them with the necessary background information and to work with them on any pertinent legislation which might ultimately be deemed appropriate by them.

On the national scene, at present, there is no explicit statutory and regulatory regime which deals with subseabed emplacement directly. Further technical information will have to be evolved before it can be definitely determined whether additional regulation is required. At present, even though the Ocean Dumping Act prohibits ocean dumping of high-level wastes and provides for EPA licensing of low-level dumping, this statute simply does not reach the subseabed emplacement mode (a disposal methodology radically different from dumping in the legal, technical, and environmental senses).

Because of the very nature of the emplacement mode under consideration, international and multinational political and legal concerns are an important consideration of the Program. Under the recent Presidential Executive Order designating ocean seabed areas as the "world's commons" and requiring the evaluation of the effects on foreign nations by a program such as this one, possible favorable geo-political aspects of subseabed emplacement are receiving intensified evaluation. In essence, one primary geo-political advantage of the subseabed option, if made available to other nations, will be to afford an alternative to those nations who lack a terrestrial storage or disposal option for high-level wastes. Without such an alternative, such nations might be forced to "bargain"

with other nations having large uninhabited areas for storage rights, and the necessary price might well be the transfer of high-level nuclear technology under inappropriate circumstances; the latter might well have a destabilizing effect on worldwide nuclear arms nonproliferation.

Even though a multinational or international regulatory regime dealing with subseabed emplacement might well be a preferable alternative, the legal basis should be maintained to preserve this disposal option on a unilateral national basis if that should ultimately prove to be necessary and advisable. In that connection, it would be most unfortunate if the current ongoing Law of the Sea negotiations under U.N. auspices were to lead to any international legal impediments against the subseabed option should it prove to be otherwise viable. The SDP will therefore maintain liaison with concerned U.S. officials involved with the negotiations in order to provide them information as to the program's progress in order to minimize the possibility of future legal impediments to U.S. action in this regard. Notwithstanding this concern, cooperation with interested foreign governments and international agencies remains a primary concern of the program. The International Seabed Program is a major means of addressing this concern.

As in the U.S., no international treaties, laws, or regulations directly address the subject of controlled emplacement of waste within the subseabed geological formations, in contrast to ocean dumping, which has received considerable attention.

The U.S. has not disposed of any radioactive waste in the ocean since 1970; however, several European nations dispose of low-level waste under the aegis of the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD). The NEA requires prior notification and consultation between NEA member nations as well as supervision of dumping operations by NEA representatives.

An international agreement on ocean dumping was reached in December, 1972, resulting in the London Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Materials. It prohibits the dumping

of high-level wastes and requires special permits for the dumping of other than high-level radioactive wastes. Provisional definitions and recommendations concerning the dumping of radioactive wastes have been issued by IAEA and are being used by the London Convention contracting parties.

In its ongoing concept feasibility assessments, the SDP will continue to evaluate the above-discussed political, legal, and institutional concerns to ensure that, in the event the concept is ultimately feasible, the national and international regulations will be in phase with this new technology so that it can be legally implemented if desired.

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