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E. M. Carlin
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January 1984

Prepared for
Pacific Northwest Laboratory
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THE INTERNATIONAL PROGRAM TO STUDY SUBSEABED DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES

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1.0 INTRODUCTION

The Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) is sponsoring an international program to study the feasibility of utilizing geologic formations beneath the oceans for burial of solidified high-level nuclear wastes. This disposal concept is usually referred to as seabed, or subseabed, disposal, but may also be referred to as seabed or subseabed burial, and seabed or subseabed emplacement. At present Canada, the Federal Republic of Germany, France, Japan, the Netherlands, Switzerland, the United Kingdom, the United States and the Commission of the European Communities are conducting research on the concept, and are members of the NEA Seabed Working Group (SWG).

This report provides an overview of the international program to study seabed disposal of nuclear wastes. Its purpose is to inform legislators, other policy makers, and the general public as to the history of the program, technological requirements necessary for feasibility assessment, legal questions involved, international coordination of research, national policies, and research and development activities. Each of these major aspects of the program is presented in a separate section.

2.0 THE SEABED DISPOSAL CONCEPT

The objective of seabed burial, similar to its continental counterparts, is to contain and to isolate the wastes. The subseabed option should not be confused with past practices of ocean dumping which have introduced wastes into ocean waters. Seabed disposal refers to the emplacement of solidified high-level radioactive wastes (with or without reprocessing) in certain geologically stable sediments of the deep ocean floor. Specially designed surface ships would transport waste canisters from a port facility to the disposal site. Canisters would be buried from a few tens to a few hundreds of meters below the surface of ocean bottom sediments, and hence would not be in contact with the overlying ocean water (Figure 2.1).

The concept is a multi-barrier approach for disposal. Barriers, including waste form, canister, and deep ocean sediments, will separate wastes from the ocean environment. High-level wastes (HLW) would be stabilized by conversion into a leach-resistant solid form such as glass. This solid would be placed inside a metallic canister or other type of package which represents a second barrier. The deep ocean sediments, a third barrier, are discussed in the Feasibility Assessment section. The waste form and canister would provide a barrier for several hundred years, and the sediments would be relied upon as a barrier for thousands of years.

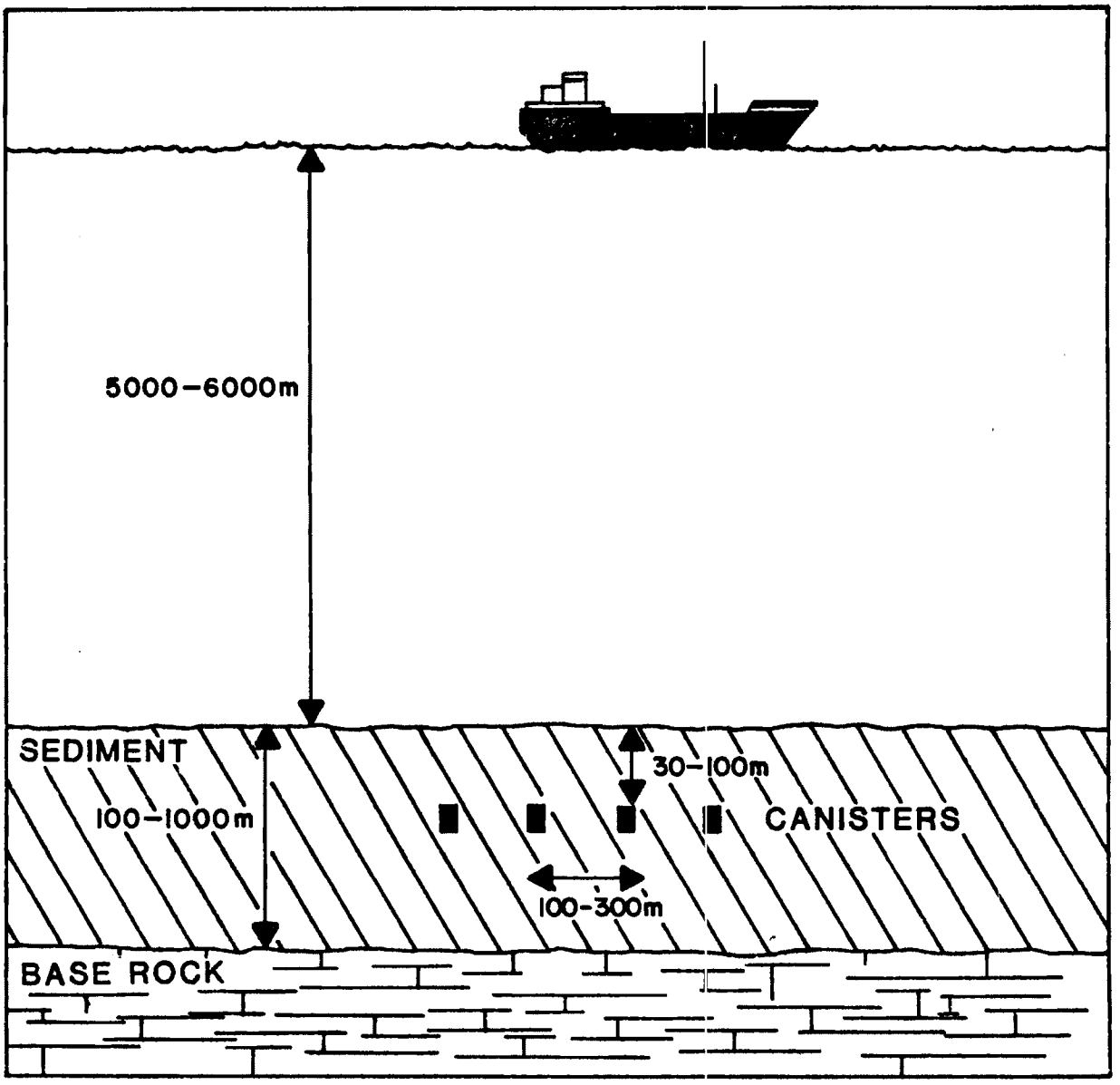


FIGURE 2.1. An Idealized View of a Seabed Repository in the Deep Ocean

3.0. HISTORY OF SEABED INVESTIGATIONS

Research on seabed disposal began in the U.S. in 1974 at Sandia National Laboratories under the Atomic Energy Commission (1) and has continued under the Energy Research and Development Agency (ERDA) and the Department of Energy. During 1974 and 1975 the Seabed Disposal Program (SDP), using largely existing oceanographic information, narrowed the research to the central regions of the oceans for burial of high-level wastes. Large portions of these regions are exceptionally stable geologically, nearly devoid of commercially important resources, and are remote from most present or projected human activity. Placement of HLW into deep-sea trenches at the leading edges of tectonic plates was considered and rejected (2). Trench areas are unstable and geological processes unpredictable, hence wastes buried there might later become exposed to the water column. Placement of waste containers on, instead of within, the ocean floor was also rejected since it was difficult to conceive of a practical container which would last the tens to hundreds of thousands of years believed necessary to keep the potentially dangerous wastes from mixing with ocean waters.

The U.S. program entered a second phase in 1976 which will be completed about 1990 (4). Its objective is to collect new data and build the computational tools essential to assess the scientific and environmental feasibility of seabed disposal.

The NEA Radioactive Waste Management Committee (RWMC) defines and periodically reviews NEA's program of work in the area of waste management. The RWMC decided at its first session in 1975 that workshops should be organized to determine the interest, nature, and scope of possible international cooperation in field investigations of feasible waste disposal options. The first workshop on seabed disposal of high-level wastes was held in 1976. Based on that workshop, and a second in 1977, the Seabed Working Group was formed as an NEA-restricted group (i.e., membership is limited to those nations with active programs investigating the deep seabed waste disposal option). The SWG has

held annual workshops from 1978 to the present (5). Workshop participants, including both SWG member and non-member nations, are listed by year in Table 3.1.

The SWG has promoted the exchange of information so that member countries can avoid unnecessary overlap of their research programs. There has been considerable cooperation in research programs among the member countries although jointly funded research projects did not begin until 1983 (6).

TABLE 3.1. Nations Participating in Annual SWG Workshop (P) and SWG Member Nations (M)

	Year							
	76	77	78	79	80	81	82	83
Australia	P							
Belgium					P	P		P
Canada	P		PM	PM	PM	PM	PM	PM
CEC[a]	P		P	P	P	PM	PM	PM
FRG[b]	P			PM	PM	PM	PM	PM
France	P	PM	PM	PM	PM	PM	PM	PM
Italy							P	P
Japan	P	PM	PM	PM	PM	PM	PM	PM
Netherlands				P	PM	PM	PM	PM
Switzerland					P	P	PM	PM
United Kingdom	P	PM	PM	PM	PM	PM	PM	PM
United States	P	PM	PM	PM	PM	PM	PM	PM

(a) CEC - Commission of the European Communities
(b) FRG - Federal Republic of Germany

REFERENCES AND NOTES

(1) A history of the early U.S. program may be found in D. M. Talbert Subseabed Disposal Program Annual Report, January to December 1979, Volume I--Summary and Status. SAND 80-2577/1, August 1981.

(2) W. P. Bishop and C. D. Hollister, 1974, "Seabed Disposal--Where to Look," Nuclear Technology, 24.

(3) The external reviews may be found in D. M. Talbert Seabed Disposal Program Annual Report, January to December 1975, SAND 76-0256, May 1976.

(4) The U.S. program's projected schedule, definition of task, and policies may be found in: Anderson et al., (1980), The Strategy for Assessing the Technical, Environmental, and Engineering Feasibility of Subseabed Disposal, SAND 79-2245; Seabed Programs Division (1981), Subseabed Disposal Program Plan, SAND 81-000711; and Seabed Programs Division (1981), Program Criteria for Subseabed Disposal of Radioactive Waste: Research Strategies and Review Processes, SAND 80-2384.

(5) D. R. Anderson et al., eds. (1976) Report to the Radioactive Waste Management Committee on the First International Workshop on Seabed Disposal of High-Level Wastes, Woods Hole, Massachusetts, February 16-20, 1976, SAND 76-0224; D. R. Anderson, ed., (1978) The Third International Seabed High-Level Waste Disposal Assessment Workshop, Albuquerque, New Mexico, February 6-7, 1978; A Report to the NEA Radioactive Waste Management Committee, SAND 78-0369; D. R. Anderson, ed., Proceedings of the Fourth Annual Seabed Working Group Meeting, Albuquerque, New Mexico USA, March 5-7, 1979, SAND 79-1156; D. R. Anderson, ed., Proceedings of the Sixth Annual NEA-Seabed Working Group Meeting, Paris, France, February 2-5, 1981, SAND 81-0427; D. R. Anderson, ed., Seventh International NEA-Seabed Working Group Meeting, La Jolla, California, March 15-19, 1982, SAND 82-0460.

(6) A short overview of the international research may be found in K. R. Hinga, 1982, "Ocean Research Conducted for the Subseabed Disposal Program," EOS 63 (40) 802-803.

4.0 FEASIBILITY ASSESSMENT

The goal of the SWG is best described in the Seabed Working Group Status Document published by the NEA (1). "The goal of the Seabed Working Group is to provide scientific and technical information on disposal to enable international and national authorities to assess feasibility." "There is no intention by any of the participating countries, either unilaterally or through the NEA, to begin a disposal operation in the near future."

The question of feasibility can be divided into three parts:

1. Will selected deep ocean sediment types adequately contain buried wastes for the long periods of time believed necessary?
2. Assuming sediments of proper barrier characteristics exist, are they found in geologically and climatically stable regions of the ocean floor?
3. Is it possible to implant wastes in such a manner as not to impair the barrier properties of the sediments?

Each of these three questions requires a different research approach. The following sections on barrier assessment, geologic setting, and emplacement techniques describe the approach used by the SWG participants and the research conducted to answer each question. An additional topic, potential environmental effects, is also addressed.

4.1 BARRIER ASSESSMENT

Large areas of the ocean floor are covered with thick layers (tens of meters to kilometers) of very fine-grained clay sediments. These sediments are highly adsorptive to most of the waste elements and very resistant to water movement. Such sediments would retard the movement of wastes once these were released from the canister and waste form.

Since a repository must contain wastes for thousands of years, it is not possible to build an experimental repository and wait to see if the sediments, in combination with canister and waste form, provide adequate containment. It is necessary to build mathematical models that describe the processes relevant

to repository performance. However, these same predictive models can be used for calculating short-term effects, which are subject to laboratory and field verification.

The sediments surrounding the canister provide the major barrier to the release of wastes. Studies are being conducted to measure the sorption of waste elements to deep sea clays and to directly measure effective diffusion rates through sediments. Other studies measure the chemical and mechanical responses of ocean sediments to waste-generated heat for the first few hundred years. Corrosion rates of canister materials and the leach rates from various waste forms under deep sea conditions are being measured. Physical oceanographic, biological , and geochemical data are being combined to provide models of water column transport of isotopes. When all these models are combined, it will be possible to calculate the radiological consequences of a waste disposal scenario.

Preliminary models are presently available and will be refined and tested in the next five years of research. Much of the data necessary to make predictions has been collected, and laboratory and field work are continuing.

Descriptions of the model development can be found in the SWG reports (2), the U.S. annual reports (3), and in the SWG and U.S. status documents (4). Preliminary results indicate the sediments are a very good barrier. Burying waste material at a depth of 20 to 30 meters appears to be sufficient to meet U.S. performance standards (equivalent to the standards presently under development for mined repositories), even in the absence of a stable canister.

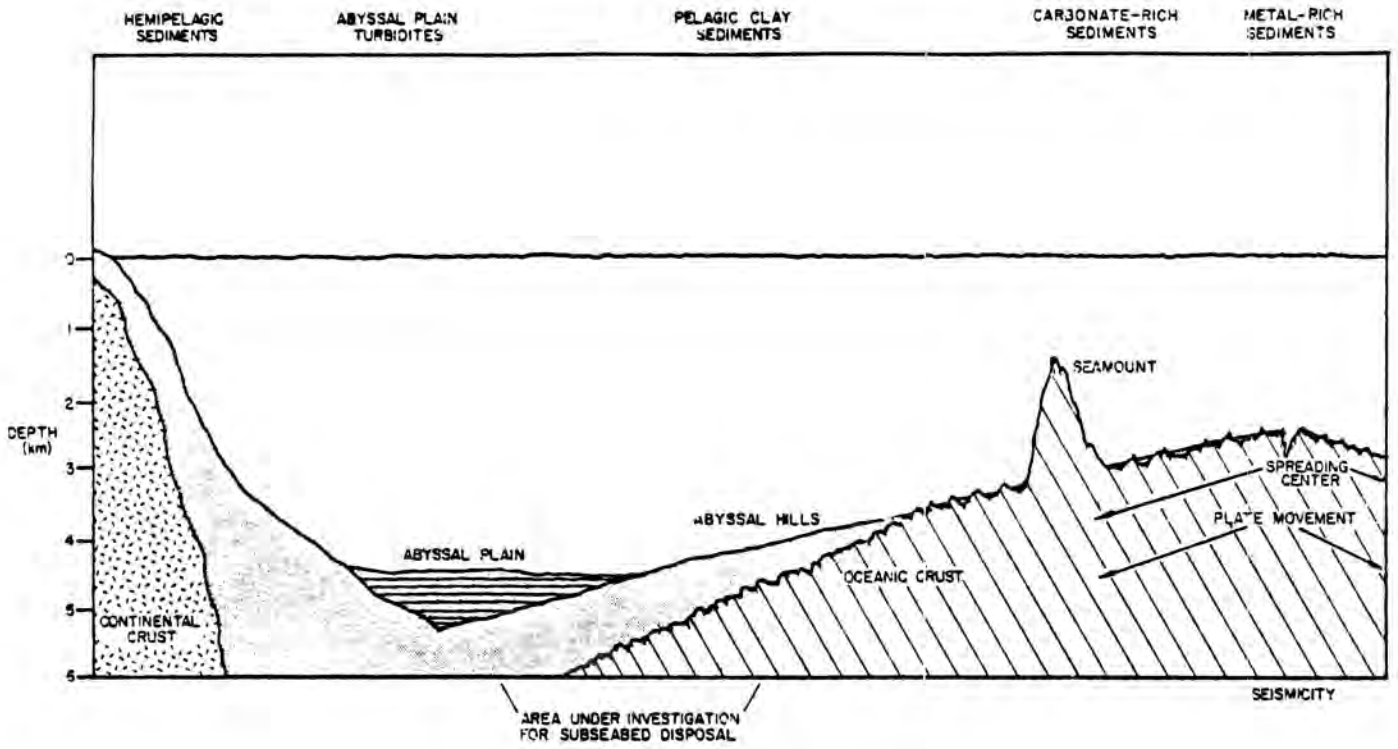
4.2 GEOLOGIC SETTING

The future geologic stability of any location can be predicted only if the geological processes acting on the location and the effects of past geologic events in the area are understood. The earth's crust consists of very large tectonic plates continuously created at the mid-ocean ridges and subducted in the trenches. The plate edges are sites of seismic activity and volcanism resulting from stresses created as the tectonic plates move past each other and as the plates collide with continental masses. In contrast, the mid-plate areas are geologically quiet. Areas within these mid-plate regions have had,

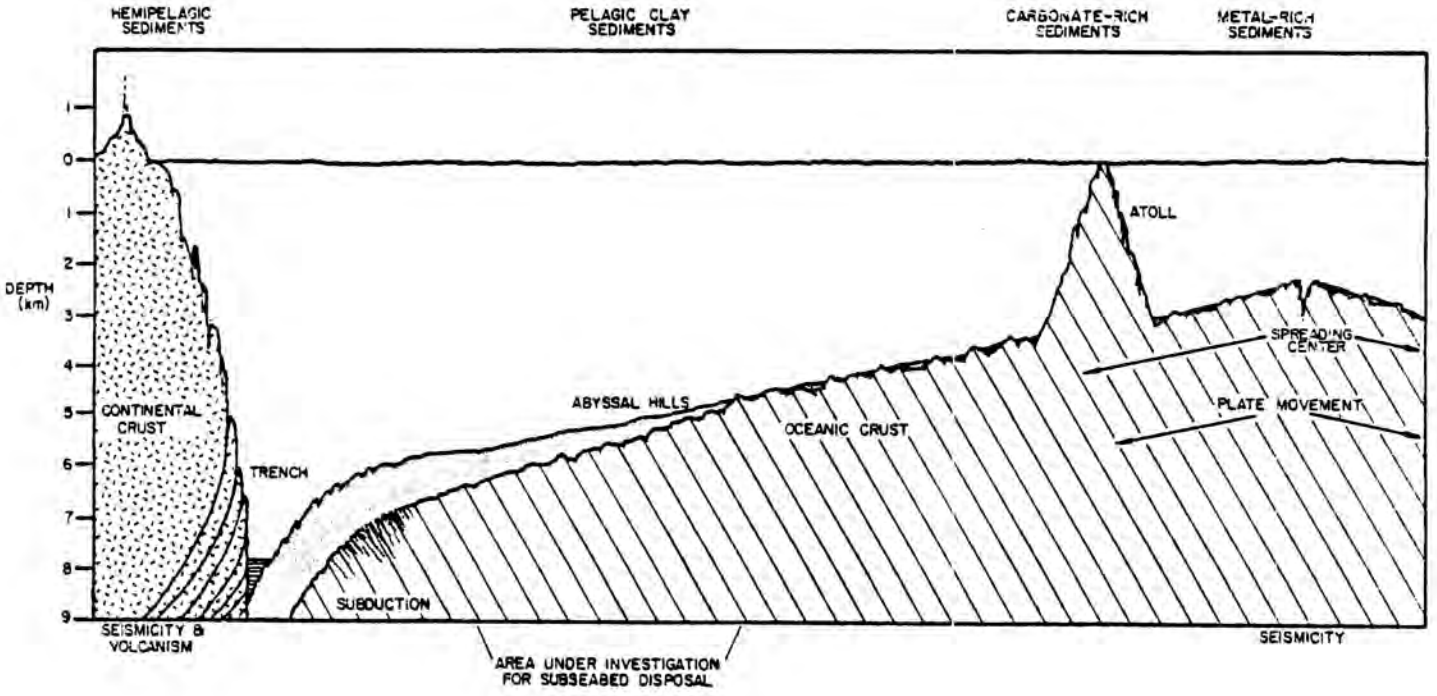
for many million years, a continuous deposition of sediments with the proper barrier qualities necessary for successful seabed disposal. This continuous deposition, without measurable erosion, has continued during periods of time when the earth has experienced glaciations and climates quite different from today's. In the next few hundred thousand years the plates will only move a few kilometers, not far enough to significantly change the depositional environment for a mid-plate site. The task of unravelling the geologic history of a location in the ocean is relatively simple. The oldest ocean floor is only 200 million years of age in contrast to the 4.5-billion-year history of the continents. The seabed research is directed to locations in mid-plate regions as shown in Figure 4.1.

Figure 4.2 shows the locations considered by the SWG. The three Western Pacific locations appear to meet the requirements (6) of a repository site and have uniform qualities over large areas. The SWG, however, has recently decided to concentrate on two Atlantic locations, where sediments are thicker than in the Pacific. This may be desirable for some emplacement techniques, but these sites are not as large or as uniform as the Pacific locations.

Site studies typically involve detailed mapping of the sediments using acoustic techniques. Seismic reflection studies of sub-bottom reflectors indicate the depth of the sediments, the uniformity of sediment layers, and whether there has been past slumping of sediments indicating instabilities. Cores are taken to provide samples for laboratory work, such as sorption studies, and to determine the history of sedimentation in the region. More detailed site characterization is required for locations in both oceans, to assure that the locations are free from outcropping seamounts, sediment slumps, and similar geological inhomogeneities which would invalidate the predictive models.



ATLANTIC TYPE PROFILE



PACIFIC TYPE PROFILE

FIGURE 4.1. Geologic Areas Under Investigation for Seabed Disposal

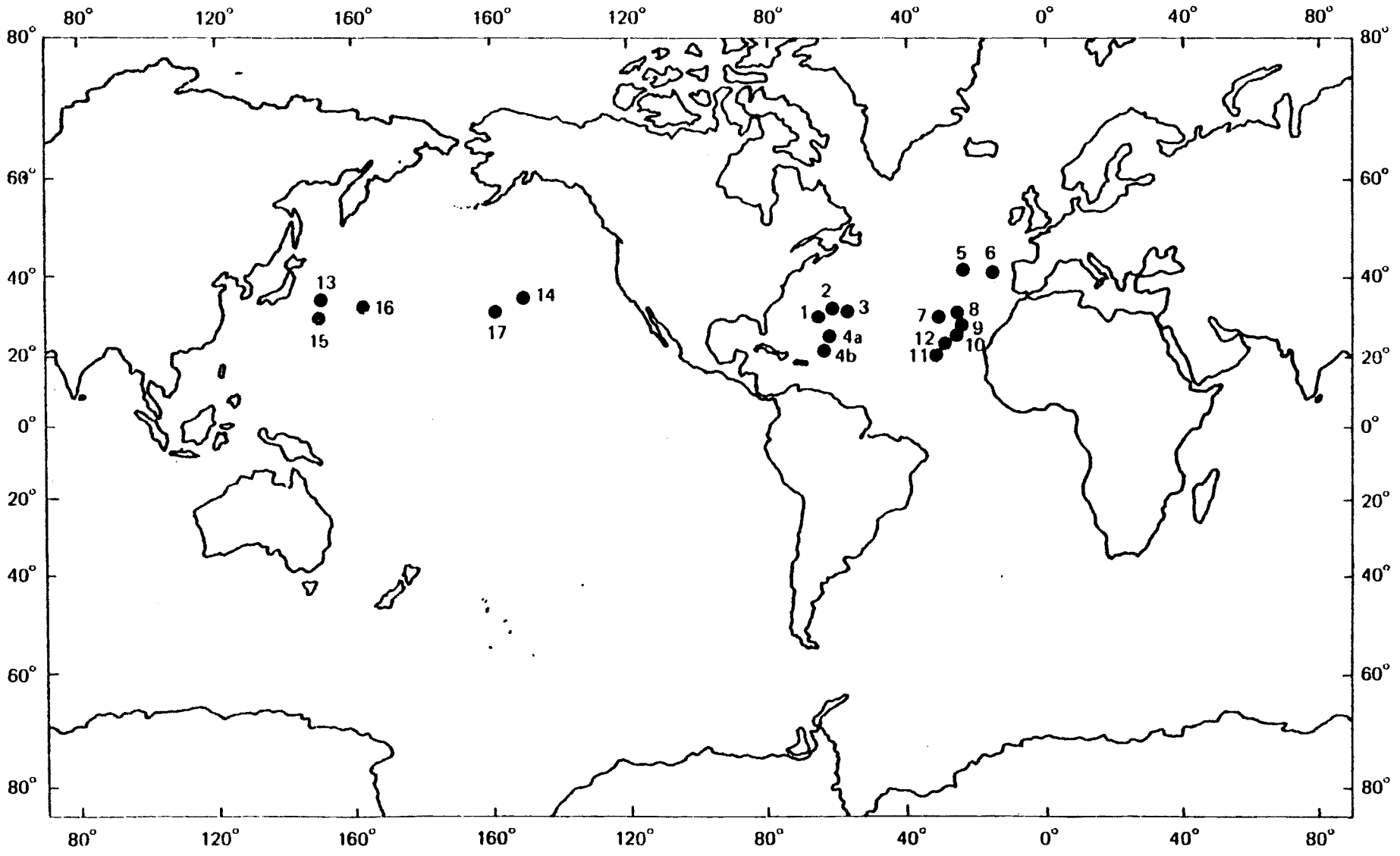


FIGURE 4.2. Map of SWG Study Locations for Seabed Disposal

FIGURE 4.2 LEGEND. Locations That Have Been Studied by SWG Participants

Map Location		Area Name
1	(SBR)	Southern Bermuda Rise
2	(NBR)	Northern Bermuda Rise
3	(SSAP)	Southern Schm Abyssal Plain
4a	(NNAP)	Northern Nares Abyssal Plain
4b	(SNAP)	Southern Nares Abyssal Plain
5	(KTF)	Kings Trough Flank
6	(Ibl)	Iberia-l
7	(GMW)	Great Meteor West
8	(GME)	Great Meteor East
9	(M)	Madcap
10	(CV1)	Cape Verde Abyssal Plain (East)
11	(CV2)	Cape Verde Rise
12	(CV3)	Cape Verde Abyssal Plain (West)
13	(B1)	B1 area of PAC I
14	(MPG-II)	MPG II area of PAC II
15	(C1)	C1 area of PAC I
16	(E2)	E1 area of PAC I
17	(MPG-I)	MPG I area of PAC II

4.3 EMPLACEMENT TECHNIQUES

Unlike long-term repository performance and geologic stability the emplacement techniques can be demonstrated in real time before a disposal operation begins. The SWG task group responsible for engineering studies has decided to investigate two emplacement techniques; penetrator emplacement and drilled emplacement (7). Other possible techniques are considered variations of these two.

Penetrator emplacement involves free-fall or velocity-boosted canisters of appropriate design, burying themselves to the required penetration depth in the ocean bottom. Present mathematical models indicate the hole would immediately

close behind the penetrator (8). In 1982 the U.S. subseabed program field-tested mathematical penetration models and through-the-sediment telemetry systems with a 0.2-meter diameter, 0.34- ton, penetrator in shallow water. At the SWG meeting in 1983, the United Kingdom and the Commission of the European Communities reported that 30-meter penetration had been achieved in 5,000 meters of water with a 0.325-m diameter penetrator. The models predict that up to 100 meter penetration might be achieved by this technique. The mechanical response of deep sea sediments to both fast and slow displacements, as would occur in free-fall and drilled emplacement, is also under study.

Emplacement could also be achieved by using a drill ship or platform. The research drill ship Glomar Challenger has been drilling in deep ocean depths (6,000 m) since 1968 and routinely re-enters specially prepared drill holes. Although the Glomar Challenger itself would not be a suitable emplacement ship much of the technology to design such a system is available.

A requirement for either method of emplacement is the accurate placement of canisters, probably at spacings of about 100 meters. At this distance the canisters, or stacks of canisters if drilled emplacement is used, would be thermally and chemically isolated from one another. Present oceanographic instrumentation can measure the position of a package on the ocean bottom to within one meter in 5,000 meters water depth. With proper care it is presently possible to place a package within a few meters of a desired target, as with drill re-entry. Additional development would be necessary, however, before such tasks can be performed routinely.

The U.S. program had scheduled much of the engineering development for later phases of the program. With the increasing level of effort being applied to subseabed research by the other SWG member nations, a considerable acceleration of emplacement studies and other aspects of operating a seabed disposal operation is expected in the international program.

No work has been conducted on waste-handling techniques for land transport or port facilities since it is believed that these would be identical or very similar to the techniques being developed for land-based repositories.

4.4 POTENTIAL ENVIRONMENTAL EFFECTS

The objective of a HLW repository is to prevent the radionuclides in the waste from reaching the biosphere in harmful amounts, thereby ensuring human protection, prevention of ocean pollution and effects on biota. A properly operating seabed repository meeting human health protection standards is not expected to affect the oceanic biota.

The amount of radioactive materials reaching the ocean floor is expected to result in concentrations much less than the natural concentration of radioactive materials. Deep-ocean sediments have concentrations of radionuclides that are on the average higher than terrestrial soils; Furthermore, deep-sea organisms are not expected to be particularly radiation-sensitive. Some of the highest reported doses to an organism from natural sources are to deep-sea shrimp. On the average, organisms in the deep ocean receive approximately the same doses as shallow-water and terrestrial organisms.

The sediments near the waste canister will be subject to high temperatures and, for some canister designs, a high radiation dose. Sediments at expected repository depths, however, are not inhabited. The inhabited layer of sediment is about 10 cm deep. The temperature rise at 10 cm below the sediment-water interface above a canister buried at 20 meters is calculated to be a maximum of 0.04°C, less than would be expected to affect organisms.

The implantation of a canister will mechanically disturb a few square meters of the inhabited surface sediment. Since it is likely that canisters will be placed about 100 meters apart, the area disturbed would be a very small portion of the total repository area.

The program also must consider what will happen if one or more canisters break up, fail to penetrate to the proper depth, or are dropped onto the sea floor. The effects on the biota would largely depend on canister design and the waste form. There would certainly be some local effects from increased temperatures during the first few hundred years. The predictive models being developed will be able to estimate potential doses to biota and to man that would occur after the canister corrodes and release of the radionuclides to the surrounding sediments begins.

REFERENCES AND NOTES

(1) Quotations are from the draft NEA Coordinated Program on Seabed Disposal of Radioactive Wastes; Status Report by the Seabed Working Group of the NEA Radioactive Waste Management Committee. To be published by the NEA in December 1983.

(2) D. R. Anderson et al., eds. (1976) Report to the Radioactive Waste Management Committee on the First International Workshop on Seabed Disposal at High-Level Wastes, Woods Hole, Massachusetts, February 16-20, 1976, SAND 76-0224; D. R. Anderson, ed., (1978) The Third International Seabed High-Level Waste Disposal Assessment Workshop, Albuquerque, New Mexico, February 6-7, 1978; A Report to the NEA Radioactive Waste Management Committee, SAND 78-0369; D. R. Anderson, ed., Proceedings of the Fourth Annual Seabed Working Group Meeting, Albuquerque, New Mexico USA, March 5-7, 1979, SAND 79-1156; D. R. Anderson, ed., Proceedings of the Fifth Annual NEA-Seabed Working Group Meeting, Bristol, England, March 3-5, 1980, SAND 80-0754; D. R. Anderson, ed., Proceedings of the Sixth Annual NEA-Seabed Working Group Meeting, Paris, France, February 2-5, 1981, SAND 81-0427; D. R. Anderson, ed., Seventh International NEA-Seabed Working Group Meeting, La Jolla, California, March 15-19, 1982, SAND 82-0460.

(3) W. P. Bishop, ed., Seabed Disposal Program--A First-Year Report, December 1974, SAND 74-0410; D. M. Talbert, ed., Seabed Disposal Program Annual Report, January-December 1975, SAND 76-0256; D. M. Talbert, ed., Seabed Disposal Program Annual Report, January-December 1976, SAND 77-1270; D. M. Talbert, ed., Seabed Disposal Program Annual Report, January-December 1977, SAND 78-1359; D. M. Talbert, ed., Subseabed Disposal Program Annual Report, January-December 1978, SAND 79-1618; D. M. Talbert, ed., Subseabed Disposal Program Annual Report, January-December 1979, SAND 80-2577; Seabed Programs Division, K.R. Hinga, ed., Subseabed Disposal Program Annual Report, January-December 1980, SAND 81-1095; Seabed Programs Division, K. R. Hinga, ed., Subseabed Disposal Program Annual Report, January-September 1981, SAND 82-0664.

(4) Both the U.S. program and the SWG are separately preparing comprehensive status reports for publication late in 1983. Also see reference (1).

(5) For further discussion of deep sea sedimentation in relation to waste management see K. R. Hinga et al., "Disposal of High-level Wastes by Burial in the Sea Floor." Environmental Science and Technology 16, 28A-37H.

(6) Site selection procedures and criteria for the U.S. program may be found in Laine et al. (1982), Program Criteria for Subseabed Disposal of Radioactive Waste: Site Qualification Plan, SAND 81-0709.

(7) D. M. Talbert, 1980, Subseabed Radioactive Waste Disposal Feasibility Program: Ocean Engineering Challenges for the 80's, SAND 80-0304.

(8) Two different computational models give similar results. See the annual reports for 1980 and 1981 in Ref. 3.

5.0 INTERNATIONAL AND U.S. LAW

The concept of emplacing high-level radioactive wastes beneath the deep ocean floor presents legal questions which center on the concept's relation to legal requirements for protection of the marine environment and appropriate use of the seabed. Seabed disposal is not addressed explicitly in any present international convention or in any U.S. national legislation.

5.1 INTERNATIONAL LAW

Initial legal analyses have focused on determination of applicability of international conventions and general principles of international law. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention)(1) is the most comprehensive international agreement regulating marine pollution by dumping. Signatories to the Convention now number fifty-two, and include all major maritime nations.

Because the London Convention does not address seabed disposal and because certain key provisions are ambiguous, several legal issues have arisen. Primary among these is uncertainty about whether seabed disposal equals "dumping" as defined in the Convention (Article III). The treaty prohibits "dumping" of high-level radioactive wastes (and a number of other substances); any disposal of such wastes would therefore be permissible only if not regarded as dumping (2).

In addition to the Convention's explicit provisions, the implied intent or purpose of the treaty is being examined, as well as the circumstances under which drafting occurred. While there is no stated intent in the original draft to regulate seabed disposal of nuclear wastes, it has been argued that the implicit goal of the Convention is to control all possible sources of pollution of the marine environment (3).

The second major international treaty which must be considered is the Convention on the Law of the Sea (4), signed by 130 nations, which will become international maritime law once it is ratified by at least 60 nations. Despite the failure of some countries, including the United States, to adopt the

treaty, all nations will be bound by the Convention's general principles to the extent that these are, or become, customary international law.

Legal analysis of the applicability of the Law of the Sea Convention to seabed disposal is focusing on three major sets of provisions, those dealing with protection of the marine environment, appropriate use of the seabed, and the conduct of marine scientific research.

The treaty contains no specific provisions on deep-sea disposal of radioactive waste either in the definition of "pollution" or in its Articles (Part XII) applicable to the protection and preservation of the marine environment (5). However, the broad definition of "pollution" may be used to argue the treaty's applicability to the seabed disposal concept (6).

The Law of the Sea Convention (Part XI) considers the area of the seabed and its resources, located outside national jurisdiction, to be the common heritage of mankind (7). Relevant provisions governing appropriate use of the seabed include Articles 1, 137, 145, and 157 (8). These articles concern: preventing states from exercising rights over any part of the international area; defining activities in the international area that would be subject to regulation; requiring that activities in the international area be carried out with "reasonable regard" for other activities in the marine environment; and providing special powers to an international authority created by the treaty.

Convention provisions regarding scientific marine research in the international area are also being reviewed for their applicability to seabed field studies (9).

Other international agreements with implications for the transport of nuclear wastes, nuclear liability and enforcement are being reviewed (Convention for the Safety of Life at Sea, Convention for the Prevention of Pollution from Ships, Convention of the Physical Protection of Nuclear Material, IAEA Regulations for the Safe Transport of Radioactive Materials, and the Paris Convention of 29th July 1970 on Third Party Liability in the Field of Nuclear Energy) (10).

In addition to the various international conventions that may be found applicable to seabed disposal, certain general principles of international law

will apply. These norms apply to all nations and will have to be considered by nations who may wish to operate a seabed repository.

The evolution of international environmental law has resulted in a requirement for all nations to protect the marine environment. A second international principle requires states to assume liability for any breach of their international obligation to safeguard and preserve the human environment. This obligation includes a prohibition of pollution of the seas (11).

At present, at least three international groups of legal experts are assessing the questions described above. Two of these groups meet under NEA auspices, and a third is meeting under the direction of the Contracting Parties to the London Convention.

The SWG Legal and Institutional Task group was created in 1982 to assess legal and institutional implications of the seabed disposal concept. The Task Group submitted a preliminary legal and institutional analysis to the SWG Executive Committee in May, 1982 (12).

A second international group of legal experts is assisting the NEA in a comprehensive study of legal, administrative, and financial aspects of the long-term management of radioactive wastes.

Finally, legal experts will meet at the instruction of the Intergovernmental Maritime Organization (IMO) Secretariat according to a resolution (13) passed at the 1983 Consultative Meeting of the Contracting Parties to the London Convention. The group's task is to clarity the interpretation of Article III of the London Convention in relation to disposal of high-level radioactive and other hazardous waste within the seabed (14). A report of findings is expected to be presented at the Eighth Consultative Meeting in 1984.

5.2 U.S. DOMESTIC LAW (15)

The language of a U.S. statute, the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) (16) appears to prohibit seabed disposal of high-level wastes by the United States. EPA (17), ERDA (18), NDAA (19), and DOE (20) have reached this conclusion. In addition, a Department of State

official has stated that MPRSA "seems to prohibit any American disposal of high-level wastes in or under the ocean" (21). Twenty-two environmental/public interest groups have endorsed testimony before the House Subcommittee on Oceanography that MPRSA prohibits seabed disposal (22).

The conclusion that the seabed concept is illegal under MPRSA is based on the Act's prohibition of the issuance of permits to dispose of high-level radioactive wastes in the ocean (23). The Act also bans the transport of high-level radioactive wastes for dumping at sea (24). It has been contended that careful emplacement of waste into subseabed geologic formations does not equal dumping within the Act's intended coverage (25). This contention is based on the exclusion of certain activities from the Act's definition of dumping. The exclusion, however, appears to exempt only an experimental seabed disposal project in which retrievability is provided for (26).

In addition to MPRSA, several other U.S. laws appear applicable to the seabed concept. Under the National Environmental Policy Act (NEPA) (27), seabed disposal falls within the scope of Executive Order 12114 ("Environmental Effects Abroad of Major Federal Actions") (28). This order extends EIS requirements to "major Federal actions significantly affecting the environment of the global commons outside the jurisdiction of any nation (e.g., the oceans or Antarctica)" (29).

The Endangered Species Act (30) would require at least consultation with the Secretary of Commerce or the Secretary of the Interior before implementing a seabed disposal program (31). The scope of the law includes "any action authorized, funded, or carried out by a Federal agency (which would) result in the adverse modification or destruction of a critical habitat (of an endangered species)" (32). The Biological Assessment Section requires agencies to conduct a biological assessment of the area if any species may be present that is listed or proposed to be listed as endangered (33).

Finally, the Marine Mammal Protection Act (34) would be directly applicable to a subseabed repository if its development or use involved the knowledgeable or anticipatable injury, capture, or killing of a protected marine mammal species (35).

REFERENCES AND NOTES

(1) Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, December 29, 1972; in force August 30, 1975; in ILM 11 (1972): 1291 (hereafter cited as the London Convention).

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(3) Initial discussion of Treaty intent can be found in Marine Resources Project, Seabed Disposal: The Legal, Institutional and Political Context; and Queneudec, Effects of Changes in the Law of the Sea.

(4) Convention on the Law of the Sea, adopted April 30, 1982, not yet in force.

(5) Patrick Reyners, Legal Aspects of Deep-Sea Disposal of Radioactive Waste (International Nuclear Law Association, 1981), p. 19.

(6) Ibid., p. 20. See also Marine Resources Project, Seabed Disposal: The Legal Institutional and Political Context, p. 67-68, and Queneudec, Effects of Changes in the Law of the Sea, p. 6-8, 11.

(7) Convention on the Law of the Sea, Article 136.

(8) For discussion of the applicability of these Articles, refer to Marine Resources Project, Seabed Disposal: The Legal, Institutional and Political Context, p. 78-81; Queneudec, Effects of Changes in the Law of the Sea; John Norton Moore, Some Preliminary Considerations Concerning the Legal and Foreign Policy Aspects of a Regime of Subseabed Disposal of Nuclear Wastes (unpublished), Sandia Laboratories, 1982; and D. A. Deese et al., Political and Institutional Implications of the Seabed Assessment Program for Radioactive Waste Disposal, Urban Systems Research and Engineering, Inc., Cambridge, MA, 1981.

(9) See Marine Resources Project, Seabed Disposal: The Legal, Institutional and Political Context, p. 79-80; and Queneudec, Effects of Changes in the Law of the Sea, p. 15-17.

(10) Marine Resources Project, Seabed Disposal: The Legal, Institutional and Political Context, p. 71-78.

(11) Queneudec, Effects of Changes in the Law of the Sea, p. 13.

(12) The Task Group analysis will be reported in the 1983 Seabed Working Group Status Document, Section 5.

(13) The Resolution was submitted jointly by the Federal Republic of Germany, Norway, and Spain.

(14) IMO, Resolution on Matters Related to Dumping of Radioactive Wastes at Sea, LDC 7/WP.9, 17 February 1983.

(15) The discussion on U.S. Domestic Law is adapted from Carlin, The Sub-Seabed Option: Political and Legal Implications from a National Perspective.

(16) 33 U.S.C. 1401 et seq. (Supp. IV, 1974).

(17) Letter dated 10 September 1976 from Roger Sterlow, Assistant Administrator for Air and Waste Management, EPA, to Congressman Morris K. Udall, Chairman, House Subcommittee on Energy and the Environment.

(18) ERDA Memo dated 4 August 1976 from Stephen Greenleigh, Assistant General Counsel for Program Development, to James Liverman, Assistant Administrator for Environment and Safety.

(19) MDAA Memo dated (approximately) November 1978 from Daniel Finn, Staff Attorney (through Eldon Greenberg, General Counsel), to Sam Bleicher, Deputy Assistant Administrator for Coastal Zone Management.

(20) DOE Memo dated 14 January 1981 from James Glasgow, Attorney, Office of General Counsel, to Hank Edler, Office of Gereral Counsel.

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(22) Statement of Clifton E. Curtis, Center for Law and Social Policy, before the Subcommittee on Oceanography, Rouse Committee on Merchant Marine and Fisheries, November 20, 1980.

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(26) David Deese, Nuclear Power and Radioactive Waste, A Sub-Seabed Disposal Option? (Lexington, MA: Lexington Books, 1978), p. 71, note 35.

(27) National Environmental Policy Act, 42 U.S.C. 4341.

(28) Executive Order 12114,'Environmental Effects Abroad of Major Federal Actions," issued 4 January 1979, by President Carter, Section 1-1.

(29) Ibid., Sections 2-3 (a) and 2-4 (a).

(30) Endangered Species Act, P.L. 93-205, December 28, 1973, as amended five times through December 28, 1979.

(31) D. A. Deese et al., Political and Institutional Implications of the Seabed Assessment Program, p. 71.

(32) P.L. 93-205, Sec. 3 (11).

(33) D. A. Deese et al., Political and Institutional Implications of the Seabed Assessment Program, p. 71-72.

(34) 16 U.S.C. 1361, October 21, 1972, as amended through July 10, 1978.

(35) D. A. Deese et al., Political and Institutional Implications of the Seabed Assessment Program, p. 71-72.

6.0 OECD/NEA AND SEABED WORKING GROUP COORDINATION OF SEABED STUDIES

6.1 OECD/NEA COORDINATION (1)

The Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) promotes cooperation among its 24 member governments in two major areas: nuclear energy development, and safety and regulation. As part of the Agency's safety responsibilities, the NEA supports national efforts toward reliable treatment, storage, and disposal of nuclear wastes. NEA activities such as information sharing, establishment of joint research and development projects, and the discussion of issues and strategies are overseen by the Radioactive Waste Management Committee (RWMC).

The Nuclear Energy Agency's involvement in high-level nuclear waste disposal focuses on the capability of geologic formations for ultimate disposal. The Agency provides a framework for several international cooperative projects designed to contribute to the assessment of this capability. These projects include the Stripa Project in Sweden (2), the International Sorption Information Retrieval System (ISIRS) (3), and the International Seabed Working Group (SWG). Under the sponsorship of NEA, the SWG exchanges information and coordinates research and development activities to evaluate the feasibility of seabed disposal.

The NEA's primary role as sponsor and administrative secretary to the SWG appears to be expanding. It was suggested at the Eighth Annual SWG Meeting that responsibility for publishing SWG documents be transferred from the United States Seabed Disposal Program to OECD/NEA. A more active NEA role is also suggested by the Agency's significant contribution to the SWG Legal and Institutional Task Group's meetings.

In addition to its contributions in the area of scientific and technical research of the high-level waste problem, NEA has undertaken a comprehensive study of the legal, administrative, and financial aspects of long-term nuclear waste management. Along with legal and administrative aspects now under consideration by the SWG, NEA would be interested in an economic analysis of the seabed disposal concept.

A number of questions have arisen regarding the appropriate role for OECD/NEA in the research and possible development of the seabed disposal concept. Some countries view the NEA as too limited a forum to pursue a question as important as whether or not high-level nuclear wastes should be disposed of in the seabed, and suggest that the International Maritime Organization (IMO) or the signatory level of the London Dumping Convention would be more appropriate. Other countries favor a more restricted forum, fearing that a wider forum would further politicize the issue, resulting in loss of efficiency and interruption of research. Still other countries desire NEA auspices for the research phase only, and would support broadening the forum for a possible operational phase. If the seabed disposal concept were put into operation, it would need to be determined whether the NEA could be an adequate surveillance or regulatory mechanism, possibly linked to other international conventions as in the case of sea dumping.

Within the Nuclear Energy Agency, questions of priority, timing, and strategy are being considered. Should the NEA assign the same priority to seabed disposal it assigns to land-based geologic disposal for high-level wastes? Should the NEA encourage the SWG to move ahead quickly with its research program or to proceed with slow deliberation? Will NEA encourage a limited, or a broad, international forum for research and/or possible development stages of seabed disposal? Can NEA prevent the same kind of political difficulties the Agency has experienced in regard to the low-level dumping issue from developing around the seabed disposal concept?

As OECD/NEA continues to facilitate international research of the seabed option, the Agency and its Member countries face some difficult legal, political, and tactical questions. The NEA and the SWG hope to resolve these, so that continued research leading to a feasibility determination will be possible.

Some of these questions may be clarified after the December 1983 IMO Secretariat meeting of legal experts (discussed in the International Law section). On behalf of the SWG, NEA will prepare background information for this meeting.

6.2 SEABED WORKING GROUP COORDINATION

The policy and direction of the SWG research has been determined by the SWG Executive Committee. A member from each SWG nation sits on the committee. The chair of the Executive Committee was held by the U.S. delegate until 1983, when it passed to the Netherlands Representative. The studies of the SWG have been conducted by the following eight task groups:

Systems Analysis Task Group (SATG)
Site Selection Task Group (SSTG)
Biology Task Group (BTG)
Physical Oceanography Task Group (POTG)
Sediment Barrier Task Group (SBTG)
Near Field Task Group (NFTG)
Engineering Studies Task Group (ESTG) (formed in 1981)
Legal and Institutional Task Group (LITG) (formed in 1982)

Each group may have one or more interim meetings during the year. In recent years there have been some joint task group meetings, as dictated by needs of task groups to exchange information.

The SWG's role has been changing in recent years from a forum for informational exchange to active coordination of research among the participants. At the 1982 annual meeting a temporary coordination task group was formed until suggestions for reorganization of the SWG could be considered. At the 1983 meeting several changes were made. The task group lead correspondents were redesignated task group leaders and were asked to take a more active role in their groups. A new level of organization was added: two coordinators were appointed, with one to two more expected later, who will spend up to full time with the SWG activities. The coordinators report to the Executive Committee. In 1984 the Executive Committee will not meet with the task groups at the annual workshop, but will meet with the task group leaders and the coordinators about two months later.

REFERENCES AND NOTES

(1) Discussion of the OECD/NEA coordination of seabed studies is based on non-attributable interviews of NEA policy-level officials, conducted by Elaine M. Carlin.

(2) For a description of the Stripa Project see Nuclear Energy Agency, Organization for Economic Cooperation and Development, The International Stripa Project, Paris, March 1983.

(3) For a description of the International Sorption Information Retrieval System see Nuclear Energy Agency, Organization for Economic Cooperation and Development, International Cooperation for Safe Radioactive Waste Management, Paris, 1983, p. 11-12.

7.0. NATIONAL POLICY SUMMARIES (1)

The extent and nature of a country's participation in the Seabed Working Group's international research program is largely a function of government policy. The continuation of the research program, and the possible development of a seabed disposal operation, will depend on present and future policy decisions.

Current national positions and priorities on the seabed burial option, vis-a-vis other high-level waste disposal options, are presented below. In addition to each country's current policy position, several factors that may affect future policy are considered. These include urgency of disposal needs, domestic political developments, and the international status of the concept.

7.1 CANADA (2)

Canada's association with the Seabed Working Group of the NEA derives from its very significant scientific interest in the deep seabed, its desire to be well informed on seabed disposal in the event that international agreements are required, and its long term interest in the activities of the NEA. If the results of the SWG are developed enough by the late 1980s, they would be included as background information for review as a part of the concept assessment process for irradiated fuel waste disposal. Canada has no expectation of using seabed disposal and has not set priorities on any geologic media other than the first choice of hard granitic rock.

The irradiated fuel waste disposal research and development program in Canada is focused on the concept of deep disposal in the granitic rocks of the Canadian Shield. The program is a research program only and no site selection can be started until after the concept has been accepted by regulatory agencies, subjected to public hearings and approved by the federal and provincial governments. This process is not expected to be concluded before 1990. The earliest possible date for operation of a disposal facility would be early in the next century. Meanwhile, the irradiated fuel will be safely stored in supervised retrievable storage systems.

A budget of $740,000 was approved for 1982-1983 for research related to seabed disposal, while approximately $37,000,000 is being spent annually on the research related to granitic rock disposal.

The quantity of irradiated fuel in underwater storage at the nuclear power reactor sites in Canada is close to 6000 tonnes as of July 1983. The annual production quantity today is 1000 tU/yr and on completion of the planned reactor construction program in 1995 this production rate will increase to approximately 2000 tU/yr. No date has been set for the start of a commercial disposal facility. However, the quantity of irradiated fuel accumulated to that time should be less than 100,000 tonnes.

Canada, in common with most countries with nuclear programs, has experienced local public protests to the geological research work. These protests seem to have abated as the public obtains a clearer understanding of the program. Canada does not dump low-level radioactive wastes at sea, but does participate in the scientific evaluation and analysis of the NEA sea-dumping.

The Canadian Government has not yet defined its official position on the applicability of the London Dumping Convention to seabed disposal. It is Canada's position that an international agreement (rather than a bilateral or multilateral consensus) should be reached before seabed disposal is implemented (assuming concept feasibility). The international community should assure widespread acceptance of the potential risks and should bear the ultimate responsibility.

7.2 FEDERAL REPUBLIC OF GERMANY (3)

Authorities in the Federal Republic of Germany see seabed disposal as a worthwhile area for international research, and intend to step up their participation in the OECD program in the areas of near-field and systems analysis. Currently, their main interest is in obtaining a scientific basis for making decisions in response to the questions about seabed disposal which are developing in the international program.

The German waste management reference concept is achieved in the frame of the so-called "integrated waste management concept." The key elements of this

concept are reprocessing of spent fuel, recycling of plutonium and uranium in light water reactors (LWR) and (according to the state of implementation) in fast breeder reactors, disposal of low-level, medium-level, and high-level waste in deep geologic formations. The time schedule for the realization of the elements of the integrated waste management concept envisages that all plants are in operation on an industrial scale by the year 2000. The first German commercial reprocessing plant with a capacity of 350 tU/yr is to be in operation in 1992. Until then, most of the spent fuel out of German LWRs will be reprocessed by COGEMA (France) and BNFL (Great Britain).

In 1979, the heads of the Federal and State governments called for the investigation of "other waste management technologies," especially the direct disposal of spent fuel. By the mid 1980s an assessment is to be made if the direct disposal of spent fuel brings decisive advantages in terms of safety in relation to the integrated waste management concept.

The reference concept for the disposal of low-level, medium-level, and high-level waste in the FRG is deep geologic disposal. A first repository for low-level waste and waste from decommissioning is to be operational in 1988 in the Konrad iron ore mine. A repository for high-level, medium-level, and low-level waste in the Gorleben salt dome is to go into operation at the end of the 1990s. The contract for sinking of the shafts was placed in October 1983. A decision, if the Asse salt mine will be reopened as a repository for low-level and medium-level waste, was expected to be made at the end of 1983. If the decision is positive, Asse could be in operation in 1988, similiar to Konrad.

Interim storage facilities for various wastes are scheduled so that no difficulties may appear relating to the opening dates of the repositories.

The total amount of radioactive waste generated in the whole range of nuclear power applications in the Federal Republic up to the year 2000 (including the waste returned from COGEMA and BNFL) is expected to be about 330,000 cubic meters of low level and medium level waste, and 6000 vitrified blocks of high-level wastes (preliminary canister date: glass volume 150 l, diameter 43 cm, length 150 cm).

Germany does not, and for the time being does not intend to, participate in the sea-dumping of low-level waste, but does participate in the program of surveillance of the dumping site and in the other research programs of the OECD in that respect. Research work may begin on methods for conditioning for a safe sea disposal of short-living gaseous nuclides from reprocessing, with the aim of making safety comparisons to the reference concept of deep geologic disposal.

Today, Federal Government expenditures for research projects in the frame of OECD's programs, as mentioned previously, amount to 2 million marks per year (0.8 million U.S. dollars).

7.3 FRANCE

France's policy on seabed disposal is to consider the concept as a possible geologic disposal option for low and intermediate alpha-bearing wastes, and high-level wastes. The Government's first-choice option for high-level disposal is geologic land formations. However, selection and research of potential geologic formations for high-level wastes ranks third after two other national nuclear waste management priorities: First, the choice and implementation of a new shallow land burial site for low-level nuclear wastes, and second, the selection and study of geologic formations for deep disposal of low and intermediate alpha-bearing wastes. France considers seabed disposal an attractive disposal option, but only as an alternative because it is not known how much time will be required to solve technical, scientific, and international political problems.

In 1984, the French Government will spend between 5 and 10 million francs (0.6 to 1.2 million U.S. dollars) on seabed disposal research, in addition to funding a research cruise.

One important factor that may affect a country's policy on waste disposal options is the urgency of its disposal needs. In the case of France, it does not appear that urgency will affect government decisions on seabed disposal. Although France requires a disposal solution for low-level and alpha-emitting wastes within four to five years, it has at least 20 years before it must dispose of high-level wastes. As of mid-1983, the quantity of high-level waste

glass in storage is about 300 m^3. In the year 2000, France anticipates a quantity of about 3000 m^3 of glasses. France reprocesses spent fuel for Japan, the FRG, the Netherlands, Switzerland, Italy, and Beligum, but reprocessing wastes produced are to be returned to the country of origin for ultimate disposal.

A second factor that may affect France's policy on seabed disposal is domestic political considerations. In France, these do not appear to have the potential to affect decisions on seabed disposal. While the major parties support nuclear energy development, one faction (primarily local people) opposes terrestrial disposal. This opposition, however, is not great enough to preclude a terrestrial disposal option. Another larger, more diffuse, faction opposes sea disposal. However, France continues its low-level liquid waste-dumping operations.

A third factor, the international status of the concept, may also affect policy decisions. The French Government has not adopted an official position regarding the applicability of the London Dumping Convention to seabed disposal. However, the Ministry of Environment and the CEA (Atomic Energy Commission) consider that the Convention is not applicable to seabed disposal which is a particular case of geologic disposal. This question will be discussed at the governmental level. France believes if seabed disposal were operationalized (assuming concept feasibility), it must be within the framework of international cooperation (rather than bilateral or multilateral consensus). For international political reasons, there should be no rush toward seabed disposal, but rather increased study of the ocean bottom (including further comparison of research techniques). International acceptability, along with engineering feasibility and safety, are the three major components of seabed disposal that must prove acceptable.

7.4 JAPAN

Japan's policy on seabed disposal is to collect information about the concept, but not to engage in direct research. The Government defines seabed disposal as a kind of geologic disposal (when geologic disposal is broadly defined). The seabed concept is considered an alternative to geologic disposal

on land (in granite, tuff, and other materials), Japan's first priority disposal option for high-level wastes.

Even though Japan is not presently conducting research on seabed disposal, the Government believes that Japan can make a valuable contribution to the Seabed Working Group by sharing results from research on geologic isolation, and from observations of its low-level nuclear waste dumping operations. Japan considers many of the scientific problems involved in environmental and safety assessment to be common to both geologic disposal on land, and seabed disposal options.

The Japanese Government spends approximately 9.6 to 12 billion yen per year (40 to 50 million U.S. dollars) on the entire high-level nuclear waste program. Of that amount, approximately 48 million yen per year (0.2 million U.S. dollars) support research applicable to seabed disposal.

In Japan urgency is not expected to affect national decisions on the seabed disposal option. Presently there are only 150-200 cubic meters of high-level liquid wastes in storage. By the year 2000, the Government expects to have at most 10,000 containers (30 cm diameter, 150 cm height) of these wastes. Japan has storage space available, and must store its vitrified high-level wastes at least 30-50 years for cooling. A solidification and storage pilot plant for wastes will be operational in 1987. The Government has scheduled test disposal in a geologic land repository for the years 2015-2025. Spent fuel is shipped to France and the United Kingdom for reprocessing, and according to contractual agreement, will be returned to Japan in approximately ten years. Meanwhile, work on a domestic reprocessing capacity continues.

A second factor potentially affecting Japan's policy is domestic political developments. The Government is presently experiencing difficult social and political problems as a result of its proposal to dump low-level nuclear wastes in the Pacific Ocean. Because the ocean represents an international property belonging to everyone, ocean disposal of high-level wastes appears to present more potential political problems than disposal on land belonging only to Japan.

The Japanese Government has officially determined that the London Dumping Convention is not applicable to seabed disposal, and that an international agreement (rather than a bilateral or multilateral consensus) will be necessary before seabed disposal could be operationalized (assuming concept feasibility).

7.5. THE NETHERLANDS

The Netherlands' policy on seabed disposal is to pursue research of the concept as a back-up, low priority alternative. This policy represents a change from the government's previous classification of seabed disposal as a second priority alternative to geologic isolation on land (salt formations). At present, both geologic disposal on land (including exploration of salt beneath the North Sea) and seabed disposal options for high-level waste disposal take second priority to the government's first priority--development of interim storage facilities.

Currently, the Netherlands' nuclear energy policy is undergoing extended societal discussion to determine if nuclear energy development should proceed. Once a decision is reached, further changes in policy may occur.

The Netherlands Government spends about 1.5 million guilders per year (0.5 million U.S. dollars), including shiptime, on seabed disposal research.

It does not appear that urgency will be a factor in the Netherlands' policy decisions on seabed disposal. At present there is no storage of high-level waste. The Netherlands ships spent fuel to France and the United Kingdom for reprocessing. These wastes could be returned to the Netherlands as early as 1991. Being developed is an interim storage facility which will accommodate waste production from the existing nuclear facility power stations (which total 500 MWe) over the stations' lifetime. If the outcome of the current societal debate is to build three 1000 MWe nuclear power stations (as the Government has decided in principle), the interim storage facility would be able to hold all vitrified high-level wastes from the nuclear program for 30-40 years (annual production of 15-20 m^3 of glass cylinders).

The Netherlands has found political opposition to either land or sea disposal options to be the same in character. The Government abandoned its sea

disposal program for low- and intermediate-level wastes in 1982 for domestic political reasons and has maintained a no-dumping policy in 1983.

At this time, the Government has no official position on the applicability of the London Dumping Convention to the seabed disposal concept, or on whether international agreement will be necessary to operationalize seabed disposal (assuming concept feasibility). It is expected, however, that there would be a preference for an international agreement instead of a simple multilateral consensus in view of the fact the Netherlands is a member of the London Convention, and has undersigned the OECD/NEA multilateral surveillance mechanism for the sea-dumping of low-level wastes.

7.6 UNITED KINGDOM

The United Kingdom's policy on seabed disposal is to conduct research on the concept in order to assess its feasibility. The Government considers seabed disposal as one possible alternative for high-level nuclear waste disposal, and intends to complete its assessment by the year 1990. Government priorities with respect to high-level disposal have now resolved into continued safe storage. Disposal to the seabed and on land are being given equal priority until the present research program is completed at the end of the decade.

The United Kingdom research operations are carried out and funded according to Five Year Plans. The current plan ends December 1987, at which time funds for seabed disposal research must be renewed. However, no impediment is expected to continued funding of the seabed disposal research program. There is no active research program of geologic land disposal because virtually all of the information needed for the U.K.'s assessment is now available.

The United Kingdom spends 2.5 million pounds per year (4 million U.S. dollars) on seabed disposal research, and 1 million pounds per year (1.6 million U.S. dollars) for general research on nuclear wastes in the marine environment.

The United Kingdom does not perceive that urgency will affect policy decisions on seabed disposal. There is currently about 1000 m^3 of liquid high-level waste in storage. After solidification the volume will be reduced to

about 200 m^3. It is expected that the quantity of these wastes will be between three and five times greater in 50 years, depending on the size of the national nuclear energy program. The national plan for high-level waste management provides for 50 years of storage. The plan will allow time for thermal decay of the wastes, and time for the Government to arrive at a long-term solution. The United Kingdom reprocesses spent fuel for Japan, the FRG, Switzerland, the Netherlands, and Italy, but contracts provide for these wastes to be returned to the countries of origin.

Domestic political developments are a second factor potentially affecting United Kingdom policy on seabed disposal. Because both major parties have supported nuclear energy development, there is no significant opposition within the government to land disposal of high-level wastes, or to the low-level waste ocean-dumping program. Non-governmental opposition has occurred in response to characterization of potential waste repository sites. Once sites are designated, political problems (primarily in the form of local opposition) are expected. However, these problems are unlikely to be significant enough to affect policy decisions on seabed versus land disposal options. Despite limited opposition to low-level waste ocean-dumping, the United Kingdom policy is to continue sea disposal of low-level wastes.

The United Kingdom does not have an official view on the applicability of the London Dumping Convention to seabed disposal. However, the unofficial view of those participating in the NEA review of the issue is that the research program is outside the Convention, as will be deep disposal within sediments. There is an official Government position that an international agreement (rather than a bilateral or multilateral consensus) will be necessary before any country proceeds with seabed disposal (assuming concept feasibility).

7.7 UNITED STATES (4)

United States' policy on subseabed disposal is to continue assessment of the concept of burying high-level radioactive waste in the stable sediment of the deep ocean floor, to assess and cooperate with other nations' seabed disposal programs, and to keep this option open for potential use by the U.S. for disposal of nuclear wastes, at least until the second mined repository is

approved. The major milestone for the U.S. Subseabed Disposal Program is to complete research and development necessary to determine concept feasibility in 1989.

The United States has assigned first priority to mined repositories in stable land formations for high-level radioactive waste disposal, while continuing research, development and investigations of alternative means and technologies for high-level waste disposal (Nuclear Waste Policy Act of 1982, Section 222). The seabed disposal option is the only alternative to mined repositories that is currently funded.

The United States has spent 6 million dollars on seabed disposal research in fiscal year 1983.

Urgency is not a factor that will affect U.S. policy on the seabed disposal option. At present, high-level wastes in storage amount to approximately 300,000 million cubic feet of defense wastes (primarily in salt cake form), with about 11,000 metric tons of commercial spent fuel and a relatively small volume of liquid high-level waste. By the year 2000, commercial spent fuel arisings are expected to amount to 58,000 metric tons of spent fuel. Storage tanks for defense wastes are designed for a 50-year service life, and can be replaced if required. In the case of commercial high-level wastes, sufficient total storage capacity exists, or can be constructed to assure adequate storage until completion of the first mined repository, expected to be completed by 2000.

Domestic political developments are a second factor potentially affecting United States policy on seabed disposal. It is expected that political opposition to seabed disposal, and to land-based disposal would be about the same in magnitude, but originate from different sectors. Some local political and transportation concerns developing after selection of a seabed disposal system would be no different from those developing after selection of a land repository site. Domestic policies on the dumping of low-level wastes at sea could have a potential impact on future policies on seabed disposal. For this reason, it is considered important to clarify the essential differences between "dumping" of waste into the oceans, and the burial of waste within the geologically stable formations of the deep seabed.

A third factor which may affect national policy on seabed disposal is the international status of the concept. Presently, the United States has no official position on the applicability of the London Dumping Convention to seabed disposal. Unofficially, there are different interpretations within federal agencies concerning the LDC and its application to seabed disposal. From a practical standpoint it is assumed by the U.S. seabed disposal participants that an international regulatory regime would have to be established, with internationally acceptable safety standards and criteria promulgated as a basis for operating a seabed disposal system. The continuation of research and development, and the acquisition of data required to assess concept feasibility of seabed disposal, is not considered to be an issue under the terms of the London Dumping Convention.

7.8 BELGIUM (observer to SWG meetings) (5)

Presently, Belgium attends the NEA Seabed Working Group as an observer through the Studycenter for Nuclear Energy (SCK/CEN).

Priority is given on R&D to disposal of conditioned high-level and alpha-bearing wastes in a continental clay formation. This option was taken in accordance with the recommendations of an Evaluation Committee on various aspects of future energy policy, which was installed by the Minister of Economic Affairs in 1974. No specific R&D is planned for Seabed Disposal of solidified HLW during the program period 1981 to 1985.

Nevertheless, CEN/SCK believes its expectation on clay and argillaceous host rocks can be valorized in the studies of the Seabed Working Group on barriers against dispersion of radioelements. Exchange of results and opinions with other programs on waste disposal is considered very important by CEN/SCK for the shaping of its own R&D program on radioactive waste disposal.

Taking into account the timing of the present program on clay, a decision on the use of a clay formation as host rock for disposal may be proposed towards the end of the present decade. It would then take a few more years before an actual disposal facility could be made available. It is also foreseen that the HLW, including that which will be returned from France following the reprocessing of spent fuel from Belgium power reactors, will have to be

stored for about 50 years in cooled surface facilities, unless a reliable cooling device could be installed in the geological disposal facility. The public and the media are regularly being informed about the status and the results of the R&D work of CEN/SCK on clay.

In Belgium, the responsibility for the management of high-, intermediate- and low-level wastes, lies with the public organization ONDRAF/NIRAS.

7.9 ITALY (observer to SWG meetings)

Italy's policy on seabed disposal is to observe the Seabed Working Group's research program. Italy considers the concept an interesting disposal option that might work as a long-term alternative to terrestrial disposal. The Government is developing a capability for geologic disposal on land (in clay) at a slow rate, with no established deadlines.

Even though Italy has no official research program on seabed disposal, contributions to seabed disposal could be made by providing results from research on clays, and from engineering developments.

It does not appear that urgency will affect Italy's policy on seabed disposal. The Government has no high-level wastes ready for disposal at this time. The volume of high-level liquid waste in storage is in the order of tens of cubic meters. Italy has produced almost no high-level solid waste. Presently there is no deadline for disposal of these wastes.

Local opposition to disposal on land is expected once sites are designated. The public, however, has not identified the waste problem as a key issue in the nuclear energy debate. Italy plans to participate in the low-level nuclear waste ocean dumping program. The Government's emphasis on land or ocean disposal options may shift according to domestic political opposition to these concepts.

At this time, the Italian Government has no official position on the applicability of the London Dumping Convention to the seabed concept, or on whether international agreement will be necessary to operationalize seabed

disposal (assuming concept feasibility). Italy expects objections from Third World countries if attempts are made to operationalize seabed disposal (assuming concept feasibility) by developed countries.

REFERENCES AND NOTES

(1) Information provided in this section is based on a series of non-attributable interviews of national policy-level officials. The content of this section is the sole responsibility of the interviewer and author, Elaine M. Carlin, with the exception of the Canadian, German and Belgium policy summaries which were prepared by the interviewed officials.

(2) This summary was prepared by the interviewed Canadian official.

(3) This summary was prepared by the interviewed German official.

(4) For a detailed assessment of United States policy with regard to seabed disposal, see Edward Miles, Kai N. Lee, and Elaine Carlin, Sub-Seabed Disposal of High-Level Nuclear Waste: An Assessment of Policy Issues for the United States, Institute for Marine Studies, University of Washington, July 1982.

(5) This summary was prepared by the interviewed Belgian official.

8.0. NATIONAL RESEARCH SUMMARIES

The research summaries presented, especially the budget information, must be considered approximate. Much general oceanographic research advances the ability of the SWG to model oceanographic processes. Thus, a national contribution is often greater than that funded specifically for HLW disposal research. Further, there is some overlap with other radioactive waste disposal research. Mined repository work on waste form and canister provides useful information for seabed research. Studies of the Northeast Atlantic dumpsite for low-level wastes overlap considerably with the water column modeling being conducted for seabed research. Research on shore discharges, which provides information on biological effects, further complicates accounting.

A number of the SWG nations are members of the Commission of the European Communities (CEC). The CEC provides partial support for many programs at national laboratories of the European community (typically the CEC provides 50% of the total cost). The CEC programs conducted at its own laboratories and the joint programs are given in Table 8.1. The national summaries that follow will often include work that is in part funded by the CEC.

Summaries of the national research programs may be found each year in the reports of the SWG annual workshops (1). A status report of the research is being prepared by the SWG to be published by the NEA.

8.1 THE COMMISSION OF THE EUROPEAN COMMUNITIES

The Commission of the European Communities is currently spending 1 to 1.5 million ECU (1.6 million U.S. dollars) per year on seabed disposal research. The CEC has participants in the systems analysis, biology, sediment and rock, and waste form and canister task groups, and is providing one of the coordinators.

The CEC is developing a number of areas for research. Some of the CEC studies involve expansion of mined repository research programs to include conditions relevant to subseabed disposal. Programs at the Joint Research

TABLE 8.1. Current Research Areas of the CEC at the Joint Research Centre (JRC), and Cooperative Programs with Other Nations. (From SWG 1982 Annual Report)

Research Area	Topic	Program
Sediment studies	Properties of ocean sediments in relation to disposal of radioactive waste into the seabed (UK)	Management and Storage of Radioactive Waste
	Migration processes in marine sediments caused by heat sources (NL)	Management and Storage of Radioactive Waste
	Study of the sorption and the migration of radionuclides through samples of abyssal sediments in the North Atlantic (F)	Management and Storage of Radioactive Waste
	Differential migration of Pu in the delta estuaries of Rhine, Meuse, and Scheldt (NL)	Radiation Protection
	Radionuclide migration in deep ocean sediments (JRC)	Safety of Nuclear Material
	Collection and characterization of deep ocean sediments (JRC)	Safety of Nuclear Material
	Corrosion processes of canister material in deep ocean sediments (JRC)	Safety of Nuclear Material
Engineering studies	Feasibility study of offshore disposal (UK)	Management and Storage of Radioactive Waste
	Review of the needs and requirements for hyperbaric facilities (UK)	Safety of Nuclear Materials
Marine biology	Measurement of levels of radioactivity in the marine life and waters of the Irish Sea and their contribution to radiation dosage of the population (EIR)	Radiation Protection
	Actinides in the marine environment: study of their physicochemical behavior in seawater and marine sediments and their transfer between sediments and benthic specics (F)	Radiation Protection
	Environmental and health protection implications from nuclear plants discharging into coastal marine echosystems (I)	Radiation Protection
	Bioavailability of actinides in selected freshwater, estuarine, and seawater species and the related effects of environmental factors on the modeling of their behavior (B)	Radiation Protection
	Chelation of radioelements (Pu-239 and -237) in the marine environment. Roles of microorganisms and various natural and bioorganic degradation compounds (F)	Radiation Protection
	Cellular biochemistry of U, Pu, Am, and Cm in the common marine mussel *Mytilus edulis* (UK)	Radiation Protection
	Resuspension of radioactive nuclides released from the ocean surface (F)	Radiation Protection
	Environmental studies of artificial radioactivity in soil, plants, and the sea-air interface (UK)	Radiation Protection
	Radioecological studies in temperate and arctic waters in the North Atlantic region with emphasis on transuranic elements (DK)	Radiation Protection
	The remobilization of actinides from contaminated intertidal sediments (UK)	Radiation Protection
	Behavior of freshwater entrained radionuclides in the event of contact with seawater (F)	Radiation Protection
Risk Analysis	Development of risk assessment methodology for the assessment of the disposal of HLW into deep ocean sediments	Safety of Nuclear Materials
	Evaluation of the performance of geological formations	Community Plan of Action
Oceanography	Lagrangian current measurements and large-scale, long-term dispersion rates (UK)	Management and Storage of Radioactive Waste
	Behavior of radionuclides in the marine environment in support of the disposal of wastes arising from the utilization of nuclear energy (UK)	Radiation Protection

Centre (JRC) Ispra (direct action programs) include studies on physical and chemical properties, migration processes (including those caused by heat sources), and geochemical changes caused by heat and radiation. Corrosion studies at the JRC focus on the use of thick layers of low-cost corrodible materials, and glass-leaching studies.

8.2 CANADA

The Canadian Government approved a budget of $740,000 for 1982-1983 for research related to seabed disposal. Canada has participants in the systems analysis, site selection, biology, physical oceanography, and sediment and rock task groups.

The major part of Canadian research has been related to site studies. Canada had sponsored research cruises in 1980, 1981, 1982, and another is planned in mid-1984. The work on the cruises has included seismic studies to delineate the geology of the Sohm and Nares abyssal plains, current measurements, coring, and biological studies.

In 1982, studies pertinent to radionuclide behavior in biological processes were initiated.

Discussions are presently under way for Canada to participate in the first major in-situ model verification experiment (heat transfer) planned by the U.S. program.

A Canadian-developed model for risk analysis that incorporates measures of uncertainty is being adopted by the Systems Analysis Task Group.

8.3 FEDERAL REPUBLIC OF GERMANY

Present FRG research expenditures for seabed-related research and for sea disposal of nuclear wastes total 0.5 million marks per year (1.2 million U.S. dollars). The FRG has representatives on the biology and physical oceanography task groups.

The FRG has active programs in physical oceanographic modeling and in biology. The modeling effort includes a world circulation model to describe

the reaction of ocean currents to potential climatic changes and a North Atlantic model, with a grid size of 1°, to study variations of the currents on shorter time scales.

The biology studies include field-sampling to examine the vertical distribution of radionuclides in seawater and in marine organisms, as well as to determine the biomass distribution.

8.4 FRANCE

In 1984, the French Government will spend between 5 and 10 million francs (0.6 to 1.2 million U.S. dollars) on seabed disposal research, in addition to funding a research cruise. France is active in the systems analysis task group and has participants in the other task groups.

France conducted research cruises to the Cape Verde Abyssal Plain in 1979 and 1980 and to the Northern Bermuda Rise in 1978. Studies included geological investigations to define the area and studies to characterize the biology. Some samples taken during those cruises are still being processed. France has also initiated engineering emplacement studies for penetrator emplacement and has a biological program to study radionuclide uptake and transfer by organisms.

8.5 JAPAN

The Japanese Government spends approximately 9.6 to 12 billion yen per year (40 to 50 million U.S. dollars) on the entire high-level nuclear waste program. Of that amount, approximately 48 million yen per year (0.2 million U.S. dollars) support research applicable to seabed disposal. Japan participates in the site selection, physical oceanography, sediment and rock, and waste form and canister task groups.

As part of its program to assess low-level waste dumping in the Pacific, Japan has conducted numerous cruises assessing bottom topography and geology, water chemistry, ocean currents, distribution of fishes, plankton and benthic organisms in a region of the Pacific that has been studied for HLW burial by the U.S. program.

8.6 NETHERLANDS

The Netherlands Government spends about 1.5 million guilders per year (0.5 million U.S. dollars), including shiptime, on seabed disposal research. The Netherlands has participants in the systems analysis, site selection, sediment and rock, and engineering task groups.

The Netherlands has had an active site survey program. In 1980, a cruise studied the geology of the Madeira Abyssal Plain and in 1982 Dutch cruises studied the Southern Nares Abyssal Plain, the Kings Trough Flank and the Maderia Abyssal Plain. The Netherlands has also conducted studies of actinide sorption to deep ocean sediments as a function of temperature, water flow measurements, modeling of pore-water flow around a heat source, and heat transfer studies in ocean sediments. The Netherlands is developing equipment capable of penetrating 50 meters into the sediment, instrumented to perform a series of geotechnical measurements, in-situ, and to recover samples from that depth.

8.7 SWITZERLAND

The Swiss Government currently spends 0.5 million francs per year (0.25 million U.S. dollars) for monitoring ocean-dumping of low-level wastes. Switzerland has participants in the task groups for systems analysis, site selection, biology, physical oceanography, sediment and rock, and waste form and canister.

8.8 UNITED KINGDOM

The United Kingdom, through the Department of the Environment, spends 2.5 million pounds per year (4 million U.S. dollars) on seabed disposal research and 1 million pounds per year (1.65 million U.S. dollars) for general research on nuclear wastes in the marine environment. The U.K. participates in all the SWG task groups.

The total research program is comprehensive and similar in scope to the U.S. program. The U.K. expects to obtain sufficient information to assess the feasibility of marine disposal options, especially seabed, by 1990.

The U.K. site activities have included cruises, up to three per year, to seven study locations in the Atlantic. Recent activity has concentrated on the Great Meteor East location, which will be the U.K. reference location for feasibility determination. Activities include characterization of the areas with standard sediment profiling, GLORIA (deep ocean side scan sonar) and coring.

Canister corrosion laboratory studies and modeling are concentrating on thick-walled carbon steel canisters. Sediment barrier studies, both information collection and modeling, include physical properties of sediment, natural geochemistry processes, and sorption to deep-ocean sediments. The mechanical properties of sediments are also being studied and modeled.

The U.K. has probably the largest program to study and model the biological transport of radionuclides and has also conducted many field studies on biological/geochemical transport processes. A large physical oceanographic modeling effort and numerous field studies in the Eastern Atlantic are being conducted.

The U.K. is also the leader in engineering studies, having actually implanted penetrators to 30 meters in 5000 meters of water, and is conducting engineering studies for both penetrator and drilled emplacement.

Radiological assessment studies, including accident scenarios, have been conducted and are continuing.

8.9 UNITED STATES

The United States has spent 6 million dollars on seabed disposal research in fiscal year 1983 (2,3). The U.S. has participants in all task groups.

The major effort in the U.S. program is the model development and property characterization for all processes that need to be described to assess feasibility. These include thermal processes, waste-form leaching, canister, near-field chemistry, thermally-induced canister and sediment movement, emplacement, hole closure, far-field ion transport, biological transports, physical transports, and dose-to-man. At present, at least one model is available to

describe each process, and efforts have begun to test the accuracy of these predictive models (4). It is expected that scientific feasibility could be determined before 1990.

The U.S. site program has conducted surveys of five locations in the Pacific. In the last few years, however, the U.S. site activities have been limited to participation in the European cruises. A U.S. cruise to the Southern Nares Abyssal Plain is planned.

The emplacement studies have included a shallow-water test of penetration models and will involve deep-water tests in 1984.

In addition to some preliminary legal and institutional studies sponsored by the U.S. seabed program, the U.S. Department of State has sponsored policy research (5).

8.10 BELGIUM (observer to SWG meetings)

Belgium is planning to evaluate how its research efforts on clay as a disposal medium could apply to the SWG program. Fields of study include sediment and waste characterization, corrosion, and modeling techniques. Belgium is also interested in the potential application of its marine biology research.

8.11 ITALY (observer to SWG meetings)

Potential research contributions by Italy would be made as a result of its research on clays and of engineering developments. An Italian company has produced advances in penetrator design.

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