DUMPING OF NERVE GAS ROCKETS IN THE OCEAN

HEARING

BEFORE THE

SUBCOMMITTEE ON OCEANOGRAPHY

OF THE

COMMITTEE ON COMMERCE

UNITED STATES SENATE

NINETY-FIRST CONGRESS

SECOND SESSION

ON

DUMPING OF NERVE GAS ROCKETS IN THE OCEAN

AUGUST 5, 1970

Serial 91–76

Printed for the use of the Committee on Commerce

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1970

49-905

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WEDNESDAY, AUGUST 5, 1970

U.S. SENATE,
COMMITTEE ON COMMERCE,
SUBCOMMITTEE ON OCEANOGRAPHY,
Washington, D.C.

The subcommittee met at 10 a.m. in room 6202, New Senate Office Building, Hon. Ernest F. Hollings (Chairman of the subcommittee), presiding.

Present: Senators Hollings, Spong, and Cook.

OPENING STATEMENT BY THE CHAIRMAN

Senator HOLLINGS. Gentlemen, the committee will come to order.

Today's hearings open Senate consideration of a Department of the Army decision to dump into the Atlantic 418 steel-encased concrete vaults containing over 12,500 rockets, with more than 65 tons of liquid nerve agent called GB. Public concern about the dumping is very real. It is concern for public safety as the nerve gas is moved overland. It is concern for the ocean environment when the gas is released into the surrounding waters.

We want to explore the reasons for encasing the rockets in concrete, a decision that has precluded use of several other means of demilitarizing the rockets. We shall look at the problems of overland transportation from Anniston, Ala., and Blue Grass, Ky., to Sunny Point, N.C. We shall look at the capabilities of the Sunny Point facility to load the vaults safely aboard a hulk out of the Reserve Fleet.

The scuttling of the hulk, the possible catastrophic release of the nerve gas, and the environmental impact of the nerve gas when it is released into sea water, will all be explored. We particularly want to discuss possible alternatives to dumping this material in the ocean, and to determine what military plans and facilities will be used for demilitarization of such munitions in the future. Many other questions, of course, will arise during the hearing.

We shall first hear from the Honorable Thaddeus R. Beal, Under Secretary of the Army, who is accompanied by several people whom I would appreciate your introducing at the appropriate time.

The Honorable Russell E. Train, Chairman, Council on Environmental Quality will discuss with us the environmental considerations involved in this dumping operation. Dr. Jesse Steinfeld, Surgeon General of the Public Health Service, Department of Health, Education, and Welfare, and Charles Meacham, Commissioner of the Fish and Wildlife Service, Department of the Interior, will discuss their respective departments' involvement.

Staff member assigned to this hearing: H. Crane Miller.

The Deputy Legal Adviser of the Department of State, John B. Rhinelander, accompanied by Herman Pollack, Director of International Scientific and Technical Affairs, is here to discuss international legal considerations. Dr. Martin A. Paul, who served as the National Academy of Sciences staff member to the Kistiakowsky committee, will testify on the role played by the Academy.

We also welcome Dr. Howard L. Sanders, senior scientist at the Woods Hole Oceanographic Institution and noted benthic ecologist, who will describe the environment into which the nerve gas is proposed to be dumped, and some of the ecological impacts of the dumping. Since Dr. Sanders must catch a flight back to Woods Hole early this afternoon, I shall ask him to testify after Under Secretary Beal has made his presentation.

Secretary Beal, I think you have an illustrious group accompanying you. If you will introduce them, we will be glad to hear from you at this time.

STATEMENT OF HON. THADDEUS R. BEAL, UNDER SECRETARY OF THE ARMY; ACCOMPANIED BY BRIG. GEN. JOHN E. MURRAY, DIRECTOR OF ARMY TRANSPORTATION, OFFICE OF THE DEPUTY CHIEF OF STAFF; BRIG. GEN. WILLIAM STONE, DIRECTOR OF CHEMICAL AND NUCLEAR OPERATIONS, OFFICE OF THE ASSISTANT CHIEF OF STAFF; R. KENLEY WEBSTER, DEPUTY GENERAL COUNSEL OF THE ARMY; DR. CONRAD CHEEK, CHEMICAL OCEANOGRAPHER, OCEAN SCIENCE DIVISION, NAVAL RESEARCH LABORATORY

Mr. BEAL. Thank you.

The four people with me at this table are, beginning on my right, your left, Brig. Gen. John E. Murray, who is Director of Army Transportation; from the Office of the Deputy Chief of Staff of the U.S. Army, Brig. Gen. William Stone, Director of Chemical and Nuclear Operations of the Office of the Assistant Chief of Staff. On my left, R. Kenley Webster, Deputy General Counsel of the Army; then Dr. Conrad Cheek, chemical oceanographer of the Ocean Science Division of the Naval Research Laboratory.

Senator HOLLINGS. Glad to have them with us.

Mr. BEAL. May I, sir, read the fairly brief opening statement on our position in the matter? I think the context in which you can then ask questions will be clear.

Senator HOLLINGS. We shall also include at the end of your testimony your personal biography in the record.

Thank your, sir.

Mr. BEAL. Mr. Chairman, you have asked me to appear before you to explain the background, the plan, and the necessity for the disposal at sea of certain unserviceable chemical munitions sealed in concrete vaults overlaid with steel plates welded at the seams.

We welcome this opportunity to present the reasons why we believe there is no practically feasible alternative to the course of action we are following. Throughout consideration of this difficult problem, the two criteria have been to avoid hazard to people and to minimize damage to the environment.

This operation disposes, at sea, of 418 vaults about 250 statute miles off the Continental Shelf, and about 280 miles from our coast in an established munitions disposal site at a depth of about 16,000 feet, which is almost 3 miles down. The vaults will be transported by special trains, which will be escorted from their place of storage at Anniston, Ala., and Blue Grass, Ky. Army depots to the Military Ocean Terminal at Sunny Point, N.C. They will then be loaded on a surplus hulk, which will be towed to the disposal site and scuttled.

During the first half of 1968, a number of nerve agent-filled rockets were determined to be unserviceable and, thus, should be marked for elimination from our deterrent stockpile of chemical munitions. Consequently, they were placed in concrete vaults for disposal at sea in accordance with then-standard procedures. They were included in a disposition plan, developed last spring, which contemplated a much larger disposal operation. It was anticipated that this original plan would proceed promptly, as had the chemical munitions disposal plans, which were carried out in 1967 and 1968. We encased the munitions in concrete and steel vaults to assure that they would sink to the bottom of the ocean, to minimize the hazards of transportation and to eliminate the danger of leakage of the toxic chemicals they contained.

Because of the public concern over the proposed transportation contemplated in the original plan, we requested the advice of the National Academy of Sciences in May of last year. The Academy recommended detoxification on land of all the chemical warfare munitions, except for the vaults, which from the outset presented the most intractable problem. With respect to rail transportation of the vaults, the Academy noted that the "probability of a catastrophic accident is essentially nil." The Academy added that the probability of a catastrophic accident during the towing of the hulk containing the vaults is vanishingly small. However, the Academy recommended that the Army convene a group of technically qualified experts to determine if there was any practically feasible alternative to sea disposal, and, if not, to dump them at sea. According to the Academy, any alternate method had to be safe to neighboring population and positive in the sense that toxic and explosive contents of the vaults could be destroyed within a predictable time.

We have followed the recommendations of the Academy, and now, over a year later, after numerous studies by experts and tests for alternatives, we find that all study groups and agencies, which have reviewed this matter, support the conclusion that there is no practically feasible alternative to dumping the vaults at sea—other than by nuclear explosion, which is unsatisfactory to the Atomic Energy Commission.

Furthermore, time is of the essence. In the followup study to the Academy report, a group of qualified munitions experts, headed up by Dr. Paul M. Gross, professor emeritus of chemistry at Duke University, noted it is necessary to assume that the hazard of storing the vaults is increasing because of the possible deterioration of the propellant inside the rockets and the interaction of the nerve agent with the propellants and explosives, which are sealed in the concrete and steel vaults. Accordingly, the Gross committee recommended disposal of the vaults without delay.

We know of no way to detoxify these encased munitions safely on land under the circumstances. It is agreed that immersing them in sea water will dilute and detoxify the chemical agent when it escapes from the vaults. While we cannot guarantee that there will be absolutely no effect on the environment at the disposal site, which is about 3 miles below the surface, based on the best scientific data available, we believe this effect will be inconsequential. Therefore, it seems clear to us that this disposal operation is the only reasonably feasible course of action to dispose of these vaults.

Last July, we gave orders to insure that no more chemical munitions will be placed in concrete. We have taken every precaution to avoid the necessity of future sea disposal of chemical munitions. Apart from this one disposal, which we believe is unavoidable, we do not anticipate any future sea disposal of such items. We believe that we have the technology to implement methods of detoxification on land which will meet the highest standards of safety to people without danger to the environment.

Mr. Chairman, I would like to introduce into the record a series of papers which are very relevant to our considerations of this matter, and I would ask Mr. Webster to offer them while I describe them.

Senator HOLLINGS. Yes, sir; go ahead and introduce them into the record. They will be accepted, and you can refer to them as you wish.

Mr. BEAL. The first report, No. 1, would be the report of the ad hoc advisory committee of the National Academy of Sciences, which we received June 25 of last year.

In light of public opposition to the original operation, the Academy was requested, on May 14, 1969, by the Department of Defense, to review the Army's plan for sea disposal of various items, mostly chemical warfare munitions.

The Academy convened a committee of 12 who, over a 2-day period, received a series of 10 briefings concerning all facets of the proposed operation.

On June 25, 1969, the Academy filed its report, which recommended the detoxification on land of all chemical warfare munitions except for the M–55 rockets encased in concrete overlaid with steel. With respect to the vaults as noted above, the committee recommended that the Army convene a committee of munitions experts to determine whether there is any practically feasible alternative to sea disposal, and if not, to sink them in the ocean, either at the site off the coast of New Jersey or at the site which will be used under the current plan.

That is our first paper, [1] sir.

No. 2, we would like to submit at this time the initial report of the Gross committee, [2] dated July 25, 1969.

Following the recommendations of the Academy, the Army appointed a commission of experts headed by Dr. Gross, who is professor emeritus of chemistry at Duke University. The committee's initial report recommended that the vaults be disposed of by nuclear destruction, and if this could not be accomplished, that they be dumped in the ocean in as deep water as possible. The committee noted the disposal of the vaults must be completed no later than August 1, 1970.

[1] See p. 97.
[2] See p. 102.

The committee also recommended that the Army conduct experiments to explore alternate disposal methods on land. The committee recommended the consideration be given to several alternative suggestions to nuclear detonation. These suggestions included: (*a*) Immerse the vaults in a solution to disintegrate the concrete; (*b*) Construct a remote-controlled facility, drill holes through the concrete into each rocket, and drain out the liquid agent; (*c*) Utilize ionizing radiation to decompose the nerve agent and dispose of the vaults by above-ground detonation; (*d*) Incinerate the vaults; (*e*) Explode the vaults by utilizing diamond drills to penetrate the rocket's fuzes; (*f*) Expose the rockets for extraction by cutting through the concrete with a diamond-edged saw; (*g*) Expose the rockets to extraction by utilizing a high pressure water jet to broach the concrete; (*h*) Expose the rockets for extraction by utilizing charges to penetrate the end of the vault; (*i*) House the vaults in a suitable enclosure capable of containing the explosions and immerse the vaults in a suitable solution which can chemically neutralize the agent.

This first Gross committee report, sir, is our No. 2 submission.

No. 3 document is the Atomic Energy Commission's [3] feasibility study dated September 15, 1969, updated July 10, this year.

This study concluded that although the chemical munitions in the vaults could be reliably destroyed by an underground nuclear explosion, the estimated time for execution was 15 months, which was not considered desirable with the August 1 disposal date recommended by the Gross committee.

Our fourth document for submission at this time is the Department of Interior [4] study dated November 13, 1969. The working group of the Department of Interior preparing this study considered the original Operation CHASE and in general recommended against ocean disposal of chemical munitions. With respect to the vaults, the only remaining item for sea disposal, the working group concluded that because of the present hazard to human safety and the unavailability of a feasible alternative method of disposal, ocean disposal of these hazardous materials is necessary. With respect to the proposed dumping site suggested by the Academy, the working group concurred in its selection, noting that the site is on the seaward side of the Gulf Stream in a less productive area; the bottom currents are minimal so that toxic material leaking from the containers would be confined in a rather small area; there is no evidence of any upheaval at the site; and the site is already marked on navigation charts as a chemicals, munitions, and explosives dumping area.

The fifth document [5] is the followup report of the Gross committee which is also called the second Gross committee report. This is dated May 15 of this year. After the committee's first alternative of underground detonation of a nuclear device to destroy the vaults was found to be unsatisfactory, the committee reviewed the Army's studies of their alternative land disposal suggestions. They concluded that these tests revealed no feasible alternative and recommended sea disposal "without delay."

And our sixth and final paper for submission is the "Environmental Impact Statement" [6] submitted July 30 of this year in accordance

[3] See p. 106.
[4] See p. 117.
[5] See p. 119.
[6] See p. 126.

with Public Law 91–190. This statement concluded that the only unavoidable adverse environmental effect of the ocean disposal was a temporary contamination of water in the vicinity of the disposal site and the possible poisoning of some of the sparse marine animal life in the same area.

Mr. Chairman, we would also like to submit the following scientific papers which are considered relevant to Operation CHASE, (*a*) "Study of Effect of Concrete on GB Stability," [7] by the Analytical Chemical Department, Chemical Research Laboratory, Research Laboratories (April 30, 1970); (*b*) "Report of Estimated Contamination Possible from Underwater Explosion of Vaults" (Nov. 28, 1969); (*c*) Memorandum by F. H. Crist concerning the "Probability of Initiating a Detonation of Entombed M–55 Rockets" (June 15, 1970); (*d*) "The Properties of GB and H in Sea Water" [8] by Dr. Joseph Epstein and Mr. James D. Wood.

I am prepared to walk through the phases of Operation CHASE here, sir. This is my report. But it may be better simply to assure you these details have been carefully considered and that the men sitting with me are available to answer specific questions about the following aspects of the operation: General Murray—transportation; General Stone—the potential dangers of the rockets and vaults; Dr. Cheek—the effects on the ocean bottom; and Mr. Webster—our compliance with the law.

I would be glad to go through this phase of the report, if you would like.

Senator Hollings. The sound system is not on. We hope to get it on. In the meanwhile, we've got to move on. We will include the rest of your statement here relative to the rail movement report, sea movement disposal site and otherwise, in the record at this time.

(The statement follows:)

Phases of Operation Chase

1. rail movement

The rail routes selected for movement of the 305 vaults from Anniston and the 113 vaults from Blue Grass to Sunny Point are normal freight routes, selected to avoid, where possible, major population centers. Safety, and avoidance of population concentrations were the prime criteria used in the development of the rail routes.

The routes were developed in close collaboration with the representatives of the Association of American Railroads. Of the routes considered in detail, the two selected traverse the lowest concentration of population. The trains' speed will not exceed 35 miles per hour, well below the speed ordinarily considered reasonably safe for trains carrying hazardous substances.

Each of the munitions trains will have an advance pilot train to ensure against previously undetected defects or other hazards in the rail or roadbed. Aboard each munitions train will be security and medical personnel with a special military escort team trained and equipped to inspect and handle chemical munitions and to take precautionary emergency action, including the detoxification of chemical agents in the highly unlikely event that this should be necessary.

2. port

Sunny Point was selected as the loading port because of its facilities especially designed and constructed and used exclusively for handling ammunition and hazardous material and because of its relative remoteness from populated areas.

[7] See p. 130.
[8] See p. 133.

Ships leaving the terminal have direct access to the open sea. The stevedore crews are experienced in working under rigid safety regulations while handling hazardous materials. The terminal is situated on over 20,000 acres, and the operational area can be completely isolated from all other base activities.

3. SEA MOVEMENT

The loaded hulk will be towed to sea under the direction and protection of the US Navy. The US Coast Guard will escort the tow and warn all commercial shipping in the area. Mariners will be warned by the Navy in advance of the disposal operation.

4. DISPOSAL SITE

The disposal area will be at 29°20′N, 76°0′W which is designated on the charts as an explosives, chemicals, and munitions disposal area. The proposed dumping area is about 250 statute miles off the continental shelf, as already noted. This site, having the advantage of 16,000 feet of depth, was recommended by the National Academy of Sciences for chemical disposal operations through a southern port, and the Department of Interior concurred.

Marine life is sparse at the site's great depth. Due to its great depth and its designation on navigational charts as an explosives, chemicals, and munitions dumping area, the site is unlikely to be used for commercial or technological purposes.

Since the time it was designated on nautical navigation charts as a disposal area for explosives, chemicals and munitions, no chemical munitions have been dumped there by the Army.

This is an international disposal site, and we do not know what items other nations may have discarded in it.

5. ECOLOGY

The eventual environmental impact of the proposed action will be due to the ultimate release of nerve agent contained in the munitions probably after the concrete vaults reach the ocean bottom. Release of the agent will contaminate a volume of water at the ocean bottom. The maximum adverse environmental impact would be the temporary contamination of approximately 1 cubic mile of water. However, this would occur only if all of the vaults ruptured simultaneously, which is extremely unlikely. It is more likely that the contaminated volumes will be much smaller in view of the expected slow release of the agent at the ocean bottom.

6. COMPLIANCE WITH LAW

Two recent Public Laws are particularly applicable to this proposed movement. The requirements of both statutes have been satisfied.

First, Section 409 of Public Law 91–121 requires the Secretary of Defense to bring to the attention of the Secretary of Health, Education and Welfare the particulars of any proposed transportation of lethal chemical agents. The Secretary of Health, Education and Welfare may then recommend precautionary measures necessary to protect the public health and safety. This review was made by the Surgeon General of the U.S. Public Health Service. To assist him, the Surgeon General assembled experts from within and outside the Department of Health, Education and Welfare. Included were physicians, engineers, scientists, transportation and other experts. After thorough review of the movement plan for several weeks, and after suggestion of certain revisions in the plan, which were adopted by the Army, the Department of HEW had no further recommendations.

The Secretary of State, whose department has carefully followed Operation CHASE since June, 1969, has studied the plan for the transportation and disposal of these chemical munitions and found no basis for a determination that the transportation and disposal in question will violate international law.

As required by the Act, the President of the Senate and the Speaker of the House of Representatives were duly notified more than 10 days prior to planned movement and the Governors of the states concerned were formally informed and were also provided briefings. In addition, a briefing was provided for state health authorities.

Second, we have complied with the other applicable law, the National Environmental Policy Act of 1969 (P.L. 91–190). Section 102(2)(c) requires that a detailed statement concerning the environmental impact of and alternatives to ocean

disposal of the chemical munitions be prepared, circulated for comments to certain agencies, and then be submitted to the Council on Environmental Quality.

The statement notes that a significant amount of the chemical agent will probably be destroyed in the vaults by action of the sea water seeping through the concrete. The remainder of the agent, if released, will hydrolyze and/or be diluted beyond physiological effectiveness in the vicinity of the vaults.

The statement also says that marine life is sparse at the great depth of the disposal site. Due to this, and its present designation on navigational charts as a munitions, explosives and chemicals dumping area, the site is less susceptible to commercial or technological use than other parts of the ocean bottom.

The site is much deeper than any at which fish are caught for human consumption. Also, the animal species at this depth are scavengers, not used as a food source for man.

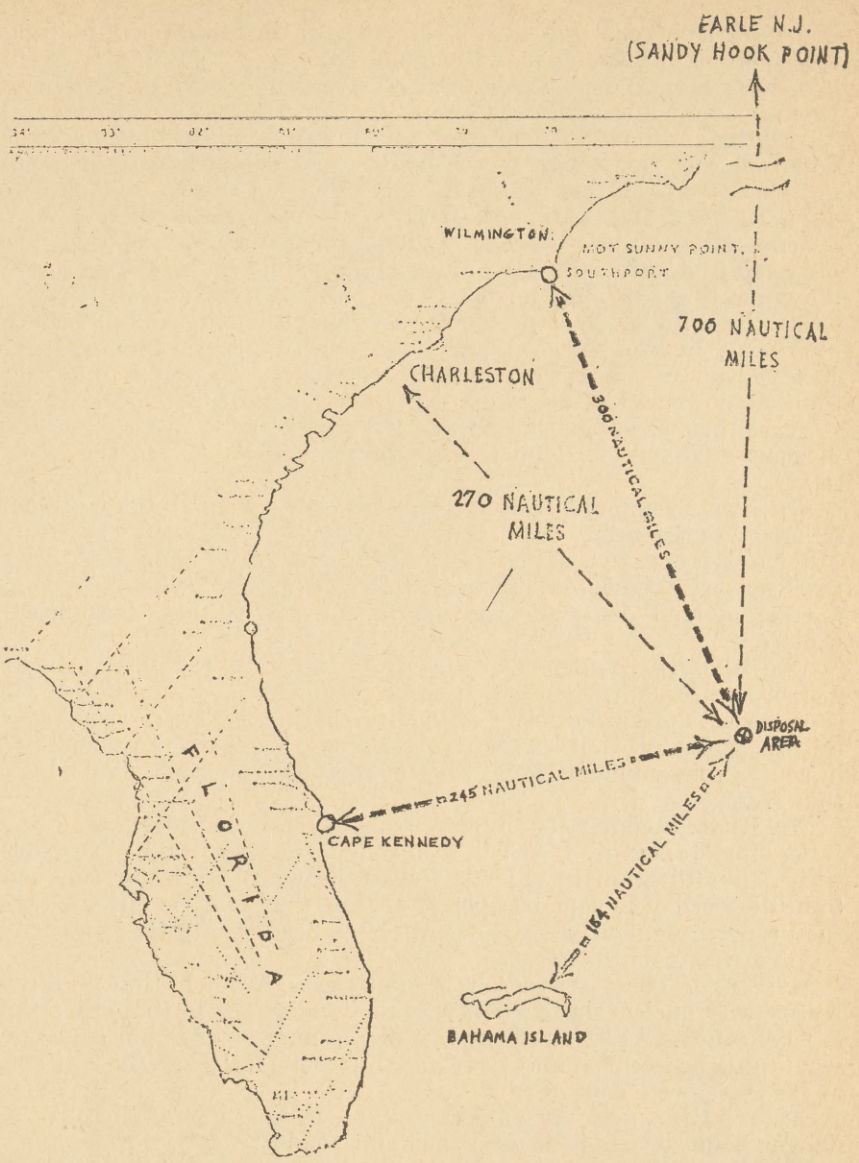
Mr. Chairman, this completes my formal statement. We will be pleased to address your questions.

BIOGRAPHICAL SKETCH OF THADDEUS R. BEAL, UNDER SECRETARY OF THE ARMY

Thaddeus R. Beal was born in New York City on March 22, 1917. He graduated from Yale College in 1939 and Harvard Law School in 1947. He served in World War II as a member of the United States Navy from 1941 to 1945 obtaining the rank of Lieutenant Commander.

After graduating from law school, Mr. Beal practiced law in Boston, Massachusetts for ten years with the firm of Herrick, Smith, Donald, Farley & Ketchum, becoming a partner in the firm in 1956. In 1957 he was elected a Vice President of Harvard Trust Company of Cambridge, Massachusetts, and was made President of the Company in 1962. During this period of employment at Harvard Trust Company, he was associated with various business and community organizations in the greater Boston area. He was a Trustee of the Cambridge Savings Bank, a Trustee of Boston Personal Property Trust, and a Director of Middlesex Mutual Insurance Company. He was also a member of the Cambridge Redevelopment Authority, Trustee of Radcliffe College and Member of the Executive Council of the American Bankers Association.

Mr. Beal was sworn into office as Under Secretary of the Army on March 8, 1969.



Senator HOLLINGS. In your statement you say that hereafter you are going to make certain you don't encase this stuff in concrete because evidently this makes detoxification processes next to impossible—certainly not a satisfactory solution. You don't sound like you are enthused about putting it in the ocean.

In order to prevent this particular situation, you are saying in your statement that you are not going to encase it in concrete. Why was it encased in concrete then?

Mr. BEAL. We then thought that the safest method of detoxifying this kind of munition was to dump it in the ocean as we had in 1967

and 1968. In other words, this was done with the full expectation that that method of disposal would be followed.

Senator HOLLINGS. Can you tell briefly what occurred in 1967 and 1968; how much was dumped and where?

Mr. BEAL. About 1,706 of these similar vaults, at the bottom of the ocean off the New Jersey coast, sir. We took the vaults to the depot in New Jersey and then towed them in hulks out to sea, to a suitable dumping area. There are at least 1,700 of these valults there now.

Senator HOLLINGS. There are 1,700 of them there now, and you are prepared to do this with 418 additional ones, but yet you say you are not going to do this any longer. Is the problem leakage?

Mr. BEAL. The main problem was that although we still believe hydrolysis by sea water is the most effective way of detoxifying chemical munitions encased in concrete vaults, the public outcry at the announcement of our proposed Operation CHASE last year was so great that we obviously had to seek other disposal methods.

Senator HOLLINGS. Public outcry didn't involve itself in the Gross report.

Mr. BEAL. The public outcry came before we went to the National Academy of Sciences.

Senator HOLLINGS. When you had this separate committee, after the National Academy of Sciences study, Dr. Gross' study, it recommended a land disposal approach to this, did it not, by nuclear explosion?

Mr. BEAL. It recommended that we look into that; yes.

Senator HOLLINGS. In fact, it recommended it over and above the sea disposal approach, didn't it? Didn't they say, "Look, we're planning on putting this at sea, but do you know of a better method? See if you can recommend to us a better method than they did?" Isn't that true?

Mr. BEAL. Looking at the precise language in the report, sir——

Senator HOLLINGS. It seems to me that the AEC said, "Yes; but with 15 months' time in order to follow through." Somehow this had to be disposed of in a shorter period of time than in 15 months. Given the proper time, land disposal would have been the better approach.

Am I wrong on that?

Mr. BEAL. That, at least, was one reason. We felt that was the reason why nuclear destruction was not satisfactory to the AEC.

I believe the AEC is prepared to discuss in greater detail with you what other problems it may have had. Fifteen months was the clincher, as far as we were concerned.

Senator HOLLINGS. At what rate is this leaking now? Where is the danger point, or has it reached the danger point?

Mr. BEAL. In the opinion of the Gross committee, it has reached the danger point.

Senator HOLLINGS. It has already reached the danger point. What is the danger right now?

Mr. BEAL. The danger is that with the rockets encased in the vaults, some propellant may leak into the agent and perhaps trigger an explosion or corrode the case, and some agent may leak out of the container itself.

Senator HOLLINGS. There is no way to control this once it is encased in the concrete?

Mr. BEAL. That's the problem.

Senator HOLLINGS. Now, you see, we have oceanography and surface transportation subcommittees under the Commerce Committee, and we are interested in the safety with which it is transported to Sunny Point, N.C., and out to sea.

But I am pursuing specifically this matter of disposal in the ocean. I guess the international legal expert in the State Department will give us the international law on international munition dumping grounds.

As far as the Department of the Army is concerned, this has been for some time considered a dumping ground or munitions ground?

Mr. BEAL. Yes, sir; it is marked on navigation charts as an international dumping area. It is the marked dumping area farthest off the Atlantic coast.

Senator HOLLINGS. I want to read from an article about "hot earth," for it relates to land disposal. They brought 600 tons in and buried it in my backyard in South Carolina. I remember that. I couldn't find the New York Times article but I found it referred to in the June 1970 issue of Esquire:

> In January of 1966, a B–52 on its way home from the Russian border collided with its refueling tanker over Spain and dropped three hydrogen bombs in the Village of Palomaras and a fourth into the Mediterranean. Spain immediately withdrew overflight rights to American nuclear planes. When TNT jacketing one of the bombs exploded and blew out plutonium, radioactivity spread over 64 acres. The alpha rays of plutonium lodged in the skeleton, and a delay of from 12 to 30 years is expected before cancer may develop. One Spaniard had the unique claim to fame for having kicked a hydrogen bomb; he was putting out a fire around the one that had split open when he did it. The hot ground was shipped to South Carolina in 4,827 steel drums * * *.

And on and on. It goes on to tell of that disposal at the AEC site at the Savannah River plant in Augusta, Ga. If, in order to make the sea safe in the Mediterranean, we dump it landside all the way back in the continental limits in South Carolina, it seems a little inconsistent for the Army to turn around and make the sea unsafe off the Florida coast.

Do you have an explanation for that policy?

Mr. BEAL. We do not think it will make the sea unsafe.

Senator HOLLINGS. You do not?

Mr. BEAL. This is our preferred method of detoxification. We believe that hydrolysis sets in very fast, and hence the ocean disposal will not make the sea unsafe. Dr. Cheek is here to give you more details with respect to what happens chemically.

Senator HOLLINGS. Can we hear from Dr. Cheek briefly as to how he feels this will not make the sea unsafe? That is what we are concerned with.

Dr. CHEEK. This nerve agent will be destroyed by the process of hydrolysis, which is simply reaction with water. Fortunately this reaction is accelerated in sea water, because of the presence of some multivalent ions, mainly magnesium and calcium.

We are going to describe the rate of this reaction in terms of what we call a half-life. In one half-life, the quantity of this material that remains is one-half. That is, whatever quantity we started out with at the beginning of this interval, at the end of the interval, only half of it remains.

I am going to demonstrate, sir, with a piece of paper just what fraction of the paper would remain after 10 half-lives. This is an eight by eight inch sheet of paper which is subdivided into quarter-inch squares. There are 1,024 of these quarter-inch squares on this piece of paper. I am going to simulate the destruction of the nerve agent by cutting—by halving this piece of paper 10 times. You will notice here in the first cut, I remove half of it. That is one-half life. That is two, three, four, five, six, seven, eight, nine, 10 cuts. One-quarter-inch square remains. I would like you to compare that to the size of the original sheet. Less than one one thousandth of this material remains.

Now, for a better comparison, I have blackened one square here on a piece of paper of the original size. Now, if we were to repeat this process again, that is to halve this black square 10 times, the remainder would be a dot about the size of a pencil point. I have placed such a dot on this piece of paper, but it is so small you are unable to see it from your seat. If we do this through a total of 20 half-lives, we will reduce the quantity of material by a factor of over 1 million.

Senator HOLLINGS. Getting down to the 10 half-lives, the thrust of your statement is there is no remaining effect of the other nine half-lives or the rest of that sheet of paper.

What about the dead fish? What about the rest of the sheets of paper?

Referring here to Secretary Beal's National Academy of Sciences report of June 25, 1969, the Academy said on page 5, "In either case live fish are likely to be attracted to the contaminated area by dead animals." That is the other little nine pieces of paper we have. The effects of these events on the oceanic environment cannot be estimated, but could be very serious.

Dr. CHEEK. I want to point out two things: First, this process of hydrolysis continues as long as this material exists in the water. Second, under the conditions at the bottom of the ocean where the temperature is two and a quarter degrees, the half-life for decomposition of this material is about half a day, somewhat less than 12 hours. Let's take the half-life as half a day. This means that 10 half-lives would be 5 days. In 5 days the quantity of this material would be down by a factor of over a thousand, and in 10 days, down by over a factor of a million.

Now, if we released the total 135,000 pounds of this material into the water, at the end of 10 days, only about 0.135 pounds would be left. That is one millionth of it, which is about 2 ounces.

During this period of time, the remaining nerve agent would be distributed over a large quantity of water.

Senator HOLLINGS. And we are positive about that, at 16,000-foot depths? We know that much about the ocean?

Dr. CHEEK. Yes, sir. We have been to the area and made measurements.

Senator HOLLINGS. You actually dropped encasements down there before? You were talking about New Jersey a minute ago.

Dr. CHEEK. Sir, I am talking about a predump survey we made at the proposed disposal site off Florida.

Senator HOLLINGS. Will you describe for the committee the experience there? When was that done?

Dr. CHEEK. This was done during the period from the 5th of July to the 12th of July.

Senator HOLLINGS. Of last year or this year?

Dr. CHEEK. Of this year, just last month.

Senator HOLLINGS. What kind of measurements were made and what were the results?

Dr. CHEEK. We made chemical measurements of the deep water. We determined the oxygen content, the fluoride concentration, the salinity, and the temperature at the bottom. We measured the distribution of a gas called radon, which is radioactive, and from that distribution, we were able to determine that any nerve agent that would be released at the bottom would not rise above the depth of a hundred meters from the bottom before it would be destroyed.

We also made current measurements, so that we know what the direction and magnitude of the currents are in this area. In addition, bottom photographs were taken. Our purpose there was to get a base line on what marine life existed at the bottom, for comparison with results that would be obtained on subsequent photographs of the bottom.

Senator HOLLINGS. Dr. Cheek, as a marine scientist you would prefer this be dumped in the ocean, rather than disposed of on land, then, is that correct?

Dr. CHEEK. I don't believe the consequences would be any different, sir.

Senator HOLLINGS. It would not be any different?

Dr. CHEEK. Well, let me put it this way. If a significant amount of this material is released in the ocean at one time, there may be the destruction of some of the very sparse, deep marine life. This would be a temporary situation, in our view. It would have no consequence whatsoever to mankind.

Senator HOLLINGS. I don't want to take all the time. I am going to yield now to Secretary—to Senator Spong.

Senator SPONG. Thank you, Mr. Chairman.

Senator Hollings has explored mostly the effects upon the ocean, but due to the news reports that I've been hearing since early this morning, I would appreciate it very much, Mr. Secretary, if you would have General Murray review for us the precautions taken insofar as the transportation is concerned.

And I notice in your statement, quoting from the report, "The probability of a catastrophic accident is essentially nil", I would appreicate his reviewing what will be done, and I would also like to ask General Murray if he will address himself whether there is one selected route to transport this, or if there are alternative routes.

I notice that the routes selected have been done to avoid population centers, and yet the news reports this morning indicate there are alternative routes which may involve some population centers.

Mr. BEAL. Would you take over?

General MURRAY. First of all, we analyzed each mode of transportation. We quickly discarded the use of air or truck, and decided that rail was the safest way to go.

We have one primary route from each one of the depots and two alternate routes from each one. Safety was the foremost consideration, and that included the population areas through which the train would go.

Our selection of the routes was based on not only the population, but the type of track that we had to use, the safety of the track

involved, and the route that we were taking. We have arranged for the scheduling of the trains where there is a fairly high density of population through the low density routes so that the trains will pass through during the early morning hours when the town itself will be less populated.

Concerning safety, we have coordinated with the officials of the American Association of Railroads, the Department of Transportation and the Federal Railroad Administration. We have visually reviewed the routes with our technicians and have made an aerial survey. Of course, during the progress of the train, there will be constant aerial surveillance.

The Federal Railroad Administration has gone over the track with its track inspectors, and they have reviewed the trestles, bridges, right-of-way, and rail. The track has been recently checked to make sure there are no defects in it. Practically all the tracks have been surveyed by this Sperry mechanism, in 1970, and some in 1969.

We have analyzed causes of accidents at Sunny Point. There have been two accidents due to hotboxes. This type of accident should not recur because we are going to have roller bearings on the cars. Also there was one accident because of an open switch. This could be due to vandalism or carelessness. We hope we can take care of that on this particular movement.

We are also operating on a clear track; that is, no trains will be coming toward us, and the track will be cleared ahead with the pilot train.

There will be 11 stops on one route, 12 on another for engine and train checks, and at that time we will make the technical adjustments necessary. Chemical and analytical personnel will also analyze the lading.

As far as the packaging is concerned, the packaging of the trains has been approved by the Armed Forces Explosives Safety Board. They have made certain changes. The packaging has also been approved and checked by the Department of Health, Education, and Welfare, and we have made changes in accordance with their recommendations, including the wearing of a protective device that will absorb any leakage that may occur en route.

There will be fire engines and medical personnel on the trains. There will be everything that may be needed to take care of any eventuality.

Mr. BEAL. May I make one or two comments on the remarks of the previous two witnesses? One, we have taken many precautions with respect to things we do not think will happen at all. For example, we do not think there will be any leakage from the vaults in the course of this transportation. You may ask, "Why do we have vermiculite?" We have it because someone asks, "What if there is an accident?" We are highly confident there will be no leakage short of some collision, which we have taken every precaution to avoid.

Mr. Chairman, I would also like to add something to Dr. Cheek's response to your question about fish. Assuming that some fish are in fact poisoned as a result of being in the immediate vicinity of one of the vaults at the 16,000-foot depth, there is in our opinion a very important distinction between the situation when that dead fish is eaten by another fish and the situation where a fish killed by DDT is eaten by another fish. We have had no evidence presented to us that nerve agent accumulates in the food chain as DDT does. Quite

distinct from a DDT type of situation, the fish poisoned by nerve agent dies but does not transmit this poison through the chain of larger kinds of fish.

Senator SPONG. Pursuant to Public Law 91–190, you have filed, I believe, as No. 4 with the reports the environmental impact statement dated July 30. Who prepared that report?

Mr. BEAL. That was prepared at the Office of General Counsel of the U.S. Army.

Senator SPONG. And Dr. Cheek, I take it from your testimony that you concur in the findings of that report, insofar as the environmental effect?

Dr. CHEEK. Yes, sir.

Senator SPONG. Thank you, Mr. Chairman.

Senator HOLLINGS. Senator Cook?

Senator COOK. Thank you.

Mr. Secretary, 113 of these vaults are at the Blue Grass Arsenal in Lexington. When were these rockets placed in these concrete vaults?

Mr. BEAL. I believe it was the first part of 1968, 1968 through the early part of 1969, sir.

Senator COOK. Now, in the material that was given out at the briefing the other morning, there is a question and answer sheet in the back of it which was prepared by you.

Question No. 7 says, "How old are these rockets?" And you answer—the answer was, "The rockets were manufactured during the period 1962 to 1966." Now, do you consider those rockets, which could be less than 2 years old, or at the most approximately 6 years old, to be old, as far as your arsenal is concerned?

Mr. BEAL. May I ask General Stone?

Senator COOK. Certainly.

General STONE. As I am sure you realize, there are worldwide a large number of these rockets. We are talking about a small fraction of them. We have a continuous surveillance program which consists of inspecting all stock on a lot-by-lot basis. As we determine flaws or general deterioration within a given lot, up to a certain quantity, we declare that lot unserviceable and not worth maintaining within the stockpile.

The rockets which have been disposed of previously, as well as those that were in the original Operation Chase proposed last year, represent several lots of rockets which had reached the state where it was desirable to dispose of them. The remainder of our rocket stockpile is in good condition.

Senator COOK. How long have you had a detoxification agent for the disposal of this liquid gas without encasing it in concrete?

General STONE. Sir; for many years, we have had chemicals which are capable of reacting with and completely detoxifying nerve agents as well as any other chemical agents.

Senator COOK. Why was this not done with these rockets?

General STONE. Sir; for a number of years, our standard procedure for disposing of ammunition of all types, including chemical ammunition, was to insure they had negative buoyancy and then dispose of them at sea.

The purpose of the concrete was to insure that the rockets in their shipping containers, which are fiberglass tubes containing some air, had negative buoyancy and would sink to the bottom of the sea.

Senator COOK. Has it always been the policy of the military to encase them in a ready-to-fire condition?

General STONE. As I said earlier, this was ammunition which had started to deteriorate. It is far safer, if you are going to dispose of this round eventually—as we had planned at that time to dispose of it—to leave it in an intact situation, and not try to disassemble the deteriorating rocket.

The safest procedure at that time, assuming we were going to follow it, was to move the concrete encased munitions to a coastal city as soon as possible and dispose of them by sea dump.

Senator COOK. I noticed one of the recommendations that was made by the Gross Committee, and I read it to you:

> C. Dump the vaults in the as-is condition, but explore encasing each vault with or without the top lid removed in an outer shell with sufficient void between the inner and outer casings to contain enough decontaminating solution to neutralize the GB in the vault. The material of the outer shell should be such that it will maintain its integrity for long periods of sea water exposure.

Was any of this ever done? Was any of this exploration done?

General STONE. This was examined on a theoretical basis. It was discarded as a procedure because it was visualized that such an outer container would decompose before the inner container of steel, and all we would do would be prolong total decomposition.

Actually, as Dr. Cheek has pointed out, we have found that sea water is quite an effective decontaminant in its own right, with the GB having a half-life in sea water of something less than half a day.

Senator COOK. That's all.

Senator HOLLINGS. General Stone, it is your conclusion that when you bury these in 16,000 feet of water at sea, that this concrete coffin just goes right down to 16,000 feet, rests right on the bottom and doesn't deteriorate—the pressure of the ocean doesn't affect it at all?

General STONE. The corrosive action of the sea water will eventually decompose the vaults. It is also true that at the depths of 16,000 feet, where we have a pressure of approximately 7,000 pounds per square inch, we have just about reached the crush resistance of the concrete.

Thus when these coffins reach the bottom, we should be approaching the point at which the concrete will begin to fracture and deform.

Senator HOLLINGS. And it could continue it?

General STONE. Yes, sir. The calculations mentioned by Dr. Cheek assumed the worst possible situation, that is, that all 418 vaults would open up at the same time and release their agent instantaneously. The extent of contamination from such an event has been calculated to be about 1 cubic mile of water for a short period.

Senator HOLLINGS. But this report that you filed with us, they actually recommend a land disposal approach, isn't that right?

General STONE. Sir, you are talking about——

Senator HOLLINGS. The Lawrence Radiation Laboratory Report.

General STONE. They said that if we could afford to wait 15 months, land disposal using a nuclear device could be accomplished effectively.

Senator HOLLINGS. It would be safer than disposal at sea?

General STONE. The report indicated that if we could hold the vaults safely for 15 months, they could be disposed of by nuclear detonation.

The explosive experts of the Gross Committee indicated they could not certify to the safety of holding these items beyond August 1, 1970,

because of the gradual deterioration of the propellants. This was the prime reason for discarding that alternative.

Mr. BEAL. They didn't compare it, from my recollection, with sea disposal. The AEC report was simply addressing the land disposal problem.

Senator HOLLINGS. In other words, they assumed from the very beginning it was going to be disposed at sea, and asked if there was any better way to dispose of it?

Mr. BEAL. There was a question put to them, "Can you do this by nuclear explosion?" I don't think they addressed the relative merits of it, as much as they did the possibility of doing it.

Senator COOK. Let me ask you a couple more questions.

Obviously the Blue Grass Arsenal is an all-purpose arsenal. I have no idea what is there. I want to know whether it is the policy of the military not to encase any more of these types of rockets in concrete.

Second, I want to know why it was necessary for the military to call on Dr. Gross. Why couldn't the military have determined for itself what Dr. Gross wrote in his report, when he said that encasement of the 30 rockets in a single concrete vault, coupled with the time delay in their disposal, has created a potential hazard entirely out of proportion to that of the individual rockets as prepared.

Now, if he and his committee determined this, why couldn't this have been determined by the military, with the full knowledge that it had detoxification material at that time?

Mr. BEAL. May I respond to that momentarily, and then turn it over to General Stone. First, last July we gave orders to insure that no more chemical munitions will be placed in concrete. Second, of course, I think the Chemical Corps could have been criticized if they had known that these rockets were going to stay encased in concrete from 1968 and early 1969 to this point. They were encasing the rockets in concrete on the assumption we would be allowed to do what we have always done, that is, get them into the ocean as soon as possible. It was done with that in mind and not with the assumption that the munitions would stay on land for this inordinate period of time.

Senator COOK. Mr. Secretary, even though you knew you could dispose of them, even though you knew you could put them at substantial depths off of New Jersey and substantial depths in other places in the ocean, he proceeds to say it is recognized there were serious safety problems which led to the rockets' encasement in concrete, and the longtime delay in their disposal was not envisioned.

A potential hazard from an explosion may have been substantially increased by the encasement in the vault. The confinement could lead to a high order explosion. There is no possible assurance further hazards could not result from the possible sympathetic detonation of adjacent rockets, involving 630 pounds of explosives including the rockets' motors. Now this could happen in the ocean as well as on land.

Mr. BEAL. It could happen, but we are not concerned if it happens in the ocean. That is the way it will be released and then hydrolyzed. This point needs to be made here—hydrolysis is, in our opinion, one of the most efficient ways of detoxifying nerve agent.

Senator COOK. Let me ask you this: The rockets that are presently in the ocean off New Jersey and the 400 and some odd encasements—what is the total number?

General STONE. 12,540.

Senator COOK. And the 12,540 that are here, what percentage of the total number of rockets that have been disposed of does this represent?

In other words, those that have been encased in concrete and those that have been detoxified by chemical means—what percentage of the total that have been disposed of does this represent?

General STONE. Sir, to date, we have disposed of no rockets per se, other than by dumping at sea in concrete. We are now in the process of fabricating automated remote control equipment to permit safe disposal on land in the future. Very obviously, with the stockpile of these rockets we have, we are going to have lots as time goes on that we will wish to detoxify and demilitarize. We plan to use the automated disposal equipment henceforth.

Senator COOK. General, it's my understanding that the rockets encased in concrete represented approximately—or less than 1 percent of all of the rockets that had been detoxified. Would you explain that?

General STONE. Yes, sir. I believe the 1 percent figure was mentioned. I was not present at that particular briefing. The total amount of material proposed for the original Operation CHASE last year included a number of different types of munitions, not just the rockets in the 418 vaults. The total tonnage included the weight of the chemical agents, concrete, and the steel hardware of the munitions themselves.

Comparing only the weight of chemical agents in last year's proposed Operation CHASE, which included mustard agent as well as nerve agent, with the weight of the agent in the 418 vaults, the latter is about 1 percent of the former total.

We have succeeded in finding other techniques for disposing of 99 percent of the agent material which was represented in the original operation, Operation CHASE. For the remaining 1 percent, we have no alternative to this proposed operation.

Senator COOK. The reason you have no alternative is because it is encased in concrete, and you have tried every means available to remove it? Correct?

General STONE. Exactly.

Senator COOK. But now you are saying to this committee that this need not be done any more, and that adequate detoxification of this type of gas is now available short of disposal in concrete and steel containers?

General STONE. It will be available, sir. We will be doing this in the future.

Senator HOLLINGS. Mr. Secretary, we were referring to the New Jersey site, and the standard operating procedure of the Army in disposing in 1967 and 1968 off the coast of New Jersey or the ocean disposal route. Pursuant to that standard operating procedure, the ocean was under consideration when the directive was given to the Lawrence Radiation Laboratory to study the nuclear explosion possibility. That's shown in the first sentence of the Lawrence Radiation Laboratory Report—"The Army is forced with public and congressional objection to the dumping of obsolete chemical munitions into the ocean."

Now, Dr. Cheek, what biological testing have you made off the New Jersey coast?

Dr. CHEEK. Sir, we didn't make any biological tests off the New Jersey coast. We didn't participate in any predumping survey of that area. However, there was a postdump survey made in the general area. It did not include, to my knowledge, any biological measurements.

Senator HOLLINGS. How can we be so sure, if no biological measurements were made off that dumping ground?

Dr. CHEEK. How can we be sure of what?

Senator HOLLINGS. Of no biological damage to marine life?

Dr. CHEEK. From the photographs made in the general area. There is no evidence from those photographs obtained that there was any measurable or detectable change in the ecology.

Senator HOLLINGS. That was done off New Jersey?

Dr. CHEEK. Off the New Jersey coast, about a year ago.

Senator HOLLINGS. About a year ago?

Dr. CHEEK. Yes, sir. This is a separate survey from the one that I spoke of a moment ago. There were water samples taken, and some chemical measurements made, but no biological measurements, I don't think.

Senator HOLLINGS. At the exact site where it was——

Dr. CHEEK. No, sir. Admittedly we can only say this was the general area. At that time those hulks had not been located, so it is difficult to tell how close to the hulk these photographs were taken.

Senator HOLLINGS. Isn't it a fact you couldn't find it?

Dr. CHEEK. They can be found later, I think, sir.

Senator HOLLINGS. Isn't it a fact as of this moment they have not been found? Isn't that right?

Dr. CHEEK. It is a fact; they were not found.

Senator HOLLINGS. As a scientist you are giving exact testimony but the fact is you haven't found the sunken hulks off the New Jersey coast, isn't that true?

Dr. CHEEK. Yes, sir.

Senator HOLLINGS. Secretary Beal, will you tell us which gentleman will be the appropriate one to testify as to the sinkability of this ship, and the weather concerns and other related facts? I do a little bit of boating, and it may seem easily done. I am thinking in terms of the current, actually sinking it, making certain it goes directly down at the selected site, 16,000 feet below, and what currents, if any, there are, and will it get up to Governor Kirk's beaches in Florida, or what?

Mr. BEAL. Would you introduce yourself.

Mr. FERNANDES. I am Mr. Fernandes, the transportation safety officer, Naval Ordnance Systems Command, Department of the Navy. The CHASE operations have been under my control since 1964. It is a standard procedure that we've used in the Navy for years to dispose of obsolete defective ammunition.

Senator HOLLINGS. How many ships have you sunk 16,000 feet? Any ever before?

Mr. FERNANDES. The hulks referred to are old surplus Liberty ships, not barges. We have loaded two old Liberty hulks with chemical munitions. These hulks are obtained from the Maritime Administration as surplus. None has been scuttled in 16,000 feet. The normal depth is 8,000 to 10,000 feet.

Senator HOLLINGS. These are the hulks in question; these are the ones being employed by the Army in Missouri?

Mr. FERNANDES. That is correct.

Senator HOLLINGS. Liberty hulks?

Mr. FERNANDES. Yes, sir.

Senator HOLLINGS. How do you sink them?

Mr. FERNANDEZ. First, we obtain a hulk from the Maritime Administration, which as I mentioned are declared as surplus. Under a new public law, any country now can buy these hulks. At that time we were able to obtain at no cost. Once the hulks are assigned to the Department of the Navy, we thoroughly inspect them from top to bottom, bow to stern, even using divers to check the underneath to make sure there is no chance for seams to break. Then we strip the hulk completely of all excess material. At that point we turn it over to another inspection team from the Navy to verify that this ship is in good condition for sea travel. At that point we take it to an assigned commercial shipyard where the hulk is gutted and appropriate sea valves and valves between the holds are installed. When the hulk is prepared for scuttling, it is again inspected by the Navy. If all specifications are met, the hulk will be towed to Sunny Point, and again inspected by the Navy and Army. The material is then loaded aboard. The hulk is equipped with many valves. These valves are not the standard valves you are probably familiar with, sir. These valves are reached with "reach rods" which are extended up on the deck, so that there will be no need for anyone to go down into the hulk and open at the dump site. Three of the valves allow the seawater to come in. There are other valves in addition to the one for the sea's passage which will permit the water to go from one hold to another. We have made every effort to make sure that the water penetrates into every part of the hulk to make sure it will sink, and not have any air pockets.

(The following information was subsequently received for the record:)

We have also taken other safety precautions such as:

(1) The hulk has an alarm system which will sound if 6 inches of water should enter any hold prior to scuttling. At night the alarm is augmented with a flashing light.

(2) A black diamond shape is attached to the mast indicating the ship is not manned and the sides are painted with the words "Explosives" in 6-foot high letters. These letters and strips on the stem are of reflectorized material.

(3) The hulk is completely equipped with proper running lights.

(4) An emergency tow line of 1⅝-inch steel wire cable is attached to the stern for use at the dump site.

(5) A 1,200-foot buoy marker is attached to the mast—which automatically releases when the ship goes below the water. It can pinpoint the exact location of the ship if it accidentally sinks in less than 1,200 feet of water.

When the operation is completed, we make sure that all floating debris is removed from the water to prevent damage to other craft. We have, to date, had no problem except the one in the Aleutians. Our CHASE operations have proven effective, economical, and above all—safe.

Senator HOLLINGS. These are the hulks that you sank off the New Jersey coast?

Mr. FERNANDES. Yes, sir.

Senator HOLLINGS. And, yet, you haven't been able to find those hulks?

Mr. FERNANDES. I can't answer that question concerning finding the hulks in the New Jersey area. I know when we tried to find the one in the Aleutians, which was easily found, that it was quite costly.

Senator HOLLINGS. How did you find that easily?

Mr. FERNANDES. We used a specially equipped ship, the *Silas Bent*. It has special devices for underwater detection and camera capabilities.

Senator HOLLINGS. You did not use that off the New Jersey coast?

Mr. FERNANDES. That I cannot answer. Maybe Dr. Cheek can assist me.

Dr. CHEEK. The Naval Research Laboratory has a ship called the *Mizar*. This is a ship that has been able to find the hulks of lost submarines.

As I tried to point out a few moments ago, it is possible for *Mizar* to locate these hulks, and if that assignment is made, we know the approximate coordinates and can make an easier job of it than finding some of the submarines. There is no question that *Mizar* can find those hulks.

Senator HOLLINGS. The fact is they have not found them.

Dr. CHEEK. They have not.

Senator HOLLINGS. There is no biological testing in the vicinity of the hulks.

Dr. CHEEK. That is true.

Senator HOLLINGS. What current is at the area, 220 miles off the coast of Cape Kennedy, Fla.?

Dr. CHEEK. What was the question? How far is it?

Senator HOLLINGS. The current. Is there any current there?

Dr. CHEEK. There are some currents. We have information on surface currents and currents at the bottom.

Senator HOLLINGS. Any danger of current effect whatsoever as it is sinking?

Dr. CHEEK. No, sir.

Senator HOLLINGS. Can this ship be picked up by a particular current, say down to 10,000 feet and taken aside from the site?

Dr. CHEEK. All the currents are quite slow. At the surface, maybe seven-tenths of a knot. At the bottom measurements have been made, and the average current is about a tenth of a knot. Not only is this so, the current goes in somewhat a circular fashion so the water at the bottom is very well confined so that it actually makes headway at about half a mile a day.

Senator HOLLINGS. Half a mile a day.

Dr. CHEEK. So this would mean that—if it makes a half a mile a day—in the 10 days I was talking about a while ago, it would make a distance of 5 miles from the site of the scuttling, and during this period it will again be down by a factor of a million by hydrolysis.

There is another point I would like to make, concerning the actual level of contamination of these materials compared to the amount of sea water we are dealing with. It will be instructive to point out that 1 cubic mile of sea water weighs about 9.4 trillion pounds. That is, if we take 5,280 feet and cube it, that gives us 147 billion cubic feet; each cubic foot weighs 64 pounds. Now, let's consider contamination of one cubic mile at the level of one part per million; that would require 9 million and 400,000 pounds of contaminant. Now, let's consider just the 135,000 pounds of GB agent that would be put into the ocean and assume again the long chance that all of it will get into the water at once, calculations will show this would constitute only 14 parts per billion contamination. That is a little over one-one-hundredth of a part per million.

Senator HOLLINGS. What is the water pressure at 16,000 feet?

Dr. CHEEK. About 7,000 pounds per square inch, sir.

Senator HOLLINGS. Seven thousand pounds per square inch. Have you tested these coffins under 7,000 pounds per square pressure inch? There is no actual testing—or has there been any? If you test them, you would break them. They are dangerous right now. Did you put up some mock ones?

Dr. CHEEK. Perhaps someone else could address that, sir. To my knowledge the concrete within has been tested—it is a type that has a compressive strength of about 7,000 pounds per square inch. Perhaps someone else can address that better.

Senator HOLLINGS. General Murray.

General MURRAY. I know we simulated a test; we used dynamite on them.

Senator HOLLINGS. What was the result?

Mr. BEAL. General Stone is best qualified.

General STONE. In direct answer to your question, we have never subjected an entire vault to a pressure approaching 7,000 pounds per square inch. We do know the yield strength from tests on small samples. As the yield strength of the concrete is reached, the deformation or the compressing in of the concrete and the steel begins. This does not mean it flies apart all at once by any means. It is the beginning of the formation of fissures or cracks through the concrete, and perhaps the opening of some of the seams of the steel box built around the concrete.

Senator SPONG. I would like to ask the Secretary one other question. Perhaps General Stone will answer it.

Did I understand General Stone to say that these rockets have been distributed all over the world?

General STONE. Sir, I used those words and I used them loosely. Of course, to discuss specific locations would get into classified information. These rockets are part of our stockpile. Their locations have been discussed before the appropriate committees.

Senator SPONG. Let me ask you this question: Is any other disposal at sea comparable to this going to take place anywhere else in the world?

General STONE. No, sir. Our statement concerning our future plans for disposing of this material was that it will be done by remote control and detoxification equipment regardless of where it is located. In general, we will move our detoxification equipment to the storage site and accomplish the detoxification there rather than move the material to the detoxification site.

Senator HOLLINGS. Mr. Fernandes, will you come forward, please? Senator Cook has one more question.

Senator COOK. Has the procedure of all of these particular types of valves been followed in all of your prior disposals?

Mr. FERNANDES. Yes, sir; for the chemical dumps.

Senator COOK. I was very interested to hear you say by reason of these valves, the entire vessel was flooded. There could be no sections of the vessel whatsoever that could contain any amount of captured air?

Mr. FERNANDES. No, sir. When we take these hulks through a shipyard, they are completely gutted with all avenues vented where there is possibility of air pockets vented.

Senator COOK. This was done in the project off of New Jersey?

Mr. FERNANDES. In every CHASE operation involving chemicals, we have taken this precaution.

Senator COOK. The reason I was interested to hear you say that if there would be any possibility of captured air, it could become totally buoyant at a depth short of the bottom, then it is conceivable it could just be literally floating around at 10,000 feet or 12,000 feet if it were not totally void of air. Is that not correct?

Mr. FERNANDES. That's partially correct. The water pressure at the depth would be too great to permit the hulk to hold an air pocket.

Senator COOK. Thank you.

Senator HOLLINGS. Can you give us the site and the depth off the New Jersey coast?

Mr. FERNANDES. The site was 39 degrees, 38 minutes north, 71 degrees, zero minutes west. That's 149 nautical miles or 171.5 statute miles off the shore of New Jersey. Actually, it is taken from the point called Sandy Hook Point.

Senator HOLLINGS. East of Sandy Hook? 175 miles east of Sandy Hook?

Mr. FERNANDES. 171.5 statute miles.

Senator HOLLINGS. What was the depth at that particular point?

Dr. CHEEK. 7,200 feet.

Mr. BEAL. 7,200 feet, sir. And it is marked on navigation charts as a disposal site.

Senator HOLLINGS. So this is twice the depth. We haven't had any experience then——

Mr. BEAL. That is deemed to be an advantage by the National Academy of Science.

Senator HOLLINGS. They think that is an advantage. Any other questions?

Senator COOK. Will there be any equipment of any kind to determine when this vessel really reaches the bottom?

Mr. BEAL. Yes.

Senator COOK. So it can absolutely be detected so we won't have this problem again and the fact that it has actually reached 16,000 feet, reached the bottom of the ocean?

Mr. FERNANDES. The hulk will be instrumented before it leaves Sandy Point. The instrumentation will detect data as to what is happening to the hulk as it goes down. Water samples will be taken to tell us if there is any leakage of the material once it reaches the bottom. The instruments are now being attached to the hulk.

Senator HOLLINGS. And suppose it tells you there is some leakage as it goes down, what do you do?

Mr. FERNANDES. As Dr. Cheek has mentioned, it depends on exactly what depth it reaches when it leaks.

Senator HOLLINGS. You would like to have it leak as it goes down?

Mr. FERNANDES. It might help, if at certain depths. I would like to pass that question to Dr. Cheek.

Senator HOLLINGS. How would that help, Dr. Cheek?

Dr. CHEEK. I would like to withdraw that, sir. I did not say, I don't think, that we would like the thing to leak on the way down. In fact, we would prefer to have the nerve agent completely contained until the vessel would reach the bottom. However, sir, if leakage should

occur on the way down, there is one advantage afforded by the temperature structure of the water, the water is considerably warmer toward the top. At the surface the water temperature is 26° C. At this temperature the nerve agent reacts much more rapidly with water so it has a half-time, not of half a day, but somewhat less than half an hour. I was talking in terms of days before. This would say in about 5 hours the quantity of nerve agent would be down by a factor of a thousand and in ten hours, or less than half a day, down by a factor of a million.

Senator HOLLINGS. Finally, is this dumping area marked as a dumping ground for nerve gas?

Dr. CHEEK. No, sir. It is marked as a dumping ground for munitions, chemicals and explosives. Nerve gases are chemicals, so in that respect it is within the law.

Senator HOLLINGS. Mr. Secretary, we appreciate very much your appearance, you and your colleagues. We will leave the record open, if you don't mind, for any written questions and answers.

Is there anything further you want to add?

Mr. BEAL. I think the Army to some extent was plagued by people constantly raising "what if" questions. So we have planned and talked about the worst case, which is not the situation we think will occur. For example, what might be happening inside these hulks we cannot say. The Gross committee is assuming the worst case, that is, that it will set off an explosion. We do not think this will happen, but we have to plan for that worst case. By the same token, the worst case on the bottom of the ocean is that about 1 cubic mile of sea water will be temporarily contaminated. We do not think that is going to happen, either. When you balance the two worst cases, it seems to us clear there is no practically feasible alternative to sea disposal.

Senator HOLLINGS. That is our situation exactly in politics, too. We are only given one election day.

Thank you very much, Mr. Secretary.

Dr. Howard Sanders, will you come forward, please?

Senator HOLLINGS. Let the committee come to order.

On behalf of the committee, I would like to introduce Dr. Howard L. Sanders, senior scientist, Woods Hole Oceanographic Institution. He earned his M.S. at the University of Rhode Island in 1951, his doctorate at Yale University in 1955. He has quite a biography which we will include at the end of your testimony.

Dr. Sanders, we understand you have precious time in returning to Woods Hole and we appreciate hearing from you at this time.

Do you have a prepared statement?

You can just testify.

STATEMENT OF DR. HOWARD L. SANDERS, SENIOR SCIENTIST, WOODS HOLE OCEANOGRAPHIC INSTITUTION, WOODS HOLE, MASS.

Mr. SANDERS. Senator, no. Actually this was of such short notice that I finished writing the scribbled notes at about 2:30 this morning.

I must say that I am pleased to testify before the Subcommittee on Oceanography of the Senate Committee on Commerce on the nature of deep sea life and possible implications of stresses such as lethal

gas, and other exotic materials may have on the unique assemblage of organisms found at these depths. I hope to give some insights into the nature of deep sea animal life and to dispel totally and completely the long held but false notion that the vast stretches of the deep ocean floor are not barren and desolate wastes but harbor a rich and diverse animal life. By rich I mean rich in kinds of animals, not necessarily in numbers of animals. I have been studying animal communities of the ocean floor since 1952. For the last 10 years my major thrust has been in the deep sea.

As an ecologist, I am apprehensive about the general problem of waste disposal in the ocean, particularly as it applies to the deep sea.

The concern at this subcommittee meeting deals with the specific problem of nerve gas. Our knowledge of a deep ocean and its biology is meager. Dumping of wastes into the depths of the ocean seems a simple solution to the problems that plague us. However, the apparent simplicity is rather a reflection of our ignorance.

It is ironic that we prefer to put these problems in an environment we know least about and where there is the least possibility of predicting what their effects might be.

My areas of apprehension are broad. Other than dumping of nerve gases I am most uneasy about the extensive plans for oil drilling and the discharging of domestic waste, chemicals, heavy minerals, and other byproducts of our technology by proposed giant outflows into the seep sea.

The ocean floor at these depths lies below the thermocline.

Therefore, the area of discharge, dumping, or drilling will be in a region of remarkable stability regarding its physical properties.

Temperature, salinity, oxygen conditions, and other factors in contrast to shallower waters are essentially unvarying and have changed little over many thousands and even millions of years.

In this context we must bear in mind that the driving force of evolution is toward even finer adaptations of an organism to its environment. Thus, under conditions of constancy and predictability over geologically long periods of time there have evolved in the deep sea a delicately attuned, highly sensitive assemblage of organisms with very narrow range of tolerances.

Such communities can be expected to be most fragile.

As a consequence, a perturbation or stress that might have little significance in the variable and less predictable shallow waters could have severe and perhaps catastrophic implications in the deep sea.

Deep sea drilling and the diverse and exotic wastes of which the toxic chemical agents under consideration today are prime examples that will be discharged into this environment in my opinion offer the potential for such a catastrophe.

I hope I have made it clear that we are dealing with a very different assemblage of life in the deep sea that is a product of a markedly different evolutionary history than are the animals of the variable and stressful shallow seas.

Thus, what is learned from the study of shallow water life must be extrapolated with great caution to the deep sea.

In other words, they are a different kettle of fish.

To put in some perspective the variety of diversity of animal life in the supposed inhospitable environs of the deep ocean floor, my colleagues and I undertook a comparative study of diversity of bottom-

living marine animals. Shallow water was compared with the deep water, high latitude was contrasted with low latitude, and brackish estuaries with marine habitats. The diversity or variety of life in the deep sea was about the same level as that found in tropical regions with negligible physical stresses. Diversity is considerably greater than that present in the remaining habitats.

Note, the high diversity environments are and have been invariably stable and predictable for a long period of time and the animals have narrow tolerances.

The low diversity environments alternatively have high physical stress, low predictability with animals of broad tolerance.

From the testimony given so far, it appears that a somewhat uncritical mania for secrecy has created a needless danger to our society and potentially serious although unmeasured threat to the marine environment.

In this regard I would like to ask some questions to learn how well planned was and is the marine phase of the disposal operations.

This applies to the New Jersey site primarily.

Have adequate and detailed studies been made of the bottom living marine life at the dumping site off New Jersey before the cargoes of GB nerve gas were sunk? This, of course, would allow the critical before and after comparison.

What is the level of biological surveillance being used to monitor the dumping site? And as Senator Hollings indicated or asked, has any gas leaked into the sea? If so, what effect has it had on marine life? We haven't concerned ourselves very much with the so-called M–34 clusters which contain the nerve gas GB. The Kistiakowsky report states and I quote: "There is some possibility of a large detonation of M–34 clusters upon sinking of the ship in the ocean."

Later, the report further states, "We consider that this is a probable event upon the impact of the ship's hulk on the ocean bottom (7,200 ft. deep) which it reaches at a speed that has been estimated at 10 to 100 feet per second. While the consequences are impossible to predict precisely, lethal contamination of several cubic miles of ocean * * * for a period of many days is likely, on the basis of calculations involving rates of hydrolysis of GB, its convective diffusion and expected sea currents." Further on, the report concludes, "The effect of these events on the oceanic ecosphere cannot be estimated but could be very serious."

I am presuming of course that the M–34 clusters have been sunk off of New Jersey. I merely ask what has happened?

In regard to some of the statements made in previous testimony, I am a little bit surprised that such a great amount of credence has been placed on observations that have been made over such a short period of time. I am particularly referring to the current measurements. These were done over a period of 10 days.

We have been doing extensive current measurements at our Oceanographic Institution for a number of years—studies of the gulf stream and the deeper countercurrent below it. What we have found is a tremendous amount of variability. You only begin to perceive the total picture after you have taken current measurements over a very extensive period of time. The velocity changes, direction changes, the position changes. Sometimes you cannot even pick it up; at other times it is flowing strongly at a different place.

Now these observations were made over a period of years. At the proposed dumping site off Florida, current measurements were limited to a 10-day period at one locality. From this, we supposedly know what the current regime is like, its velocity, and variability. This is placing a great deal of hope on a minimal amount of information.

Before terminating, I would like to state that my criticism is not that lethal gas encased in concrete will be dumped into the sea since this may indeed be the best of a miserable set of choices. In other words, we have painted ourselves into a corner. Rather, it is a fact that a wide assortment of lethal and exotic substances have been deposited on the ocean floor with no apparent feeling of responsibility to learn what effects they may have on the environment. We cannot afford to continue operating in a vacuum of ignorance. Only through understanding and knowledge can we make wiser and less dangerous environmental decisions.

Thank you.

Senator HOLLINGS. Thank you, Dr. Sanders.

It seems that apparently they know the dangers on the land but they do not in the ocean, particularly these dumping sites, and since they don't know and cannot be debated with, so to speak, they go ahead with this particular decision, even though the Lawrence Radiation Laboratory recommended otherwise, except for the time limitation.

Let me get into some of the differences.

Dr. Cheek was testifying about sparse sea life in the deep ocean level. Your testimony seems to differ with that.

Will you elaborate for the committee?

Dr. SANDERS. Dr. Cheek's comments are correct only in the sense that the density of life in the deep ocean floor is sparse. That is, there are few animals in number relative to other regions of the ocean. However, it is totally incorrect when we think of the variety of kinds of animals that live in this constant environment. It is surprisingly diverse. I have tried to indicate, it is as diverse as any other similarly constant environment we can find in the world's oceans, which happens to be certain tropical shallow seas. In reality it is more diverse than most other regions of the world ocean.

Senator HOLLINGS. Then referring specifically to Secretary Beal in his prepared statement, he was talking of vanishingly small possibility of a catastrophic accident such a possibility is essentially nil. You testified differently. Will you elaborate on that? You used the expression I believe, "potential catastrophe" which you said could have some severe implications.

Dr. SANDERS. The point I have been trying to make in this testimony, you cannot apply the findings from a study of one group of animals living in one habitat directly and uncritically to a different environment. The evolutionary histories are so different. The resulting products we have today are such markedly different organisms; stress that would have essentially little effect in one situation would have severe effect in the other.

The tendency is largely to extrapolate from shallow water animals or even laboratory animals which by definition are selected for their ruggedness and toughness as far as their physical tolerances go. This is the wrong sort of situation, the wrong set of criteria to use if you are going to apply them to the deep sea because there you have dia-

metrically different kinds of organisms with narrow tolerances and limitations. Obviously a great deal of further work must be done. There is very little basic research going on today on this problem.

Senator HOLLINGS. Do you know of any particular study that would show the concentration or lethal dose necessary at 16,000 feet to kill 50 percent of the fish or ocean life there? Have you made any kind of test on that?

Dr. SANDERS. I know of no such test. I would say in fairness to the previous witnesses, this will be a chemical reaction. There will be a specific half-life and to a certain degree somewhat independent of some of the biological adaptations that we are talking about. But, these biological adaptations take on more critical importance with other types of stresses, stresses of a biological sort such as wastes, other exotic chemicals that will be introduced into the deep sea and are not part of the evolutionary history of these animals. The chances are that with these kinds of compounds we may be in for some very real problems. What I have not mentioned today, there is a very strong indication from work at our own institution, that biodegredation, that is a breakdown of wastes, occurs at a surprisingly low rate in the deep sea as compared to shallow water. This poses another very severe threat. The deposition of wastes in the deep sea may indeed prove to be a poor choice because of the probable slow rate of biodegradation resulting in an accumulation of wastes which in turn can create toxic conditions.

This, coupled with the point that the organisms living there are remarkably susceptible to stress, raises a very serious problem that has not been properly put into focus.

Senator HOLLINGS. What comment would you have on the example given by Dr. Cheek when he cuts up the paper to demonstrate 10 half-lives, reducing the nerve gas to one millionth of a part of its original strength?

Dr. SANDERS. I prefer to weasel on this, primarily because I am a biologist and not a chemist. I tend to be more critical of areas that I have some competency in than in those I have a gross ignorance on. On this I would be forced to accept what he says as true.

Senator HOLLINGS. Have you heard of any reports about the leakage of nerve gas at the New Jersey dumping site having any effect on marine life?

Dr. SANDERS. I have heard of nothing official or anything I would care to comment on. I have heard rumors to this effect. I doubt whether they have a factual basis. Yet there is no excuse for why this area has not been under complete and continuous surveillance. The problem is so important and so critical that neglect is inexcusable.

Senator HOLLINGS. We have all heard the testimony that no biological studies were made afterward at the New Jersey site because they never even found the hull, and I take it none were made prior. Do you know of, in your scientific work, of any biological studies made prior to the dumping?

Dr. SANDERS. No. I know of no work that has been made prior to the dumping. We do have a station not very distant from the New Jersey site. I would suspect that the original animal life present on the dump site off New Jersey, would be similar to what we find at the same depth on our study area. Thus the animal assemblages found at our study station might serve as a reasonable representation of what was present at the New Jersey site previous to dumping.

Senator HOLLINGS. Do you know, as a marine biologist, whether the GB nerve gas has a residual effect similar to DDT? The previous testimony was that it could not be passed up the food chain. It would only have the effect on the immediate marine life around it but could not be passed on by fish to other marine life or to humans in consumption? Can you comment on that?

Dr. SANDERS. I think that is essentially a correct statement.

In regard to the persistent pesticides, they tend to be concentrated in the lipid fraction of an organism. So that when you go to the next level of the food chain, the animals that feed on these organisms, there is a considerably enhanced effect as the pesticide is selectively retained and concentrated. If you go up two or three levels on the food chain, the concentration of the persistent pesticides have increased tremendously. There is a very real possibility that in some of the work we are doing today on a local oil spill that oil itself may act in a similar sort of way as do the persistent pesticides. This is something we are studying now. Whether this will indeed be borne out should be known in a short time.

Senator HOLLINGS. Senator Spong?

Senator SPONG. Dr. Sanders, I very much appreciate your testimony. I agree with you that we are faced with a miserable set of choices from what I have heard. I share your concern that this is being done against a background of very limited knowledge and research.

In Secretary Beal's statement, there is a very brief paragraph entitled "Ecology." It deals mostly with chemical rather than biological effects. Also, filed with the reports and papers of the Army paper No. 4, entitled, "Environmental Impact Statement," which we require under the law now. I know you have not had an opportunity to review these. I will see that the staff provides you with both and I will appreciate any comment for the record that you might have later.

I assume the record is going to stay open?

Senator HOLLINGS. It will.

Dr. SANDERS. Thank you, Senator.

I did have a chance very quickly to look over the statement that Secretary Beal gave regarding environmental impact. In some sense I think it is a fair appraisal of our knowledge.

Senator SPONG. Thank you.

Senator HOLLINGS. Senator COOK?

Senator COOK. Thank you.

I want to reiterate what Senator Spong said. I cannot for the life of me understand with a detoxification method available, why any such rockets were placed in concrete other than the fact that the military concluded that it was easier to dump them in the ocean. I hope that you are as pleased as I was that apparently the military has accepted the recommendation of the Gross report that munitions should not be encased in concrete because of the difficulty of disposing of them when obsolete. They have decided they will not follow this procedure any more. Maybe we will not and maybe this will be the last time we will have to face this issue.

What concerns me is that these rockets were encased in concrete as early as 1968 and that you knew they were going to be disposed of, and where they would be disposed of. However, the only thing we have heard so far this morning is that some slight tests were made during a week's time in July of this year as to the area involved.

Apparently all during 1968 and all during 1969 this was not a very serious problem to the military.

I take it from what you said that the continual study of currents and water reactions at lower levels is necessary because of the shifts of the major currents themselves. Is that correct?

Dr. SANDERS. That is correct, Senator. Our knowledge of the deep water circulation is very poorly known. In fact, the first real data have been coming up only in the past few years. These are a very, very limited number of observations. So I think it is very dangerous to again extrapolate too broadly with what we have. Certainly it is extremely dangerous to extrapolate on data that covers only a short period of time as the case of the dumping site off Florida.

I think it points out the need for continuing and, indeed, increasing the fundamental research which will allow us to make the types of generalities that are so desperately needed today. We are so tied up with narrowly conceived relevant research that we really cannot answer anything more than the immediate problems. They don't answer long-range problems, they don't answer anything more than the narrow strictures of the questions asked. We cannot get far with this type of research. Yet, basic research is under greater pressure and under greater criticism today than it has been for a number of years.

Senator COOK. I might only add to that, Doctor, maybe this is one of the occasions when the Senate of the United States has performed a real service. The amendment that went on the act last year that required this notification, and the present Senate and House hearings indicate that we will not have to face in the future the fact that the ocean has been used as a garbage can for nonusable military explosives.

Dr. SANDERS. Thank you. I am delighted with the possibility.

Senator HOLLINGS. Dr. Sanders, once more, to make it clear in the record now, you have been in marine biology for 20 years, and are a senior scientist at Woods Hole. At 16,000 feet, can you elaborate what knowledge we have of that environment? How many testings have been made of a thorough nature? What comprehensive knowledge of the environment at 16,000 feet, by us, the French, British or any other group, do we have?

Dr. SANDERS. Well, there have been studies almost ever since the CHALLENGER expedition about a hundred years ago. However, only recently through techniques and methodology have we really gotten a truer understanding of what it was like. I have related some of these findings—this is a single largest environment on the face of the earth incidentally.

I would like to state that we still know very little about it.

Senator HOLLINGS. Tolerance is very narrow and the response very slow and could be the opposite of surface marine life.

Dr. SANDERS. Yes; they could be very different than shallow water marine life.

Senator HOLLINGS. Thank you very much, Dr. Sanders, for your appearance here this morning, we will place your biography in the record.

(The biographical sketch follows:)

BIOGRAPHICAL SKETCH OF HOWARD LAWRENCE SANDERS, BIOLOGIST, SENIOR SCIENTIST, WOODS HOLE OCEANOGRAPHIC INSTITUTION

B.A., University of British Columbia, 1949; M.S., University of Rhode Island, 1951; Ph. D., Yale University, 1955.

Research Associate, 1955–63; Associate Scientist, 1963–65; Senior Scientist, 1965 to present, Woods Hole Oceanographic Institution.

Instructor, Marine Biological Laboratory, 1960 to 1968.

Editorial Board, Limnology and Oceanography, 1962–64; Consulting Editor, Pacific Naturalist, 1963 to present; Board of Editors, Journal of Marine Research, 1964–66; Member, Committee on Arthropods for the Smithsonian Oceanographic Sorting Center (SOSC) 1965–1968; Member, Editorial Board, Archivio di Oceanografia e Limnologia 1968-present; Member, Biological Methods Panel of the National Academy of Sciences Committee on Oceanography. Chairman of the Working Group on Benthic Productivity; Member, Corporation of the Marine Biological Laboratory; Member, Bermuda Biological Station for Research; Associate in Invertebrate Zoology, Harvard University; National Science Foundation Environmental Biology Advisory Panel, Member, 1966–68; Member, Review Committee of the Duke University Cooperative Research and Training Program in Biological Oceanography, 1968–1970, Chairman, 1970; Adjunct Professor of the Biological Sciences, State University of New York at Stony Brook, 1969; Member, Advisory Panel of the National Academy of Sciences for the Central American Sealevel Canal, 1969–1970.

Research in Ecology: Ecology as applied to marine benthic, communities; Crustacean phylogeny · deep sea biology.

Author or coauthor of about 35 publications in ecology.

Senator HOLLINGS. We will next hear from Russell E. Train, chairman of the Council on Environmental Quality.

Welcome, Dr. Train. We're glad to see you once more.

STATEMENT OF HON. RUSSELL E. TRAIN, CHAIRMAN, COUNCIL ON ENVIRONMENTAL QUALITY; ACCOMPANIED BY DR. LEE M. TALBOT, SENIOR SCIENTIST; AND DR. J. GORDON McDONALD, MEMBER

Mr. TRAIN. For the record, I am accompanied on my right by Dr. J. Gordon McDonald, a member of the Council on Environmental Quality and on my left by Dr. Lee M. Talbot, senior scientist on the staff of the Council.

Mr. CHAIRMAN, I appreciate the opportunity to discuss certain of the environmental questions associated with the proposed Project CHASE. As you are aware, this plan calls for the deep ocean disposal of 418 concrete vaults in which are embedded M–55 rockets filled with GB nerve agent and propellant and dispersal explosives. The vaults are to be moved by rail from the Anniston Army Depot in Alabama and the Lexington-Bluegrass Army Depot in Kentucky to Southport, N.C. At Southport they will be loaded on to a hulk and transported to a point 245 nautical miles east of Cape Canaveral. At this point, the hulk containing the vaults will be sunk. The ocean floor is over 16,000 feet deep and the area has previously been used for dumping of munitions.

On July 8 of this year the Department of the Army forwarded to the Council on Environmental Quality a draft statement of the environmental impact of CHASE in response to the requirement of the National Environmental Policy Act of 1969. On July 30, the Army submitted its final draft and the Council sent its comments on the statement to the Army on August 4.

In his April 15 message on Great Lakes and ocean dumping, the President directed the Council on Environmental Quality to prepare

a comprehensive study on ocean dumping. The study will be submitted to the President by September 1 and will recommend further research needs and appropriate legislation and administrative actions. In that same message and in specific reference to the ocean disposal of sewage and sludge, the President declared: "We are only beginning to find out the ecological effects of ocean dumping, and current disposal technology is not adequate to handle waste of the volume now being produced."

While the Council has not completed its study of ocean dumping, we have already concluded that it is clearly inappropriate to use the oceans for the disposal of any toxic material. The oceans are a precious resource and our knowledge of them is still so limited that we cannot confidently predict the consequences of placing in them any dangerous materials.

However, with regard to Operation CHASE, the Council does not know of any more desirable means of disposal. Given the present set of circumstances and accepting the recommendations of the Gross Committee and the National Academy of Sciences, we agree that the proposed plan is the least undesirable of the available alternatives.

The ultimate deleterious impact of this operation on the environment is uncertain, but it appears less than the potential deleterious impact of the alternative actions that now appear possible. Put another way, given the present situation—the need to dispose of a large number of armed and ready rockets filled with GB agent, sealed within steel covered concrete vaults, with possibility of the explosives aging and becoming unstable, and the rockets corroding and releasing the nerve agent—the proposed ocean dumping appears to pose a lesser risk to the environment than any other course. Clearly, the potential long term environmental effects of sealing the rockets in concrete were not taken into consideration at the time the decision was made.

While the Council concurs in this case with the plan for ocean disposal—because of the absence of practical alternatives—the council wishes to comment on several aspects of the plan.

The statement filed by the Department of the Army on the environmental impact of Project CHASE deals only with the possible environmental effects after the concrete vaults have reached the ocean floor. In our comments to the Department of the Army with respect to its statement, we make clear our conviction that the transportation aspect of the project is of a nature requiring an environmental impact statement under the National Environmental Policy Act. In any event, we have had available to us the opinion of the Surgeon General to the effect that any health or safety effects involved in the transportation are negligible, particularly in view of the precautions planned by the Army. We have no reason to disagree with the Surgeon General's opinion.

The Council is concerned with the structural integrity of the concrete vaults, including possible variations among them, in that, if the munitions in the vaults are in an unstable condition, there is at least some danger that at least some of the vaults might explode, implode, or rupture before the hulk reaches botton. If this occurred at or near the surface, there is a possibility of the gas entering the atmosphere. Even if this did not happen, the contamination would be in shallower waters far richer in marine life than the lower depths.

These waters contain species of value to sport and commercial fisheries. Because of mixing by currents, the volume of water contaminated would be greater at relatively small levels than at depth. I might simply interject here, Mr. Chairman, that the Gross report does report that the chance of rupture on the way down is highly unlikely. We simply make that point because, however remote, the possibilities were not covered in the environmental impact statement submitted by the Army.

Senator HOLLINGS. The leakage potential is there without the rupture itself. In fact, the Under Secretary of the Army just testified it is dangerous right this very moment and he is working against an August deadline, after which he has to dispose of it.

We know on the outside 15 months, isn't that correct?

Mr. Train. That is what we've been informed.

Senator HOLLINGS. If we could have waited 15 months, they would have had a land disposal approved rather than this ocean one. At least it should be done no later than this particular month, August of 1970. So it is not the rupture itself, the leakage discussed.

Mr. TRAIN. The Council considers that the question of impact of the nerve agent on living organisms has not been considered in sufficient detail. The data and conclusions drawn come from experiments with several species of shallow living fresh water fish. It is not safe to assume that marine fish will react similarly. It is less safe to assume that other forms of marine life will do so. We note that there was significant variation among the species of the experimental fish in their reaction to the nerve agent.

At the present state of our knowledge, it is believed that there are relatively few living organisms at the dumping site at 16,000 feet depth. It is important, however, to realize that our knowledge of life at that depth is very incomplete. Present sampling methods may not collect the larger and more active organisms. It is known that carnivorous fishes are found at that depth. Most of the deep water fishes have eggs which rise to or near the surface. Eggs and larvae of other deep sea organisms come to or near the surface. It is believed that many organisms may make seasonal migrations from shallow to deep waters, and from coastal to deep waters. Many commercial fishes, for example flounder, which occur in shallow waters off the southeastern coast of the United States migrate into deeper waters in winter. The exact depth limits of these movements are not known. But the point is that there is a possibility that fishes, directly used by man, might pass through the contaminated zone, or might consume other organisms which have come from or passed through that zone. And it should be remembered that there are commercial surface fisheries in the general area of the dumping site.

A further point considered significant by the Council is the question of the duration of contamination in the event of leakage. The Army has provided estimates on the area and volume of sea water affected, but we consider that more attention needs be given to the duration of the effect. Of course, the duration of contamination would depend on the rate of leakage, among other things, and the Council considers that this is another area where it should be clearly stated that insufficient information exists to make any firm predictions.

The Council strongly supports the recommendation of the Departments of the Interior and of Health, Education, and Welfare that the

hulk and the dumping site be monitored. It is important to monitor the hulk itself to determine (1) when, where, and if there is any rupture, explosion or implosion in the hulk, during and after its descent; and (2) to locate precisely its final resting place. It is also important to monitor the dumping site, over the coming years. A program of sampling should be developed to maintain proper surveillance over the area and the condition of the water and marine life. A similar program should be developed for the other dumping site where chemical munitions similar to those involved in Operation CHASE were dumped.

Project CHASE focuses attention on the far-reaching requirements of the National Environmental Policy Act. This act was not in force at the time the decision was made to seal the rockets in concrete. It is the clear intent of Congress that in the future, before such decisions are taken, the full environmental consequences must be examined and reported.

Senator HOLLINGS. Dr. Train, we are probably going to have to get someone from the AEC on this land alternative. You are not too familiar with the problems involved in the 15 months' preparation?

Mr. TRAIN. No, sir. I have read AEC's report——

Senator HOLLINGS. I wonder what——

Mr. TRAIN (continuing). To the Army. This is the only——

Senator HOLLINGS. How much liaison did they have between the Army and AEC? They dispose of irradiated elements at the Savannah River site and several others in this country where they are environmentally approved to do that. And there are large areas of containment there. That's the policy. It will probably continue because it is certainly safer than putting it in the ocean.

We pointed out previously, they took part of the Mediterranean sea bottom, 600 tons of it off the coast of Spain, and disposed of it in South Carolina. I wondered why they didn't go ahead and use that same facility. They have Chalkeese in New York and a few other places like that and they try to dispose of it in that fashion.

Mr. TRAIN. Those are questions that would best be addressed to the representative of the Atomic Energy Commission.

May I interpose? I would like to say that our conclusion, that the ocean disposal of these materials is the best of a group of essentially undesirable alternatives available at the present time, is based upon the information that the retention of these materials beyond the August 1 date of this year would create undesirable hazards. And, also, it is based on the information included in the report of the AEC, that it would take a substantial period of time—they use up to 15 months, as I recall, to prepare for disposal on land by nuclear explosion.

Senator HOLLINGS. You make a very forceful statement, this is not good at all. The fact is, you talk of the fish at the deep ocean bottom coming into the shallow areas, the eggs are deposited there—there has been a complete lack of biological study. There really has been no marine biological testing with nerve gas at 16,000 feet that you know of, do you?

Mr. TRAIN. Not that we are aware of, no, sir.

Senator HOLLINGS. I don't know of any. I don't know of any witness that can testify to it, either at this site or at the New Jersey site.

They haven't even found the hulks there. They said they can, but they haven't found them yet. Do you know whether or not they have found it?

Mr. TRAIN. I know no more than the testimony that was presented here this morning. We have also been in contact with both the Army and the Navy on this point and are aware that a ship, the *Mizar*, made a brief reconnaissance of the general area and did not at that time specifically locate the exact location of the two hulks. They took a number of photographs of the bottom and also collected water samples and made chemical analysis of those water samples, which I'm informed indicated no particular biological imbalance or chemical imbalance.

Senator HOLLINGS. But your statement says that it takes much longer than 10 days to make any real determination.

Mr. TRAIN. I believe we would like to make one point which is both of a very general nature and specific as to this case, that is, that we need to do far more research in depth and in duration on the environmental aspects of actions such as this. We are not really singling out this particular case. I think this case is symptomatic of our decisionmaking process over the years. I don't want to single out the Army to point a finger at in this case. I think this represents the way all of us have done business for too long and the Environmental Policy Act, our Council, and the policies announced by the President in the furtherance of this Act are designed to move us as rapidly as possible away from that way of doing business. We must do much more research into the long-range ecological and other environmental aspects of our proposed actions.

Senator HOLLINGS. We all agree with President Nixon in your quoting of his statement "We are only beginning to find out the ecological effects," and we just don't really know. And in light of that we still go ahead with this particular solution.

Senator Spong?

Senator SPONG. I want to commend you, Dr. Train, for your statement.

Mr. TRAIN. I appreciate being called doctor. I have got a doctor on either side of me, but I'm just mister.

Senator SPONG. I picked it up from the Secretary over here.

Mr. Train, I very much appreciate your statement and I commend you for it.

Now, as I listened to the concluding remarks by Secretary Beal, he reminded us that Dr. Cheek's conclusions were based upon the worst possible eventuality. And I take it that the report filed with us this morning which the Army did pursuant to Public Law 91–190 and the very brief summary on the ecology included in the Secretary of State's statement were based upon what they thought to be the worse possible eventuality.

Now, as I listen to you, I am not at all sure that you think that the worst results would come from all of the concrete exploding, rupturing, after the hulk reaches the bottom, that even though these reports have assured us that the possibility is rather remote of anything else happening, that from the standpoint of the ecology, should there be ruptures or should there be substantial leakage prior to the hulk reaching the bottom that it could have, in your judgment, worse effects, is that correct?

Mr. TRAIN. I think the point that we were essentially trying to make is that these possibilities, and we agree that they are very remote, are not considered and taken into account by the Department of the Army in its environmental impact statement to the Council. As I pointed out, the statement only considers the environmental impact after the hulk has reached the bottom. We believe this is a deficiency. There are these possibilities, which even though very remote and which I would assume wouldn't change the situation in anyway at all, still should be brought to the attention of reviewing agencies, such as the Council, yourself, and the public.

Senator SPONG. I quite agree with that. I did not ask the question with any idea of suggesting that they have any other alternative at the moment. But I think it's important that you said this and that all of us understand that it really isn't quite as simple as it's been presented.

Now, secondly, I think it's important because the Lord is moving in very mysterious ways. The oil pollution legislation was locked up in that conference until the Tampa Bay spill. I say that without any hesitation. I certainly hope that nothing is going to happen with regard to this, but I think we all ought to know the possibilities, no matter how remote they are, and I think what you and Dr. Sanders have done here today is a great service because I think all of us ought to begin saying that there is a great deal more research needed immediately in this vast area before anything comparable to this is dumped into the ocean.

Thank you, sir.

Mr. TRAIN. At the same time, I would reiterate the statement of the Gross report which I have accepted, that is to the effect that inaction increases the hazards.

Senator HOLLINGS. Right; that's why we move it as promptly as we can.

Senator Cook?

Senator COOK. Mr. Train, I appreciate your remark on page 2, "while the Council has not completed its study of ocean dumping, we have already concluded it is clearly inappropriate to use the ocean for the disposal of any toxic material." I am wondering if the Council might consider lifting this one phrase out of its report and making his recommendation to the White House at this time rather than wait until September 1? The reason I say this is that between now and September 1, and between now and whenever the report may be accepted, that much of this may take place. I am wondering if the Council would give serious consideration to the importance of this statement and make such a recommendation in advance.

Mr. TRAIN. We would certainly be very glad to consider that, Senator.

There are problems, as I know you're aware, of definitions of toxic substance and problems of quantity, of accidental spills and things of that sort. Now, this has proved a difficult subject to deal with in connection with the recent oil spill legislation, as you know. And I would have some uncertainty whether we could hasten this up prior to September 1, which, after all is only 3 weeks away.

Senator COOK. The only reason I ask you this is because we are talking about a liquid gas that can be assimilated in the ocean at a very rapid rate.

Now, conceivably, we could be talking about other toxic materials that are being dumped into the ocean that cannot be assimilated in as rapid a manner. And the only reason I bring this up is that we're talking about the use of the bottom of the ocean for all purposes and not just for this. And the desire of this committee is to see to it that we put a stop to this at all levels.

Was any consideration given by your Council or by the U.S. Department of Public Health that it would be conceivable to encase these vaults in a decontaminating material during their removal throughout the United States and to the east coast?

Mr. TRAIN. It was not considered by our Council.

Whether it was considered by the Surgeon General, I do not know. As I indicated in my testimony, transportation was not covered by the impact statement, and we essentially accepted the judgment of the Surgeon General on the safety and health implications of the transportation aspects of this project.

Senator COOK. In your statement you say "In any event, we have had available to us the opinion of the Surgeon General to the effect any health or safety effects involved in the transportation are negligible, particularly in view of the precautions planned by the Army." Yet, the report shows these are in a very unstable condition; that they could start a chain reaction of explosions with some 30 or more rockets encased in one unit and yet apparently the Surgeon General feels that even if this chain reaction might take place, there will be adequate detoxification facilities available. I'm wondering why no consideration was given to encasing these units in a detoxification material during their transportation through the eastern States of the United States?

Mr. TRAIN. I'm getting out of my field; it's probably a dangerous area in which to speculate. I would suppose that the detoxification effect of such a substance would not operate under conditions of an explosion, if that is what your question is directed to.

Senator COOK. Apparently the Gross committee thought it might be available because they must have taken into consideration the action of the sea water at 7,000 pounds per square inch on these encasements on the ocean floor, and at least they recommended an encasement of this material in the event of an interior explosion.

If there were an internal rupture, at least there would be adequate detoxification material to neutralize the gas at this stage, whereas in its present state there is only the detoxification facilities that will be provided within the framework of the train itself.

Mr. TRAIN. I think I should perhaps reiterate, Senator, that the environmental statement filed with the Council did not cover the transportation aspects, so the particular concern you have was not before us.

Senator HOLLINGS. Back to your Council on Environmental Quality, Mr. Train. What about the remaining nerve gas? To begin with, we understand the August 1 deadline says the action of the propellant merging with the nerve gas presents a danger to the propellant itself and to the rocket. I take it that is the urgency here, that we ought to dispose of these particular selected ones. Now, you're the Chairman of the Council on Environmental Quality and you have got other nerve gas left down there, what is the Council going to do about those?

Mr. TRAIN. I have——

Senator HOLLINGS. We are closing the barn door after the horse is gone.

Mr. TRAIN. I have no information as to any remaining nerve agent explosives on hand. There may well be. I just don't know. These things would not come to the attention of the Council unless they were reported to us by the Army in connection with some proposed action.

Senator HOLLINGS. I think the record shows that they take potentially dangerous rockets and encase them, inferring of course, there is other nerve gas in the United States. Or getting right to your statement that Senator Cook referred to, that it is inappropriate to use the oceans for the disposal of any toxic materials. Can you suggest to us legislation that will at least govern the citizens of the United States to carry out that observation? We agree with you, we don't think the ocean should be used and we think the authority should be clearly stated with respect to our citizens, and I think your Council could certainly submit suggested legislation along that line.

Mr. TRAIN. We are not ready as yet to submit our report.

As I indicated, we will include recommendations as we presently foresee it for legislation, administrative action, and further research, and so on. Now, of course our present plan is to make those recommendations available to the President. We would be happy, of course, to provide staff assistance to your staff if that should be your wish——

Senator HOLLINGS. We would appreciate it.

Mr. TRAIN (continuing). Without implying any policy commitment on the part of the Council. Because we simply are not ready to make such a commitment at this time in any detail.

Senator HOLLINGS. Work with us and give us what you have.

We are trying to foresee some of these problems. We are not alarmists. We are not trying to make a headline or get on TV. The fact is, I had approved the acceptance of irradiated elements so they could be stored up on the Savannah River. On the other hand, you read these statements of the Kistiakowski report to the effect that there may be lethal contamination of several cubic miles of the ocean spread near the bottom down current from the dump and a layer covering many square miles for a period of days, and then you couple that with your story of the fish itself. You say: "Many commercial fishes, for example, flounder, which occur in shallow waters off the southeastern coast of the United States migrate into deeper waters in winter." They do give us some concern about what we don't know. We know we don't know. What we do know is that toxic materials do not disappear readily at the deep ocean levels. We ought to move in and be far more careful and just not select the course of ignorance.

Mr. TRAIN. Let me add one point which I think would be useful to the committee, and that is this: the evidence which we have, which is essentially the statement of expert toxicologists, indicates that the chance of an accumulation in the food chain of any of these nerve agents would be highly remote. The process of toxification itself is the process which breaks down the agent, so that as a fish was poisoned, if that was the case, in the usual case the nerve agent would undergo chemical changes and lose its toxic character and would not be accumulated in the body of that fish which then could be passed on to another fish which would eat it, unlike the usual persistent pesticide situation.

Senator HOLLINGS. We understand.

Do you have any further questions?

Senator COOK. Clearly, the potential long term environmental effects of sealing the rockets in concrete were not taken into consideration at the time the decision was made. I merely want to emphasize it because with the detoxification agent available I can't for the life of me see why rockets with a total of 135,000 pounds of nerve gas were encased in concrete blocks rather than individually detoxified?

Senator HOLLINGS. Do you wish to add anything further, Mr. Train, or your colleagues? We appreciate very much your appearance here.

Senator COOK. I want an answer from the chairman on the question that I asked Mr. Train relative to whether or not the U.S. Department of Public Health gave any consideration to an outer casement of detoxification material during the movement of these objects through the United States.

Dr. MCDONALD. I do not know what considerations the Surgeon General gave to this particular matter. As Chairman Train pointed out, the Army statement did not cover the transportation aspects of this project and in particular did not provide us with alternative means of transporting the materials as would ordinarily be required by the National Environmental Policy Act.

Senator COOK. I must assume that your department was aware of the recommendation of the Gross Report which stated that a jacket of decontaminating solution to neutralize the GB in the vault could be installed around the present vaults. I am again asking whether any consideration was given to such an outer jacket during the period of transportation of these units through the respective States, regardless of the effect that the deep sea would have on these jackets after they were disposed of?

Mr. TRAIN. The Council gave no consideration on that possibility and we have no knowledge of what consideration the Surgeon General gave to that recommendation. We have heard the testimony of the Army this morning, as to their reason why they didn't follow that course. But our Council has itself no direct knowledge of this, nor did it consider this possibility.

Mr. COOK. Thank you.

Senator HOLLINGS. Thank you very much.

Senator HOLLINGS. We will next have Dr. Jesse Steinfeld, Surgeon General of the Public Health Service.

Dr. Steinfeld, we appreciate very much your appearance. You can recite the entire statement that you have here or we can file the entire statement for the record with your biography, and you can summarize.

STATEMENT OF DR. JESSE STEINFELD, SURGEON GENERAL, PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Dr. STEINFELD. Mr. Chairman, Senator Cook, I would like to read the first part of my statement, which I can in about 6 or 8 minutes, and then respond to any questions you have.

The Department of Health, Education, and Welfare has been assigned by the Congress, under section 409 of Public Law 91–121, to review proposals for transportation and/or open air testing of lethal chemical or biological warfare agents.

The Department has reviewed the particulars of Operation CHASE, that is, the proposed transportation of the 418 concrete vaults, each containing 30 M–55 GB-filled rockets, except one vault also contains one M–23 mine (without explosives) containing about 10 pounds of VX, another nerve agent, and another of the vaults contains three 155-millimeter GB-filled projectiles as well as three of the M–55 rockets.

We have made recommendations to improve the safety of a carefully planned and relatively safe movement of these munitions.

Our department wishes to take this opportunity to reassure the Congress and the American people that the transportation involved in Operation CHASE is less hazardous than that occurring daily in similar mass movements of chlorine, phosgene or LPG, liquefied petroleum gas, and anhydrous ammonia. The appellation, "nerve gas" conjures images that are true enough when weapons are ready to fire, but are not similarly appropriate when the weapons are encased in concrete.

May I review briefly the history of DHEW responsibilities and actions taken in accordance with section 409 of Public Law 91–121.

This law, enacted November 19, 1969, directs the Secretary of Defense to bring to the attention of the Secretary of HEW particulars of proposals for transportation or open air testing of any lethal chemical or biological warfare agent.

On November 26 of last year the Secretary of HEW designated the Surgeon General of the U.S. Public Health Service as the official of the Department with primary responsibility for carrying out the Secretary's responsibilities for reviewing such proposals for hazards to public health and safety which may occur, and to recommend to the Secretary of Defense precautionary measures necessary to protect public health and safety.

Also, on November 26, the Secretary of HEW requested the health agencies of the Department, namely, the National Institutes of Health, the Health Services and Mental Health Administration, and the then named Consumer Protection and Environmental Health Service, to submit to the Office of the Secretary names of staff scientists who had applicable expertise and appropriate security clearance.

This permitted us to develop a roster from which review committee members could be selected. In addition, we asked the Department of Transportation on December 8, 1969, to cooperate with and make available to DHEW, experts in the field of transportation of explosives and other hazardous substances.

The Secretary of Transportation complied with the request by accrediting a panel to assist DOT in this effort.

In January of 1970, procedures for the first review were developed based on recommendations of staff members knowledgeable in this field. In February and April of 1970 two special assistants to the Surgeon General were appointed to help develop and implement these procedures.

Our review of the specific plan, which is the subject of these hearings, began when the DOD's proposal was received in my office on June 23, 1970. On June 24 I appointed a committee of HEW and DOT staff which included a group of scientists, technologists, medical care experts, and transportation experts to review the plan. Their names and biographical sketches are attached.

Members of this committee also represented organizations with operating responsibilities relating to various aspects of the transportation. Copies of the proposal and other substantiating documents were transmitted to the review committee members on June 24, 1970, the same date as their appointment to membership.

The first full committee meeting was held on June 30. I asked the committee to review the plan thoroughly to assure that every possible precaution to protect the health and safety of the public was taken during the movement of these concrete vaults.

The committee was advised that any additional information they required would be provided and that the time schedule regarding instability of the M–55 rockets was real, but not limiting if the DHEW review committee felt additional time, planning, resources, or any other activities would improve the plan from the point of view of public health and safety.

I asked the committee to forward comments, recommendations and requests for information to my office by July 6, 1970. The comments would be collated and returned to the committee members and, following that, a decision then made regarding future DHEW actions.

On July 10 their comments were formulated as positive recommendations, and were returned to the individual members for concurrence, and informally provided to the Department of Army. The members concurred unanimously with the consolidated comments and recommendations. We were notified on July 11 by the Department of Army that all recommendations were accepted and would be implemented. Attached are the consolidated comments and recommendations of the committee.

From July 13 to July 17, committee members made site visits to inspect the two depots, the tracks to be used, and the facilities at Sunny Point, N.C. This inspection was conducted through a mixture of foot, rail, motor car, and helicopter travel.

The trip report indicated satisfactory conditions: The rails are in good condition and are being used daily for trains heavier and longer than those involved in this movement; the depots are well organized; the safety plans are well conceived and practical; the personnel are adequately trained. The same comments were made concerning Sunny Point Terminal.

Acceptance of the recommendations of the DHEW committee by the Department of Army and verification of the adequacy of the physical facilities involved in the movement established the basis for my letter to the Department of Army. I transmitted the final notice of our review to the Army on July 29 stating that I had no further comments or recommendations.

In that letter, I also offered the services of DHEW staff and the regional health director for DHEW Region IV in Atlanta for the DOD briefing of the involved State health officers and their staff. This offer was accepted, and the briefing conference was held in Atlanta on July 31, 1970. The members who attended are listed in appendix 4.

The general questions raised by the State health officials on July 31 concerned State facilities which would be needed in case of an emergency, the guarding of normally unguarded railroad crossings, the possibility of demonstrations along the route, assistance which could be rendered by the States, and the main point of State contact with the Army during the movement.

The health officer of Georgia requested and obtained assurance that he would be informed immediately of the train's entry and departure from his State. An increase in the amount of 2 PAM chloride (a specific chemical treatment for anticholinesterase overdosage) on the pilot train in order to treat 3,000 additional casualties was requested and agreed to since State supplies of this oxime are limited. Military police were requested by the States to guard rail yards of major cities along the route, but the Army indicated (in line with usual military-civilian division of responsibility) that it would ask the State police to accomplish this action while military police would be available if required.

The environmental impact of this operation was reviewed using a different procedure. This review is required by Public Law 91–190. We received the draft Environmental Impact Statement from the Department of Defense In July 2, 1970.

I requested Mr. C. C. Johnson, the Administrator of the Environmental Health Service, EHS, to have his staff review the proposed statement, since the knowledge and expertise regarding the environment were organizationally located in EHS. Our comments and recommendations were transmitted to DOD on July 29. A copy is attached.

In conclusion, Mr. Chairman and Senator Cook, we have conducted a comprehensive review of Operation CHASE. This transportation has safeguards which even more hazardous commercial shipments do not possess. While I do not concur that environmental pollution was necessary in this case if foresight were as sharp as hindsight, nonetheless in the absence of any reasonable alternative proposal for disposal, it is certainly in the interest of public health and safety to expedite this disposal action.

Finally, it is our duty to place this action in proper perspective, which I interpret to be the motivation behind this congressional hearing.

Thank you.

Senator HOLLINGS. Dr. Steinfeld, tell us about nerve gas. What do you know about it?

Dr. STEINFELD. The nerve gases in this instance are anticholinesterase agents which inhibit the enzyme cholinesterase. Cholinesterase is present throughout the body and destroys the chemical called acetylcholine, which is a neural hormone, a transmitter which transmits impulses from one nerve to another or from nerve to muscle.

There are three different areas in which acetylcholine has effects. They have been indicated usually in the medical literature as nicotine-like, muscarine-like, and central nervous system manifestations. The cholinesterase will be inhibited and acetylcholine will accumulate, will continue to act on nerve endings and on muscles.

Senator HOLLINGS. How is it administered? In a gaseous state or liquid form? And what effect? Is it immediate or what length of period? Does it have a lethal effect whatsoever?

Dr. STEINFELD. Mr Chairman, it is a dose-related response. The material can be administered intravenously or intramuscularly and be lethal very quickly. Depending upon the concentration in the air, it can be lethal or it can cause other symptoms. If it gets on the skin, some may be absorbed and could cause its effects that way, depending on the type of agent. VX primarily would be absorbed through the skin; GB would not.

I could read to you the symptoms in order of their occurrence through the nerve gas overdosage, if you would like.

Senator HOLLINGS. Well, now, what about the leakage the previous witness has talked about? The hazard of leaking, what propensity does this gas have to leak and get through its container, through the rocket itself and even through these concrete and steel vaults?

Dr. STEINFELD. As I understand it, Mr. Chairman, these particular rockets were from batches where leakers had developed; however, none of these particular rockets were leaking at the time they were encased in cement.

It is conceivable they would become leakers because they came from batches where leakers had occurred in other rockets. I do not think anybody has found leakage through the cement or steel encasement as of now.

As you indicated, the interaction between GB and the propellent is unknown; we do not know whether it makes the propellent more unstable and likely to go off or less unstable.

Senator HOLLINGS. We have not made any actual tests on that?

Senator COOK. In your statement you said:

> The appellation "nerve gas" conjures images that are true enough when weapons are ready to fire, but are not similarly appropriate when the weapons are encased in concrete.

In this case we know the weapons are ready to fire. We know that they are live and we also know that they are already dangerous because it has been so testified, and the Gross report indicated that these are capable of firing.

So, with that in mind, I reiterate the question that I asked of Mr. Train.

Dr. STEINFELD. May I explain just for a minute how these weapons operate, as I understand it. They are fired from the appropriate mechanism; a force of about 12,000 pounds is applied. This causes what is a dual-action fuse to come into operation and a timeclock mechanism starts to work which brings the detonator and firing pin into line. During normal storage, and in the case of these rockets, the two things are not in line. When the first 12,000 pounds is applied the clock mechanism comes into action and brings the firing pin and detonator into line; then when the rocket hits the ground, the second impact occurs which causes the fuse to function. After the rocket is launched, there is a time delay to cause the firing pin and detonator to line up.

The liquid is dispersed into a gaseous vapor. It is designed to produce a lethal atmosphere for an area of about 100 square meters; that is, lethal to anybody who happens to be there.

The situation regarding the instability in concrete is a different situation. It is encased first in concrete, then in steel. We felt if something untoward should occur—and we certainly hope that it will not, and feel that if the movement is made soon it very likely will not—in any event, if this were to occur, we felt that there would likely be leakage of liquid rather than the kind of explosion for which the weapons were designed.

We did discuss in some detail the suggestion which you have made, namely, the vaults be encased in a caustic solution, an alkaline solution, which is the usual method of detoxification, and each of these coffins be placed in such a vat, but after some discussion and the time

required to fabricate these, the fact that we only got the plan at the end of June, we felt that the hazards were such that it would be better to put vermiculite, which would absorb any leakage, on the bottom of the gondola car. This is what we recommended to the Army, and this they accepted to proceed with the transportation.

We did consider your suggestion, but we felt that the vermiculite would take care of the problem since these rockets were encased in concrete and steel.

Senator COOK. As a matter of fact, you really were not given a great deal of time, were you?

Dr. STEINFELD. No, sir.

Senator COOK. In other words, the military has been aware of this problem and the potential leakage since 1968 and 1969. They notified you on June 30; you gave your crew 6 days to report to you by July 6; you then got everything in order and made a recommendation by July 29 to the Army, and they sent a letter to the Speaker of the House and to the President of the Senate the next day on July 30. And as a matter of fact they did not accept all of your recommendations, did they?

Dr. STEINFELD. I thought they did.

Senator COOK. Let me read you item 2 under "shipment": "That route which presents the best rail service and possibly the shortest distance should be chosen." There is some question whether the shortest distance has been accepted, isn't there?

Dr. STEINFELD. I think it is a combination, Senator Cook, of the best rail service and shortest distance and population density. Hopefully, all of these factors will be taken into account.

Senator COOK. You did say calculations of population densities of cities by themselves do not give us enough information for such judgment?

Dr. STEINFELD. Yes; our basis for that was if the rails went 2 miles outside of a big town or right through a town, let's say, half the size, but right down the center of town with people living on both sides—just the number of people in the town nearby did not tell us enough; we wanted to protect the people close to the tracks. We wanted all of these factors taken into consideration and our group did go over the tracks and look at this.

Senator COOK. Thank you.

Senator HOLLINGS. Doctor, you concluded "While I do not concur that environmental pollution was necessary in this case, if foresight were as sharp as hindsight. . . ." Now, applying foresight to the remaining nerve gas, what would you recommend as the Surgeon General?

Dr. STEINFELD. We have recommended to the Army, and I believe they have accepted the recommendation, that in any future weapon design, consideration will be given to demilitarization of the weapon with minimal hazard in any future disposition, that no weapons be encased in concrete, such as these were, but that careful attention be given to demilitarization in an area where there would be no danger to the public.

Senator HOLLINGS. What has been the response of the Army, as you see it?

Dr. STEINFELD. Very positive at this point.

Senator COOK. May I add to that, Mr. Chairman, on page 5 of the consolidation of ad hoc committee draft comments—which I assume were accepted by the military; is that correct?

Dr. STEINFELD. Yes.

Senator COOK. I would like to read item 2, "The disposal of these vaults should terminate the usage of this type of encasement of CW material." Was this accepted on the part of the military?

Dr. STEINFELD. Yes, sir; it was.

Senator HOLLINGS. Thank you very much, Dr. Steinfeld.

I am afraid we will not be able to get to the other witnesses before lunch.

(The appendixes follow:)

APPENDIX 1

Dr. Erwin Bellack, Chemist, Bureau of Water Hygiene. GS–14. 1941—B.S. Chemical Engineering, Michigan Tech.: 1942—M.S. Chemistry, University of Michigan; 1946—Ph.D. Chemistry, University of Michigan. Course in explosive chemistry as part of training in organic chemistry at Doctorate level. Toxicology of nerve gases (screening of captured materials for clinical toxicity) including antidotes. Eight years—Toxicologist in Department of Interior. Problems of toxicity of chemical compounds in water.

Mr. William K. Byrd is the Deputy Director for Operations, Office of Hazardous Materials, Office of the Assistant Secretary for Systems Development and Technology, Department of Transportation. Prior to his employment with the Department of Transportation, he was Chief of the Section of Explosives and Other Dangerous Articles in the Interstate Commerce Commission. He has also been the Assistant Chief of the Commission's Section of Motor Carrier Safety and was with the Commission's field staff. Mr. Byrd was on active duty 12 years during World War II and the Korean conflict as a Motor Transport Officer in the United States Marine Corps. He was graduated from the University of Maryland, College of Business and Public Administration with a major in transportation. In addition to his present job, he serves as Head of the United States Delegation to United Nations meetings dealing with transportation of explosives and other dangerous articles.

Dr. Hans L. Falk, Associate Director for Laboratory Research, National Institute of Environmental Health Sciences, NIH. GS–17. 1944—B.S.C. Biochemistry, McGill University; 1947—Ph.D. Biochemistry with Honors. Worked in the field of inhalation toxicology since 1947. Has worked on harmful effect of all pesticides including organophosphorus since 1963. Problems of toxicology of combustion products.

Dr. Marcus M. Key, Director, Bureau of Occupational Safety and Hygiene, Environmental Control Administration, EHS. Medical Director, USPHS. 1949—A.B. Columbia College; 1952—M.D. Graduate College of P&S ,Columbia College; 1952–53, Internship USPHS, Boston, AEC Fellow in Industrial Medicine. Harvard School of Public Health, Boston 1953–54. Master of Industrial Health 1954. Varying assignments within PHS. Director, Bureau of Occupational Safety and Health, ECA, 69-present. Presently administering a program including inhalation toxicology and epidemiology of toxic chemicals and gases. Certified Board of Dermatology, 1959. Board of Preventive Medicine (Occupational Health) 1965. Professional Affiliations: American Academy of Dermatology, Industrial Medicine Association, American Conference of Govern. and Industrial Hygienists, AMA, APHA.

Mr. Pope Lawrence, Senior Staff Scientist, Federal Facilities Branch, Bureau of Abatement and Control, NAPCA. Scientist Director, USPHS. M.S. Chemical Engineering; M.S. Industrial Hygiene, Engineering; B.S. Chemical Engineering. Advisor to Armed Forces Explosives Board. Experience in dealing with DOD problems of demilitarization and destruction of chemical munitions as relating to environmental health responsibilities.

Mr. Sim B. Shattuck, Chief, Program Services, Division of Emergency Health Services, HSMHA. GS–15. B.A.; Post Grad.—Biostatistics. In charge of field staff that handles emergencies both natural and man made. Involved in formulation of plans to meet emergency situations. Insure implementation of such plans.

In this position since 1959, has been directly involved in actual performance of disaster relief—presently involved in operation aspects of Hurricane Cecilia. Short-term training in Chemical Warfare and Civil Defense aspects thereof.

Dr. Barry D. Silverman, Medical Officer, Community Health Services, HEW Regional Office, Atlanta. Surgeon, USPHS. 1964—B.A., Ohio State; 1967—M.D., Ohio State. Residency in internal medicine at Vanderbilt 1967–69. Some case work in toxicology. Trans. of electrolytes in red cells. Pulmonary Actinomycosis. Twelve months at state and regional level in medical care. Liaison between state medical officials and PHS Regional Office, Atlanta, during this Operation CHASE.

Appendix 2

CONSOLIDATION OF AD HOC COMMITTEE DRAFT COMMENTS

Packaging

The proposed movement and disposal of the vaults poses no unusual hazard to public health and safety—provided the vaults remain intact. The actual risk of agent leakage during transportation appears comparatively small. The vaults can take the degree of temperature and vibrational exposures that they will be subjected to. The probability of leakage of these containers is not likely to be increased by the handling and transportation.

Recommendations.—Rigorous physical and chemical monitoring before and after each handling operation is recommended to identify existing or potential problems.

Shipment

1. The Army's plan appears to provide ample assurance that the vaults will be protected. The plan also appears to cover every imaginable contingency attending a railroad shipment of toxic material.

2. That route which presents the best rail service and possibly the shortest distance should be chosen. Any route passes through minor population centers and to evaluate the risk of the population, one would need to know the location of the tracks through town. Calculations of population densities of cities by themselves, do not give us enough information for such judgment.

3. *Recommendation.*—Minimum publicity should be maintained. It would appear to be in the best interest of all to limit precise information to those individuals directly involved in the planning and operational phases of the move.

Recommendation.—It would seem advisable to have aerial surveillance for the whole trip in communication with both train crews. It would give a better overview of the area including appearance of the road bed, other trains, potential accidents at road crossings, and assemblies of people.

5. *Recommendation.*—Breakdown of railroad cars is not a likely event, but the train should contain spare cars and lifting equipment to move some of the vaults if necessary.

6. *Recommendation.*—The pilot train must contain adequate medical and technical personnel and equipment to independently respond to any emergency.

7. *Recommendation.*—When there are either rivers or lakes over or near which the trains pass, it would be advisable to take extra precautions. An adequate monitoring and civilian warning procedure in case of accident involving a water supply should be available.

8. *Recommendation.*—The plan should indicate that from the time loading is commenced on the hulk at MOT, Sunny Point until the hulk clears the Cape Fear River Entrance Buoy, any additional safety precautions required by Coast Guard Captain of the Port, Wilmington will be provided by the responsible command.

9. There are three major threats during transportation to the integrity of the shipment as relating to public health.

(a) *Leakage.*—The possibility of leakage during transportation appears to be comparatively small.

Recommendation.—Monitoring, physical, chemical and through the use of a sufficient number of animal detectors properly situated should adequately protect against such an eventuality.

(b) *Sabotage.*—The time factor, accessibility to railroad and relatively slow movement of the trains especially through populated centers offer opportunities for sabotage attempts. Under those conditions the Army in coordination

with law enforcement officials would know best how to prevent such a situation from arising. The most probable attempt would be made with either small arms or an explosive charge. The Department of Army testing program on simulated vaults has demonstrated that the hazard from attack by small arms is extremely minimal and if penetration of a warhead did occur, the area of contamination would be localized and well within the ability of the escort to handle.

Recommendation.—In accordance with the Gross Committee recommendations, the Department of Army should determine the safe distance for vault separation during rail transport to negate propagation of explosive effects, both intrinsic and extrinsic.

The most serious threat to public health would seem to be as a result of an explosive charge of equivalent to 50 pounds or more of dynamite. Such an incident could result in destruction of 2 vaults and dissemination of their contents.

Recommendation.—Risk analysis of such an incident should be supplied and appropriate measures to safeguard the public could be planned for (see comments under HEALTH PROTECTION).

(c) *Collision.*—

(1) Collision with a road vehicle transporting flammable liquids are a potential hazard. Sustained heating of the vaults at 150° C. for several hours could cause detonation of the explosive elements of the vaults. However, DOT tests and experience have shown that such a road vehicle under these circumstances burns only for 20–30 minutes.

Recommendation.—As a further precaution, it is appropriate that fire fighting equipment be both on the pilot and the cargo train.

(2) Collision with a passing train will not occur since DOT will require a clear track on both sides at all times.

Health protection

1. *Recommendation.*—Personnel involved in this operation must be thoroughly trained in the medical and physical aspects of safety associated with exposure to agents involved. This includes detection, decontamination, treatment of self and casualties. This would deal with oxides of nitrogen and other hazardous gases besides the GB. It should be considered that reaction of GB in the cement may have produced a dimer which may have different properties than were anticipated. This is in analogy to an organic phosphate insecticide where such dimer was formed with very unexpected toxic properties.

2. *Recommendation.*—It would seem appropriate for the Department to be prepared to help allay public apprehension and even hysterical protests which might grow following public announcement. The public should be made aware that the full resources of the Department have been marshalled and stand ready to provide emergency medical backup in the remote event of an incident.

3. *Recommendation.*—The Surgeon General's office should brief the Medical Directors in the affected Regions (III, IV) and arrange for them to be present when Surgeon, USCONARC, briefs the appropriate State health officials (F–3). The two Regional Medical Directors should be represented at the Office of the Surgeon, USCONARC, during the operations.

The suggestions submitted in the attached appendix are essentially those which are recommended for all disasters. They were developed by the Planning and Evaluation Branch, EHS from experience gained in all types of disasters and exercises and have been tailored to fit this operation. The Department of Defense will have to assist the states with personnel and material in order to implement the attached plans.

Miscellaneous

1. *Recommendation.*—The Surgeon General, USPHS, should also receive information copies of Advance Repship, Final Repship, Report of Arrival and Report indicating Completion of Loading and Date of Departure.

2. *Recommendation.*—The disposal of these vaults should terminate the usage of this type of encasement of CW material.

APPENDIX—COMMUNITY HEALTH PROTECTION

State planning should be based on concept of supplementation of military resources to assure an adequate response to emergency medical requirements of a community in the event of an incident.

This should include, but not be restricted to:

A. Plan for allerting citizenry to awareness of danger. (This need not be a part of health plan but mention of planning responsibility should be made.)

B. Plans for evacuation in the event of an incident. (This may also be the responsibility of another agency.)

C. Plans for care of evacuees. (Generally the reponsibility of American National Red Cross but mention should be made.)

D. Plans for immediate lifesaving resuscitative measures.

It is expected that this responsibility will be carried out primarily through DOD because of specialized knowledge and equipment.

E. Plans for continuing medical care.

The medical emergency victim exposed either to life-threatening or disabling toxic materials may be expected to seek assistance at the nearest known medical resource.

Casualties in the immediate area of the incident may be first seen by medical teams of the military and transportation provided for them to the nearest medical facility either by the military or by community resources.

The state plan should therefore provide the DOD with:

1. Information concerning existing hospitals, and also PDH's and HDRI units along route, and the number of beds that might be made available according to the individual hospital disaster plan.

2. The number of ambulances in each community that can be made available.

F. Many other individuals with real or imagined symptomatology may be expected to make their way to either hospitals or physicians offices through private transportation. To provide essential continuing medical assistance for the citizenry the State Health Plan should therefore provide for:

1. Briefing of key hospital personnel on symptomatology and treatment of exposed individuals and military resources available.

2. Assistance to hospitals, if needed, in updating hospital disaster plans including evacuation of hospitals if necessary.

3. Supplementation of resources:
   (a) Drugs (Atropine).
   (b) Beds (PDH's).

4. Movement of patients either to military or other less crowded community hospitals. (This would supplement, if necessary capability of military.)

5. Movement of additional resources into community as may be indicated:
   (a) Personnel.
   (b) Drugs.
   (c) Facilities and equipment.

6. Coordination with military in the release of press statements.

SUGGESTED STATE LEVEL BRIEFING FOR GOVERNOR'S OFFICE, CONCERNED AGENCY HEADS, AND OTHERS

Representatives	Subjects
Army Representative.	The problems and the Proposed Plan.
Civil Defense Representative.	CD/Emergency Preparedness, Overall Plan, Evacuation, Assignments of Responsibilities to concerned State agencies.
American National Red Cross.	Evacuees Problems.
Welfare Representative.	Assistance to Families.
Health Representative.	Health Resources.

Special consideration

(a) Develop special contingency plan similar to Inter-Agency Radiological Health Assistance Plan—Incident/Accident emphasis.

(b) Utilize team concept for assessing situation, determining actions, and direction of operations.

(c) Develop plans for protection of population along routes of movement including health facilities.

As far as the Division of Emergency Health Services is concerned, we have experienced men in each of the states involved that are ready to assist in any way that we can. Should more be needed, they can be detailed from nearby states. If our services are utilized, it would be helpful to have as much advance notice as possible.

Appendix 3

Department of Health, Education, and Welfare,
Washington, D.C., July 29, 1970.

Hon. J. Ronald Fox,
Assistant Secretary of the Army (Installations and Logistics),
Pentagon, Washington, D.C.

Dear Dr. Fox: The committee of scientists and other experts convened by the Department of Health, Education, and Welfare has reviewed the Army's Operation CHASE plan forwarded with your letter of June 19, 1970. The committee also reviewed the addendum to the plan forwarded with your letter of July 22, 1970, which responded positively to the committee's initial comments.

I have completed my review of the particulars of the proposed transportation as required by Public Law 91–121 and have no further comments or recommendations to offer.

As discussed informally between our staffs, I concur with the desirability of the Public Health Service cooperating in a briefing session on Operation CHASE for state health personnel at our Regional Office in Atlanta. I trust that final arrangements will be expedited at the staff level.

Sincerely yours,

J. L. Steinfeld,
Surgeon General.

Appendix 4

Mr. Cecil M. Cork, P. H. Engineer 3, 205 Huntley Drive, Montgomery, Alabama.
Mr. Lyman W. Faggard, Public Health Advisor, 3243 Covered Bridge Drive, Montgomery, Alabama.
Mr. Harvey J. Roberts, Industrial Hygienist, 2036 Grant Avenue, St. Albans, West Virginia.
Mr. L. W. Frann, Director, Disease Control, 1800 Washington Street, Charleston, W. Va.
Mr. Paul D. Kates, Director, Emergency Health Services, 823—5th Avenue, St. Albans, W. Va.,
W. R. Sauthward, Jr., M.D., Director, Disaster Medical Services, State Department of Health, 109 Governor Street, Richmond, Va.
Mr. P. Schofield Bryce, Director, Bureau of Industrial Hygiene, 109 Governor Street, Richmond, Virginia.
D. H. Robinson, M.D., Chief, Preventive Health Services, Route 1, Box 73B, Irmo, South Carolina.
Mr. Robert T. Barden, Environmental Sanitarian Supervisor, J. Marion Sims. Bldg., Columbia, South Carolina.
Mr. Earl W. Mitchell, Director, Division of Emergency Health, 224 St. Andrews Road, Columbia, South Carolina.
Mr. Francis P. Jung, Director, Division of Industrial and Radiological Health, 727 Cordell Hull Building, Nashville, Tennessee.
Mr. Milliam B. Lyons, Public Health Representative, Division of Emergency Health Services, 208 Capital Towers Building, Nashville, Tennessee.
Mr. Robert H. Odom, Director, Emergency Health Care, 208 Capital Towers Building, Nashville, Tennessee.
Mr. Herbert M. Bagman, Chief, Health Mobilization Section, Route 6, Box 230M, Raleigh, North Carolina.
Mr. Joel E. Jorsaw, Assistant General Counsel, Cordell Hull Building, Tennessee Public Service Commission, Nashville, Tennessee.
Mr. Ralph C. Pickard, Director, Environmental Health, 205 Bramton Road, Louisville, Kentucky.
William P. McElwain, M.D., Commissioner of Health, 275 E. Main Street, Frankfort, Kentucky.
Dr. H. Karl Sessions, Director, Occupation Health Branch, Georgia Department of Public Health, Atlanta, Georgia.
Dr. John H. Venable, Director, Georgia Department of Public Health, Atlanta, Georgia.

APPENDIX 5

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
Washington, D.C., July 29, 1970.

Hon. J. RONALD FOX,
Assistant Secretary of the Army (Installations and Logistics),
Pentagon,
Washington, D.C.

Dear Dr. FOX: Pursuant to your letter of 2 July 1970 requesting our review of the draft environmental impact statement for Operation CHASE, we submit the following comments:

1. The Operational Plan should be attached to the environmental impact statement as a reference.

2. A more definitive description of the geographical location and known ecological characteristics of the disposal site would be desirable.

3. The draft impact statement fails to mention two potentially significant factors:

a. Other munitions, explosives and chemicals previously dumped at this disposal site and the estimated condition of this material, and

b. The impact of the CHASE propellant and explosive materials on the marine environment.

It would be desirable to initiate and maintain a perpetual inventory and monitoring of the disposal site.

4. We agree in principle with one of the conclusions of the Department of Interior Working Group's Second Report, November 13, 1969; namely, there is no choice but to accept ocean disposal of these hazardous materials as a necessary, though undesirable, expediency. This conclusion was reached after considering present hazards to human safety and to terrestrial environments and the unavailability of alternate methods of disposal.

5. We concur with the recommendations of the Gross Committee and the National Academy of Sciences that alternative disposal methods for chemical munitions and agents be developed which will have a minimum impact on the environment.

I appreciate the opportunity of reviewing this statement and assure you that this office is available to assist you in the development of new approaches to disposal problems.

Sincerely yours,

J. L. STEINFELD,
Surgeon General.

CURRICULUM VITAE

ALBERT H. STEVENSON

Born: May 18, 1914.

Education: B.S. in Civil Engineering, Union College; M.S. in Engineering, Harvard University.

Experience: Since 1937, State and local environmental health work, consulting engineering in water supply design, and, since 1941, a variety of assignments in the U.S. Public Health Service including Regional Office, research administration, program management and direction, and engineer career development guidance. Currently, Assistant Surgeon General and Chief Engineer of the Public Health Service, as well as Associate Administrator, Environmental Health Service.

Specific Activities Related to Disaster Work, CBW Agents and Handling of Toxic Materials:

1. Regional Office, New York. Participated in natural disaster relief operations over a three-year period.

2. Federal Civil Defense Administration. Assigned as Chief Sanitary Engineer for a two-year period. Planned for emergency health preparedness; participated in disaster relief operations; and directed a Civil Effects Test Group program at Operation Teapot, Mercury, Nevada.

3. Headquarters. Engaged in environmental health protection as a consultant and a member of cadre at classified site—three years.

4. Currently, as Associate Administrator, Environmental Health Service, responsible for organization, planning for emergency health preparedness and disaster response.

Publications: Numerous publications and papers on a wide variety of environmental health and engineering education subjects. More particularly:

1. Public Health and Civil Defense;
2. Feasibility of Biological Warfare Agents in Public Water Supplies. Co-authored with Dr. Bernard B. Berger, then Liaison Officer at Fort Detrick.

CURRICULUM VITAE

ROBERT P. HAYWARD

I. Education

A. Undergraduate:

Augustana College, Sioux Falls, South Dakota: Major—Biological Sciences; Minor—Chemistry; Degree—None.

Creighton University, Omaha, Nebraska: Major—Biological Sciences; Minor—Chemistry, Philosophy; Degree—B.S. August 1947.

B. Graduate:

University of Minnesota, Minneapolis, Minnesota: Major—Sanitary Science; Degree—Masters of Public Health June 1951.

II. Experience

1947–48—Teacher, Arlington, South Dakota, Public High School. Subjects taught were General Science, Biology, and Chemistry.

1948–50—Sanitarian, City of Pierre, South Dakota. Chemist/Bacteriologist, South Dakota Department of Health, Sanitary Laboratory.

1951–54—Sanitary Biologist, South Dakota State Department of Health, Water Pollution Control Program, Pierre, South Dakota.

1954–61—Chief, Environmental Health Service Branch, Division of Sanitary Engineering, South Dakota State Dept. of Health, Peirre, South Dakota.

1961–63—Staff Sanitarian, (Food) Milk and Food Branch, Division of Environmental Engineering and Food Protection Program, Bureau of State Services, Public Health Service, Washington, D.C.

1963–69—Chief, Environmental Health Services Branch, Office of Environmental Health, Indian Health Service, Health Services and Mental Health Administration, Public Health Service, Silver Spring, Maryland.

January 1969—October 1969—Regional Assistant Administrator, Consumer Protection and Environmental Health Service, DHEW Region VI, Kansas City, Missouri.

November 1969–Present—Special Assistant to Associate Administrator, CPEHS–EHS.

III. Memberships

National Association of Sanitarians (Current).

National Capitol Area Association of Sanitarians (Current) (Immediate past President).

International Association of Milk, Food and Environmental Sanitarians (Membership now lapsed).

USPHS Commissioned Officers' Association and District of Columbia Metropolitan Branch (Current).

IV. Professional Registration

Registered Sanitarian (R.S.) National Association of Sanitarians.

POPE A. LAWRENCE

Training

B.S. (Chem. Engr.)—University of Texas; M.S. (Chem. Engr. & Colloid Chemistry)—Massachusetts Institute of Technology; M.S. (Industrial Hygiene Eng.)—Harvard.

Experience

1964–1970—Provides special expertise for problems involving air pollutants of unusual toxicity. NAPCA liaison representative to Committee on Toxicology, NAS–NRC. Principal NAPCA representative to review disposal of DOD surplus emissions and chemical agents. Served as Air Pollution Control representative in evaluation of sheep kill in Utah in 1968.

1952–1962—National Cancer Institute—had responsibility for epidemiological aspects of long range study of miners' health for radioactive gas and dust. Chief

monitor (radiation) Nevada Test Site, 1953 and participated as a monitor in 1951 test series.

1942–1952—Assignment with State of Utah. Served in the office of the Governor evaluating complaints on the application of organic phosphate insecticides. Member of team investigating human response to parathion and TEPP in Wenatchee Orchards.

Served as Chemical Warfare Specialist in Civil Defense organization for the Governor of Texas. Received special training in CW, Fort Bliss, Texas. Supervised aerial application of DDT by Navy following hurricane disasters in 1946 and evaluated results.

Positions Held During Last 20 years

1950–1962—Deputy Chief, Epidemiology Branch, National Cancer Inst.
1962–1963—Chief, Staffing & Utilization Branch, DCO, OSG, PHS.
1963–1964—Chief, Personnel Utilization Branch, OP, OSG, PHS.
1964–1969—Chief, Federal Facilities Section, Div. of Air Pollution Control, PHS.
1969–1970—Senior Staff Scientist, Federal Facilities Branch, NAPCA.

ERVIN BELLACK

B.S. Ch. E.—Michigan Technological University, 1941; M.S. (Chem.)—U. of Michigan, 1942; Ph. D. (Chem.)—U. of Michigan, 1946.

1946–1954—Toxicological evaluations of chemicals, including captured war materials (Dept. of Interior, under contract from Dept. of Army).

Education—organic chemistry, graduate course in explosives.

Present assignment—chemicals in water, including toxic materials (Bureau of Water Hygiene).

Senator HOLLINGS. That will be all. The committee will recess until after lunch at 2:30, and we will reconvene in a different room. We cannot get this one. Room 1318 in the New Senate Office Building, downstairs at 2:30.

Thank you very much. The committee is in recess.

(Whereupon, at 12:45 p.m., the hearing was recessed, to reconvene at 2:30 p.m., this same day.)

AFTERNOON SESSION

Senator HOLLINGS. The committee will please come to order.

Mr. Charles Meacham, Commissioner of Fish and Wildlife, Department of the Interior, will be our next witness.

We thank you for your appearance.

STATEMENT OF CHARLES H. MEACHAM, COMMISSIONER OF FISH AND WILDLIFE, DEPARTMENT OF THE INTERIOR; ACCOMPANIED BY DR. GEORGE J. RIDGWAY; DR. ROLAND SMITH; WALTER J. HUNT; AND ROBERT KIFER

Mr. MEACHAM. May I bring to the table backup people with me?

Senator HOLLINGS. Anyone you please, yes, sir.

Mr. MEACHAM. Mr. Chairman, I would like to introduce the people that are with me.

On my immediate right is Dr. Roland F. Smith, Bureau of Commercial Fisheries.

On his immediate right is Mr. Walter J. Hunt, Chief, Industrial Processing Section, Division of Technical Support, Federal Water Quality Administration.

Robert Kifer, Bureau of Commercial Fisheries, Program Analysis, Research Plan.

Next is Dr. George J. Ridgway, Acting Laboratory Director, Boothbay Harbor, Maine.

Mr. Chairman and members of the committee, thank you for this opportunity to briefly discuss the ecological impact of "Operation CHASE."

As you are aware, the Army has announced plans for the disposal at sea of concrete vaults in which are encased M–55 rockets filled with GB nerve agent.

Of the 418 vaults to be transported by train from the Army depots in Alabama and Kentucky, one contains an M–23 mine filled with VX nerve agent as well as M–55 rockets, another contains three 155-millimeter projectiles filled with the GB agent as well as M–55 rockets.

The site selected for disposal is 282 miles east of Cape Kennedy, Fla, in an area now designated on sea charts as a munitions, explosives, and chemical disposal region.

The Department of the Interior is very much concerned about the degradation of water quality. We face growing pollution in our lakes and rivers, and are now beginning to realize the extent of pollution in our lakes and rivers, and in the estuaries and coastal zone.

To transfer the locale of disposal from the land or from shallow water to the deep sea does not resolve the problem, but merely postpones the day of reckoning.

Disregard of the consequences led to gross pollution of the Great Lakes and other important bodies of water. We should not repeat the mistakes of the past.

Disposal of wastes on the Continental Shelf or in the deep sea has occurred for years. We are concerned because this practice is accelerating. Some disposal has taken place in preselected disposal areas, but we understand, however, that much dumping has been random.

Nowhere, that we know of, is there an inventory of liquid or solid wastes dumped at sea. The Public Health Service has been compiling such an inventory of wastes disposed of by our major cities and industries.

It would probably be impossible to reconstruct the extent of damage already done. Seldom have the effects of waste disposal on the oceanic environment, or on its living resources, been monitored.

We are looking to the sea as a very important source of food in the future. We have long expressed our opposition to the use of the high seas as a dumping ground for waste material of all kinds.

One week ago, Assistant Secretary Glasgow told the House Fisheries and Wildlife Conservation Subcommittee that we have too long "deluded ourselves into thinking that the ocean was big enough to absorb all of our wastes," and that, "we have been heading toward the creation of a worldwide cesspool."

We must take immediate action, he warned, if man is to avoid drowning in his effluent. To this end, the Department is participating in a comprehensive study of ocean dumping ordered in April by President Nixon.

Mr. Chairman, this study is being coordinated by the Council of Environmental Quality. A report of that study, together with appropriate recommendations, will be presented to the President by September 1.

In June of last year, we were asked by the Army to comment on an earlier plan for disposal of the nerve agents. A working group of qualified scientists recommended against consideration of the ocean as the ultimate solution for disposal of chemical-biological warfare munitions.

Now, Mr. Chairman, this group consisted of the Interior scientists from the Bureau of Sports Fisheries and Wildlife Service, and other agencies and they made their recommendations in a report that was submitted June 27, 1969.

We were joined in that recommendation by the National Academy of Sciences, which also urged that consideration be given to an alternate method of disposal.

The Army responded by appointing a committee to explore the alternatives. That committee recommended a year ago that the nerve agent be disposed of no later than August 1, 1970, preferably by means of a nuclear device.

Deep ocean disposal was accepted as an alternative to the use of a nuclear device. Upon receipt of information from the Army that there was no way in which an atomic device could be used for this purpose on or before August 1, 1970.

I would like to digress for a moment.

In the December 4, 1969, letter, R. Kenly Webster, Deputy General Counsel, Department of the Army, addressed memorandum to the Under Secretary of the Interior which stated, "Attached status report of 'Operation CHASE.' "

It includes under 3(b) the AEC study, and I would like to quote from that letter.

> Therefore on October 13, 1969, the Army was informed by representatives of the Atomic Energy Commission that the Commission has reviewed the feasibility study and decided the vaults could be destroyed with underground nuclear explosion but not by August 1, 1970. Further, that the Atomic Energy Commission would prefer not to divert talents and resources for this purpose since it would delay or postpone action on their regularly-assigned test programs.

Going back to my text, the working group insisted upon the acceptance of the following conditions for ocean disposal:

1. That "Operation CHASE" would be the last instance in whch the ocean was used for disposal of such potentially toxic material;

2. That the ship used for disposal be equipped with instrumentation to detect explosions and the depth at which they occur;

3. That the ship used for disposal be equipped with instruments to signal its exact location on the ocean bottom;

4. That the position of ships used in an earlier disposal exercise off New Jersey be located and precisely charted; and

5. That aerial surveys of surface temperatures at both dumping sites be made on a monthly basis for at least a year to detect possible upwelling.

The Army has assured us that each of these conditions will be met.

Mr. Chairman, with regard to condition number 5, Navy has agreed to undertake oceanographic sampling from vessels until 1974, which will provide the data for comparison with pre-Operation CHASE sampling which occurred July 3–11, 1970.

The oceanographic sampling will consist of vertical temperatures, salinities, specific analyses for the presence of byproducts from the breakdown of the nerve agents in sea water, and bottom photography

to determine any possible changes. We consider this a better monitoring program than that proposed by our working group.

It is the consideration of danger to human safety that has caused our reluctant acceptance of plans for Operation CHASE. The depth at which disposal is to take place should minimize jeopardy to aquatic life and the marine environment generally.

The site selected is on the seaward side of the Gulf Stream in an area and at a depth not generally productive of marine life.

The bottom currents are slight. There is no evidence of upwelling at this site, and, as already noted, the area is already marked for disposal of explosives and chemicals.

When released, the products of hydrolysis and the remaining unhydrolyzed GB will be further hydrolyzed and diluted to the point of physiological ineffectiveness. In the event of leakage, any toxic material should be highly localized.

The site is deeper than any used as a commercial source of fish, and none affected by GB would be caught for human consumption. Even if caught and consumed, such fish should not be harmful as GB is not a residual compound and does not accumulate in the body.

That concludes my statement, Mr. Chairman, and I have these gentlemen with me and we will be pleased to try to answer any of your questions and be of as much service as we can.

Senator HOLLINGS. Mr. Meacham, you say you have long expressed your opposition to the disposal on the high seas and using this as a dumping ground.

Now Russell Train, and Dr. Sanders, and everyone else are of the same mind. Now pursuant to that conviction, I understand, let's say on June of last year, June 27, 1969 you had a group working, a group of qualified scientists working, and they recommended against this.

But this recommendation was later joined in by the National Academy of Sciences and they appointed a committee and the committee recommended that they not do this.

Now you referred to a report on June 27, 1969. You have a copy of that report?

Mr. MEACHAM. Yes, I do.

Senator HOLLINGS. Could you furnish that to the committee?

Mr. MEACHAM. Yes, sir; I will.

Senator HOLLINGS. You have it with you right now?

Mr. MEACHAM. Yes.

Senator HOLLINGS. What about the letter, of December 4, by Kenly Webster? That is the letter by the Secretary of the Interior that you quoted from? Do you have that?

Mr. MEACHAM. I don't know if we have that with us.

Dr. SMITH. Yes; we have it.

Senator HOLLINGS. If you would furnish that, we could possibly borrow it for a moment and make copies of it.

Mr. MEACHAM. We have this one copy with us; yes.

Senator HOLLINGS. Now, of course, that committee was told by the AEC that they could dispose of this dangerous material in an underground method except for the fact it would divert personnel from the established assignments within the AEC projects. Is that right?

Mr. MEACHAM. This was included in the AEC report; yes. The problem, of course, was that they could not accomplish this in the time deadline that we had of August 1.

Senator HOLLINGS. The fact of the matter is that they could have accomplished it within the deadline if they used one of the open holes they had at one of the particular sites.

We will have another witness who will be more expert on that and be more familiar with that report.

Mr. MEACHAM. I hope so.

Senator HOLLINGS. But what insistence did you make? Since you represent the Department of Interior and the Fish and Wildlife Service, and the Bureau of Commercial Fisheries, how do you impose your views when you actually have put in question the ocean disposal method as being deleterious to sea life and other marine biota, and you have recommended long since that the oceans not be used, and yet the Army continues on? What is the mechanism in the Government? Do you think they gave good attention to your recommendation, or the committee's recommendation, or the National Academy of Sciences?

Mr. MEACHAM. My understanding in the working committees that the work carried out—the final decision to be made to dump things at sea was a matter of time.

They could not be disposed of in the time element there.

Senator HOLLINGS. On that time, did you question the August 1 deadline set by the Army?

Mr. MEACHAM. Mr. Chairman, I would like to refer that to Dr. Smith. He was the person who handled this personally with them.

Senator HOLLINGS. Surely.

Dr. SMITH. Mr. Chairman, Dr. Ridgway and I discussed these points. We had the report of the Gross Committee of munitions experts. We reviewed this report, and reviewed the background of the members of this committee, and we did not feel that we could question these experts in their decision that these munitions encased in concrete vaults should be disposed of by August 1.

We discussed the alternatives with the Army and felt that AEC was sincere in saying that they could not go along with this disposal prior to August 1.

It was with considerable reluctance that we agreed to go along with this; and I might add it was only after our—only after satisfying ourselves that there would not be any serious impact on the environment in the area that was proposed for dumping.

Senator HOLLINGS. Well, the fact of the matter is that in the AEC report, they could have done this by July 15, using the already established hole that they have.

Did you look at that very closely? That they could do this in a matter of 41 weeks? They reported this in September. Of course they were prepared, but they said, for example on page 4, the laboratory report, dated September 15, stated that the existing hole site could be used and that actually they could do the job in 41 weeks' time.

In fact, when you look at the weekly schedule, you and I could cut off some of the weeks there. So they could have done this prior to the August 1 deadline, which we have already passed.

Dr. SMITH. We were aware that they had a disposal site that could be available. We were told they would not do this. This was my

understanding as I recall it. We were told they would not do this unless we could assure AEC of the relative stability of this material up until the time they would handle it.

I am not familiar with the details now, I only know that in our discussion with the Army on this we felt that they were sincere in the fact that they had considered this first alternative, which had been our recommendation, as well as the National Academy of Sciences' recommendation.

Senator HOLLINGS. Dr. Smith, did they establish that August 1 date?

Dr. SMITH. It was the Gross Committee that established that.

Senator HOLLINGS. And the Army, and everyone agreed with that?

Dr. SMITH. Yes, sir.

Senator HOLLINGS. So the stability was established there as of August 1 and there was some other consideration in that report. I don't think Interior went into it very thoroughly.

Of course, this is just referring to page 3 where you insisted upon acceptance of the following conditions and then you list the conditions, and condition No. 4, the position of the ships used in earlier disposal exercises off New Jersey be located and precisely charted.

Do you think that is going to be done?

Dr. SMITH. I can't answer for sure at this time. We do not feel we have relinquished to the Navy this condition.

Now we are aware that they have tried to find the location of this hulk that they have not been able to precisely locate it as yet. That locating this precisely would be a rather expensive operation is evident.

Now, furthermore, we do not have a series of data in this area from the time of scuttling. We anticipate that we will have a series of data from the time of the scuttling of the present Operation CHASE hulk and therefore we would prefer to wait on results of this present monitoring to decide whether or not we want to go back and monitor the New Jersey area in further detail.

Now I understand they do have some photographs taken, which we have not had a chance to look at yet, of the New Jersey area; they have made oceanographic measurements which we have not had the chance to review. But it is my understanding that they have found absolutely nothing to indicate there is any possible damage.

On the other hand, there is no evidence that they have precisely located the spot.

Senator HOLLINGS. And the 10-day survey made of the site now in question, you don't think that is an adequate survey, do you?

The picture taking and everything else, do you think that is adequate?

Dr. SMITH. It depends on what we would consider an adequate survey.

Senator HOLLINGS. That is what I want to know. What would you consider to be an adequate survey?

Dr. SMITH. I think this has been a reasonable survey of conditions in this area. They have rather comprehensive photographic coverage; they have background data on the fluoride in this water, and they have vertical temperatures—I would not know how else to go into it; I would not know what to suggest in the way of obtaining more detailed data for this area.

Senator HOLLINGS. But the Navy, itself, would require sampling for 4 years. You say the Navy has agreed to undertake oceanographic coordination until 1974.

Dr. SMITH. Now we are talking about post-CHASE sampling.

Senator HOLLINGS. Right.

Dr. SMITH. Earlier we were talking about pre-CHASE sampling.

Senator HOLLINGS. That is how they would make the comparison.

Dr. SMITH. Now I want to emphasize, Mr. Chairman, that it is our firm belief that there is no serious environmental impact on the release of this material into the ocean.

Otherwise, we would not even consider it in the first place.

Senator HOLLINGS. That is a conclusion. What marine biological study did the Fish and Wildlife Service make of this particular site?

Dr. SMITH. The Department of Interior has collected no data in this itself. We have access to data. I am talking about the deep areas. We have no data that we have taken ourselves.

We do have access to the National Oceanographic Data Center and from other oceanographic institutions, which our oceanographers have reviewed.

Senator HOLLINGS. Senator Cook?

Senator COOK. Thank you, Mr. Chairman.

The thing that runs through everybody's testimony so far from the Public Health Service, through the military, and from all others, is that you have no problem about the location at all.

The depth at which disposal should minimize jeopardy to aquatic life and marine environment generally is at 16,000 feet. Possibly it was picked because of its depth. All of the reports seem to substantiate this fact.

The site selected is on the seaward side of the Gulf Stream and in an area not generally productive of marine life.

Now Dr. Cheek testified there wasn't a great deal of marine life at this depth.

So this satisfies that requirement. Apparently there was no argument about disposing of it at 7,200 feet off New Jersey.

Now is there less marine life at 7,200 feet or more? Obviously there must be more. But there seems to be no argument about the fact that it could be dumped at 7,200 feet. I assume it is or were you not even consulted on the disposals that were made off New Jersey?

Mr. MEACHAM. Senator Cook, I will have to refer that to Dr. Smith. I was not on board at that time.

Dr. SMITH. The earlier dumping as I understand was cleared through the Federal—through an environmental committee of the Federal Council for Science and Technology of which there was an Interior representative along with representatives from other departments.

As I understand it Operation CHASE was reported as consisting of a chemical and explosive device to be released in this area. Now we have participated—that is the Bureau of Commercial Fisheries—participated in earlier Operation CHASE where they were releasing only explosives.

We satisfied ourselves that in some of these explosions that were occurring at these depths, depths of 7,000 or 8,000 feet there was no significant effect on fish life.

Senator COOK. Do you have any data to support this? The point I am trying to make is that a survey was made of this area between July 3 and July 11 and that is all. No other studies were made.

Based on that July 3 to July 11 survey the assumption is made that everything is OK. The depth is all right; there is very little marine life; we are not going to do any great aquatic damage, and yet we had testimony this morning that conceivably you could damage the environment.

As a matter of fact a survey and a study of currents based on a 7-day study is absolutely ridiculous to make any stable analysis of the ocean bottom and the potential ill effects.

Dr. SMITH. I don't think we are quarrelling with the fact that there is not—we are not suggesting there is no aquatic life there. We are saying that there is not very much aquatic life there.

We are saying that that which is present is in the form of a large number of varieties of aquatic life but the total number is small.

Senator COOK. I might say to you, Doctor, that is the same thing that we are saying about where we are going to be moving this. We are going to move it through sparsely populated cities instead of larger cities.

So it is unfortunate for you to live in a sparsely populated community.

In other words, it is great if you live in Charleston, but it is bad if you live in Sunny Point, N.C.

I am wondering why more serious arguments were not made for other types of disposal and alternatives other than just this one?

As a matter of fact, it is apparent to me that the Department of Public Health had no alternative but to accept it. They were given a short time to complete their report.

Dr. SMITH. Well, Senator, if you will go back into the record you will find that the National Academy of Sciences was asked to look into this problem. Now first you must recall there was planned originally, last June, a disposal of mustard gas, M–55 rockets not encased in concrete vaults, plus the GB agent in canisters.

Now we opposed the dumping of all of it. We also proposed along with the National Academy of Sciences, the ocean dumping of this material that was encased in concrete as an alternative.

Now what we did say along with a lot of other experts was to go back and find some other alternative, and we would review all of these alternatives and if we agreed the Army had done sufficiently exhaustive work here in exploring all the alternatives, we would reconsider the problem of ocean dumping.

Now we have reconsidered. We oppose this. I want to emphasize that Commissioner Meacham, Secretary Glasgow, and all the way up, we are in opposition to this. We have made it quite clear that this is absolutely the last time we will go along with it.

We do not condone this, but we are forced to reluctantly accept that they must get rid of this stuff in the ocean.

Senator COOK. If they want to do this again, and you do not approve, do you have the statutory authority to stop them?

Dr. SMITH. No, sir, right now we do not. But we will certainly be up here before you saying that we oppose it.

Senator COOK. This has been a subject of discussion since the end of 1968 and early 1969. It is now August of 1970. Obviously under

the Lawrence report these weapons could have been disposed of in other ways. I believe that frankly the military was not inclined to do it any other way. They have been successful in getting it done this way and this is the way they are going to do it.

I think the proof is in the pudding because you have just said that if they proposed any of this again you will absolutely not go along with it, that you absolutely oppose it, but you also say you have no statutory authority to stop them at all.

We are now beginning to realize the extent of pollution in the estuaries and coastal zones. I just wonder when we are going to do something about them.

Mr. Chairman, I think we are faced with the alternative of having further hearings or removing these units immediately to protect our population.

Senator HOLLINGS. Well I think, Senator, your point is well taken.

Mr. Meacham, you and Dr. Smith and your colleagues there, you are the principal agents of fish and wildlife for the Government. You come and attest to the fact of minimal injury; the site selected is on the seaward side of the Gulf Stream, the bottom currents are slight, the depth is not generally productive of marine life.

Dr. Sanders said it was.

You say there is no evidence of upwelling in the area and it is marked out there. The site is deeper than any used as a commercial source of fish, and even if caught and consumed, such fish would not be harmful since GB is not a residual chemical.

Everything is fine. Yet Mr. Russell Train of the Council on Environmental Quality testified previously that the Council considers the question of impact of a nerve agent on living organisms has not been considered in sufficient detail.

He mentioned that the data and conclusions drawn come from experiments of several species of shallow living fresh water fish. It is not safe to assume that marine fish will react similarly. It is less safe to assume that other forms of marine life will do so.

We note there was significant variation among the species of experimental fish in their reaction to the nerve agent.

At the present state of our knowledge it is believed there are relatively few living organisms at the dumping site of 16,000 feet. It is important, however, to realize that our knowledge of life at that depth is incomplete.

Present sampling methods may not collect the large and more active organisms. It is known that carnivorous fishes are found at that depth.

Most of the deepwater fishes have eggs which rise to or near the surface. Eggs and other deep sea organisms come through on the surface. It is believed many may migrate from shallow to deep water, from coastal to deep waters.

Many commercial fishes, for example flounder, which occur in shallow waters off the southern coast of the United States might migrate into deeper waters in winter. The exact depth limits of these movements are not known, but the point is that there is a possibility that fishes directly used by man might pass through the contaminated zone or might consume organisms which have come through or have passed through that zone and it should be remembered there are commercial surface fisheries in the general area of the dumping site.

Now these concerns of Mr. Train don't seem to be your concern, and you represent fisheries. It seems you Government people would take a stand and tell it like it is. We either agree or we don't agree.

But somehow you get a bad decision and everybody falls in line and that is the problem for the observing public. As a result, the public suffers because they cannot get a straight story about what happens after the nerve gas has leaked out. Do you think it is good for fish or not good for fish to dump these in the ocean?

Mr. MEACHAM. Mr. Chairman, I would like to make a few comments on this and I would restate my position. Maybe it is not entirely clear. I do not wish to go into Mr. Train's——

Senator HOLLINGS. Do you find anything inaccurate with what Mr. Train has said? You are in charge of commercial fisheries, fish and wildlife, in the Department of Interior. Is anything inaccurate in what I have just said?

Mr. MEACHAM. I am not saying there is anything inaccurate, but I would like to say that flounders, for example, migrating to deep water in winter—this is true. A flounder has an air bladder. Therefore it cannot live at 16,000 feet. There are a number of things that if we get to talking in generalities, that is one thing.

But if we get to specifics it is different. Flounders have eyes. Fish at 16,000 feet generally do not have eyes.

Senator HOLLINGS. So you think his reference to flounders is not well taken?

Mr. MEACHAM. Certainly. But I am sure he is not referring to flounders at 16,000 feet.

Senator HOLLINGS. Many commercial fish such as flounder, which occur in shallow waters off the southeastern coast, migrate into deeper waters.

Mr. MEACHAM. That is correct.

Senator HOLLINGS. But they do not go that deep?

Mr. MEACHAM. That is correct.

Senator HOLLINGS. They would not get into any streams affected by the deeper water?

Mr. MEACHAM. I will do the best I can with your question, but if you have more questions I will have to call on the oceanographers.

The dumping site is on the seaward side of the Gulf Stream. It is an area that has very little current at the ocean floor and the nerve agent specific gravity is 1.088 which makes it heavier than water.

Therefore, the only thing that would carry the nerve agent upward any distance would be a current, and that would cause dehydrolization rapidly. I don't see how it would get the material from 16,000 feet up into the area that could contaminate fish.

This morning I recall hearing the Department of Army testimony that if the worst set of circumstances occurred and all of the nerve agent was released simultaneously at 16,000 feet, it would encompass 1 cubic mile, in which case 5,280 from 16,000—we still have 11,000 feet of water above us not taking into account the circulation and dilution.

I don't like the operation. But maybe I could conclude my remarks by making a general statement? May I do that?

Senator HOLLINGS. Please, go right ahead.

Mr. MEACHAM. We are opposed to the use of the ocean for disposal of waste materials.

For this reason we urged more than a year ago that consideration be given to alternative methods and joined in the recommendation that a nuclear device be used.

It is our understanding that the Army was advised by the Atomic Energy Commission that nuclear disposal is not feasible within the time frame.

In the light of the warning from the Gross committee that disposal must be accomplished promptly to protect human life and the terrestrial environment we have no alternative but to accept the Army's plan as the least undesirable method.

We have insisted upon assurance that this would be the last such ocean disposal of caustic material and we have been assured of this.

I heard the Under Secretary testify this morning that there would be no further dumping of these materials in this manner.

Senator HOLLINGS. You have in there, "By the time frame." You have at the Department of Interior—according to their report you have just rendered to us dated December 4, 1969, from the Department of the Army, with the various departments of Government, on page 6, "Thereafter on October 13, 1969 the Army was informed by representatives of the Atomic Energy Commission that the Commission had reviewed the feasibility study and decided that the vaults could be destroyed within an underground nuclear explosion, but not by August 1, 1970."

Why not?

Further, that the AEC would prefer to not divert talent and resources for this purpose since it would delay or postpone action on regularly assigned test programs and because of the strong possibility of adverse publicity generated by this additional detonation could jeopardize further underground nuclear explosions.

Now that was the reason. That was the reason they did not want to divert talent and they did not want the publicity. I am sure they got more adverse publicity from this standpoint or stage, I would say.

Excuse me, did you have another question?

Senator COOK. Mr. Meacham, you specifically stated that over a year ago you were opposed to this. Also that you made your feelings known on this and that you felt the logical way to do it would be through a cooperative plan with the Atomic Energy Commission.

I would remind you again and remind the chairman again that the Lawrence Radiation Laboratory study was completed September 15, 1969.

Now if this went to the Interior in September, and they said that this could have been done at Yucca Flats in an existing hole, it would take between 41 and 45 weeks.

Now had the Interior Department asserted itself at that time, apparently it could have been done within 40 to 45 weeks and that would still be within the time limit. It would still have been completed, and it would be there now.

It would have been removed out there in a much more stable position than apparently it is now because it could have been out there well in advance of this operation and we would not be sitting here today with a deadline hanging over our head.

As the doctor so aptly put it earlier today, it is just a different kettle of fish. In other words, there is nothing we can do about it if we wanted to.

But it seems to me if pressure could have been exerted when the Lawrence report was submitted November 15, 1969, that an existing hole at Yucca would have been utilized.

It could have been accomplished between 41 and 45 weeks, and within the time limit.

Mr. MEACHAM. What you say is true, Senator, but I would like to say that we were not privy to the Atomic Energy Commission report at that time and at this time I cannot——

Senator COOK. You were not privy to it?

Mr. MEACHAM. No, sir.

Senator COOK. In other words, it is all public information now, but at that time you were not privy to it?

Mr. MEACHAM. To my knowledge we did not have the Atomic Energy report and our information was received from the Department of the Army—and I will stand corrected by the people in the working committee if I am wrong——

Dr. SMITH. Yes; that is right.

Dr. KIFER. Yes.

Mr. MEACHAM. Yes; I am correct.

Senator COOK. Were you aware of the Lawrence Laboratory doing a study for the Army in regard to this problem? Were you aware of the fact that a study had been asked for relative to the merits of an underground explosion?

Dr. SMITH. Yes, sir; we were aware.

Senator COOK. You had to be, Mr. Meacham. You just got through saying that, "Over a year ago" it was the position of the Department that they should be disposed of in this way and not be disposed of through an ocean dumping.

Dr. SMITH. What Mr. Meacham said is that we did not receive this report at that time.

Senator COOK. Well there is an inconsistency here, though, doctor, because even if you did not receive the report in September saying that an existing facility at Yucca could be used within 41 to 45 weeks, the statement of Mr. Meacham is that, "Well over a year ago" and this was not received until September of last year.

Well over a year from now which would have put you back at August or July. It was the position of your Department that it should have been disposed of by an underground explosion. Is that not correct?

It just seems to me the military decided to put this in concrete blocks and dump it in the ocean. Do you have that feeling?

Dr. SMITH. The material was in concrete blocks——

Senator COOK. In 1968?

Dr. SMITH. Yes; at the time they did not anticipate any problem, in all fairness to them. Now we only got a report from the Army as to what the AEC report contained, and it was their interpretation that alternative number one which we had recommended was not feasible by AEC interpretation and by the Army interpretation.

We did not see that it was necessary to question this.

Senator HOLLINGS. We will not belabor that point now, but of course the AEC interpretation was made on a report, amongst others, on September 15 of last year. On page 4 of the report they outline the time and the cost and impact of four different locations.

One of them is the Yucca Flats Nuclear Testing Site, and an existing hole which could have been prepared in 41 weeks, which could

occur by August 15 from that time last year. Or referring to your report, in the fall of 1968 the Department of the Army determined that the disposal of certain chemical munitions was necessary.

So it started in the fall of 1968. If they would have handled it expeditiously and in any manner of efficiency whatsoever, they could long since have done it and have done it with complete safety and not in the ocean.

Now where we are talking in a large known and unknown measure, what is known doesn't sound good, and the precedent of going along with the unknown is disturbing to the subcommittee, I can tell you that.

That is one of the main concerns we have.

Do you have anything further to question?

Senator COOK. No.

Senator HOLLINGS. Thank you very much, Mr. Meacham. Do you have anything that you wish to add?

Mr. MEACHAM. No; thank you. Thank you very much, gentlemen.

Senator HOLLINGS. We appreciate the appearance of you and your colleagues.

We will next hear from Mr. John B. Rhinelander, from the State Department and Mr. Herman Pollack, Director of International Scientific and Technological Affairs with the State Department.

Mr. RHINELANDER. Thank you very much.

Mr. Chairman, Senator Cook, before I begin my formal statement I would like to introduce Mr. Herman Pollack, who is on my left. He is a Director of the Bureau of International Scientific and Technological Affairs for the Department; and Mr. Allen Harris, on my right, who is the Special Assistant to the Legal Adviser.

STATEMENT OF JOHN B. RHINELANDER, DEPUTY LEGAL ADVISER, DEPARTMENT OF STATE; ACCOMPANIED BY HERMAN POLLACK, DIRECTOR OF THE BUREAU OF INTERNATIONAL SCIENTIFIC AND TECHNOLOGICAL AFFAIRS; AND ALLEN HARRIS, SPECIAL ASSISTANT TO THE LEGAL ADVISER

Mr. RHINELANDER. I am glad to appear before the Subcommittee on Oceanography of the Senate Commerce Committee to discuss the international legal aspects of the proposed ocean transportation and disposal of chemical munitions.

I am accompanied by Mr. Herman Pollack, Director of the Bureau of International Scientific and Technological Affairs, and Mr. Allen Harris, Special Assistant to the Legal Adviser.

As you know, section 409(c)(2) of Public Law 91–121 enacted in November 1969, provides, among other things, that no funds shall be used for the transportation and disposal of any lethal chemical warfare agent outside the United States if the Secretary of State, after appropriate notice by the Secretary of Defense, determines that such transportation and disposal will violate international law.

The statute requires the Secretary of State to report such a determination to the President of the Senate and the Speaker of the House of Representatives and, to the extent required, to appropriate international organizations.

By letter dated June 23, 1970, the Department of the Army formally advised the Department of State that due to the potential danger of

continued storage of the 418 vaults containing chemical munitions, and the absence of a reasonable alternative other than sea disposal, the Army had decided to proceed with ocean disposal as soon as possible.

Mr. Chairman, there is as yet no codified international law pertaining to ocean dumping. Article 2 of the 1958 Geneva Convention on the High Seas sets forth the general principle of international law relevant to the proposed plan.

It provides that the freedoms of the high seas shall be exercised by all states with reasonable regard to the interests of other states in their exercise of freedoms of the seas.

The disposal plan formulated by the Department of the Army was carefully reviewed within the Department of State, including the possible effects of the ocean dump on fishing, navigation, submarine cables, pipelines, exploitation of the resources of the seabed, and other uses of the sea.

Studies prepared by various experts were reviewed. In addition, Department of Defense experts were questioned in detail on the possible impact of the proposed dump on uses of the sea by other states.

Based on the information developed regarding the probable effects of the ocean dump and the findings of the Surgeon General and the Department of the Interior, the Acting Secretary of State concluded pursuant to section 409(c)(2) of Public Law 91–121 that no basis had been found for a determination that the transport and disposal in question will violate international law.

Mr. Chairman, this finding was communicated by letter dated July 30, 1970, to the Speaker of the House and the President of the Senate.

We will make available copies for your subcommittee if you do not have them already.

Senator HOLLINGS. When did you communicate that to affected countries? Don't you notify the other countries?

Mr. RHINELANDER. We notified certain countries which had earlier expressed concern on the 29th of July and 30th of July. This was done in Washington to representatives of these countries.

Senator HOLLINGS. This was just last week?

Mr. RHINELANDER. Yes, sir.

Senator HOLLINGS. Has any government issued any protest?

Mr. RHINELANDER. No, no.

Senator HOLLINGS. Have you heard a report that the Bahamian Government was going to issue a protest?

Mr. RHINELANDER. We understand that they have—first of all they have expressed concern to the American Consul General. We understand that they have expressed similar concern to the Government of the United Kingdom which represents them in foreign affairs.

Senator HOLLINGS. From their standpoint this is all short notice, is it not? Just notifying the various countries and just notifying the House and Senate on July 30? Of course you did not know until June 23, you say?

Mr. RHINELANDER. We received the formal proposal on June 25; yes, sir. We did not complete our formal review and make our determination until July 29, I think it was, and the letter was sent to the Congress dated July 30.

Senator HOLLINGS. There is no international law actually governing this particular disposition?

Mr. RHINELANDER. No, sir, there is no law.

Senator HOLLINGS. What international designation has been given this area? There has been previous testimony that it has been designated as a munitions or dumping ground. It is suggested perhaps it is mainly only for mustard gas and that no inquiry or designation has been made for other things.

Am I incorrect, do you have the correct designation? What body designates, if at all?

Mr. RHINELANDER. I have a navigation chart in front of me, Mr. Chairman. In the chart there is a circle in here and it is labeled, "Ammunition, explosives dumping area."

Senator HOLLINGS. That chart was by whom?

Mr. RHINELANDER. It is a U.S. chart issued by the Coast and Geodetic Survey.

Senator HOLLINGS. So the Coast and Geodetic Survey, Department of Commerce, is designated as the one to designate this as a dumping ground pursuant to what authority?

Mr. RHINELANDER. It is designated by the Oceanographer of the Navy as a dumping ground. Notice is given, formal notice, and it is recorded on navigational charts as a dumping ground.

Senator HOLLINGS. How long has it been so designated, do you know?

Mr. RHINELANDER. I believe since the late forties.

Senator HOLLINGS. Late 1940. Has it ever been used for nerve gas dumping before?

Mr. RHINELANDER. No, sir; not to my knowledge.

Senator HOLLINGS. Senator Cook?

Senator COOK. Thank you, Mr. Chairman.

Mr. Rhinelander, your second to the last paragraph says that based on the information developed regarding the probable effects of the ocean dump and the findings of the Surgeon General and the Department of the Interior, the acting Secretary of State, "We decided that the findings were all right and based on theirs we decided to go along."

Mr. RHINELANDER. I think anytime you give a legal opinion you have to base it on information available to you.

Senator COOK. No. 1, I don't think there is any legal significance either in the report of the Department of the Interior or in the findings of the Surgeon General. We are talking about legal opinions now as opposed to opinions as to whether there is or is not any objection as to this procedure.

I think we have to make that distinction. Were there any efforts other than to sit down with the Department of Defense and with the experts and discuss with them in detail on the possible impact of this? I assume from your second to the last paragraph that you merely took the written findings of the Surgeon General and of the Department of the Interior and went no further.

For instance, would it have disturbed you to know that all of the bases of the Department of the Interior's knowledge of the ocean bottom at this location was based on a survey that was taken during a 7-day period in July?

Mr. RHINELANDER. Well——

Senator COOK. I have never known a treaty to come out of the State Department in 7 days. I wonder if you felt whether the Acting Secretary really went into detail to find out how much had been done?

For instance, did the Acting Secretary at the time this was agreed to, know that the previous dumpings had taken place off New Jersey, that the vessels that had been sunk, that they cannot even find them? Was he aware of that fact?

Mr. RHINELANDER. I can't tell you as to what——

Senator COOK. I see.

Mr. RHINELANDER. I can assure you in the Department we were aware of that.

Senator COOK. You were aware of that?

Mr. RHINELANDER. Yes, sir.

Senator COOK. And you discussed this at the time?

If you did discuss all these things, did you find them completely compatible with a decision to take over 12,000 unstable rockets and authorize their disposal in the ocean 280-some odd miles off the coast of Florida, or 190-some odd miles from the Bahama Islands?

Mr. RHINELANDER. Senator Cook, let me note that with respect to the international law in question, we are dealing with a standard of reasonable regard.

As I indicated in my prepared statement there is no codified international law which prohibits or specifically limits dumping waste materials in the ocean.

Senator COOK. But now wait, you went further than that. Because you did not confine it merely to that portion of the statute that says that you have to determine whether there is a violation of international law.

Because you say in the paragraph on the top of the page:

> The disposal plan formulated by the Department of the Army was carefully reviewed within the Department of State, including the possible effects of the ocean dump on fishing, navigation, severing cables, pipelines, exploitation of the resources of the sea bed and other uses of the sea.

Now we are not just talking about your responsibility to notify other nations in regard to international law because you say yourself that you went further than this.

Mr. RHINELANDER. Perhaps I can explain that paragraph a little further, Senator. Article 2 of the Highs Seas Convention speaks of freedom of the high seas. There are four enumerated freedoms in this article. They are freedom of navigation, freedom of fishing, freedom to lay submarine cables and pipelines and the freedom to fly over the high seas. These are the four enumerated freedoms.

Senator COOK. All right, if those are things enumerated in the section, you did no more than to take the written findings of the Surgeon General and the Department of the Interior, and yet in regard to the impact of the proposed dump or the use of the seas by other States, the only people that you talked with were the people of the Defense Department; is that correct?

Mr. RHINELANDER. The only person—excuse me, I did not hear the last part of your question.

Senator COOK. You took the written report of the Surgeon General and the Department of Interior on their face, as I take it from your statement, but the only people that you had any serious questioning with was the Department of Defense; is that correct?

Mr. POLLACK. The principal discussion by the Department of State with respect to the substance of the studies was with the Department of Defense and the Department of Interior and some other private individuals knowledgeable in this area. Some of the men who served on the NAS Committee that was alluded to in the previous testimony.

Senator COOK. Who were these men that you talked to?

Mr. POLLACK. One was Mr. Kistiakowsky, on several occasions.

Senator COOK. All right. If you talked to Mr. Kistiakowsky did you——

Mr. POLLACK. This was some time back.

Senator COOK. He was short of being vehement about this, wasn't he, and he still is?

Mr. POLLACK. I think that all of the people who have examined this question have been very much troubled by the dimensions of the problem and by these live rockets with nerve gas warheads that are encased in concrete. I think we have all been concerned about this for some time. There is no question about that whatsoever.

Senator COOK. Well, I must say I think we all are concerned, but it took the departments of the Government an awful short period of time to agree to it.

If you want to enlarge on that remark you certainly may, but you state the Department of Public Health had about 2 weeks, and your schedule was a pretty short one.

You were advised of this on June 23. So you did not have very much time to really study this matter.

Mr. Chairman?

Senator HOLLINGS. Do you have something to add, Mr. Pollack?

Mr. POLLACK. I think I would only add that I think the time pressures on this were determined in good part by the advice of the Gross committee that subsequent to August 1, the hazard of leaving these rockets in their present location became unacceptable.

Senator COOK. May I say in all fairness you are putting an onus on the Gross report and it is unfair to do so because I think it has got to be established and laid right at the door of the military itself.

The military was aware of this problem in 1968 and 1969. This is when they were encasing them in concrete instead of detoxifying these as they have done on many, many other occasions.

As a matter of fact it was the military that asked for this report when they knew that they were living with an unstable condition.

I do not feel that it is an outside agency that is to blame.

Senator HOLLINGS. Mr. Pollack, did you have occasion to question that August 1 date set by the military?

Mr. POLLACK. I have spoken to one or two men about this subject. I do not know that I had spoken to anyone who considers himself a qualified munitions expert which is a highly specialized field, but the information that was supplied to me led me to the conclusion that there was no basis upon which the State Department could take the responsibility to challenge that date.

Senator HOLLINGS. Did they tell you in that inquiry of any testing made of the propellant with the GB or nerve gas itself?

Mr. POLLACK. To the extent that that kind of testing occurred I think that was subsequent to the time of our inquiry. That was reported in the second Gross report.

Senator HOLLINGS. What information was furnished you as to how they arrived on August 1, the date which you said you were not in a position to question?

How did they tell you that they arrived at that date?

Mr. POLLACK. My understanding, sir, is that essentially this is the outcome of years of experience in dealing with munitions and munitions that age. There is no way, as this was put forward to me, that you could establish a date in a demonstrable manner, that is where you could conduct one and then another experiment and come out with an identical conclusion.

This is a conservative date and in dealing with human lives I understand it is sensible to be conservative, a conservative date beyond which this material should not be left in its present condition, was August 1.

August 1 is the date that was difficult to challenge on a technical or other ground.

Senator HOLLINGS. Do you have anything further, Mr. Rhinelander?

Mr. RHINELANDER. No, sir.

Senator HOLLINGS. We appreciate very much your appearance here this afternoon.

We will next hear from Dr. Martin A. Paul of the National Research Council, Division of Chemistry and Chemical Technology, National Academy of Sciences.

STATEMENT OF MARTIN A. PAUL, EXECUTIVE SECRETARY, NATIONAL RESEARCH COUNCIL, DIVISION OF CHEMISTRY AND CHEMICAL TECHNOLOGY, NATIONAL ACADEMY OF SCIENCES

Dr. PAUL. Thank you, Mr. Chairman.

Senator HOLLINGS. Dr. Paul, we are glad to have you.

Dr. PAUL. Senator Hollings, distinguished members of the Subcommittee on Oceanography, Senate Commerce Committee; I was staff director last year of the National Academy of Sciences' Report of the Disposal Hazards of Certain Chemical Warfare Agents and Munitions.

As you know, the National Academy of Sciences is not an agency of the Federal Government but is a private organization having as one of its primary functions, whenever called upon by any department of the Government, to investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any services to the Government of the United States.

I think you can tell by the language that I just stated that this is from the act of Congress that incorporated the Academy in 1863.

In May 1969, the Academy was requested by the Department of Defense for an assessment of hazards involved in the execution of "Operation CHASE" and alternate plans for the disposal of certain surplus chemical warfare stocks of the U.S. Army.

An ad hoc committee of distinguished scientists and engineers was convened for the purpose by the president of the National Academy of Sciences, under the chairmanship of Prof. George B. Kistiakowsky

of Harvard University, vice president of the National Academy of Sciences.

Because of the request from DOD for an early response, the committee did not conduct an exhaustive study of all alternatives and factors involved.

It did conduct an intensive study, and delivered a report to DOD on June 25, 1969, in which disposal hazards were discussed and recommendations made for each of the five distinguishable categories of materials involved.

The committee was thereafter discharged.

I am therefore not now in any sense speaking on behalf of the ad hoc committee, nor of any of its individual members, but wish to state what the Academy's role has been in this matter before you.

The Academy has taken no part in the deliberations of the Gross committee, which was established by the Army pursuant to a recommendation of the Academy committee for further study specifically of the problem of disposing of one category of the materials, the so-called "coffins" containing unserviceable M55 rockets distributed in solid blocks of concrete.

The Academy committee recommended that the Army convene a group of technically qualified individuals, including demolition experts, to consider whether a practically feasible way could be devised to dispose of these "coffins" on an Army establishment, and failing that, two alternative sites for disposal at sea were recommended for the Army's consideration.

We understand that other recommendations of the Academy committee relating to disposal of much larger quantities of surplus, unserviceable materials, including the M–34 clusters of bomblets containing "nerve gas" in storage at Rocky Mountain Arsenal, and mustard in storage at Rocky Mountain Arsenal and elsewhere, have been followed, but the Academy has not been involved in the implementation of these recommendations nor indeed does it have that kind of responsibility.

The Academy does stand back of the recommendations contained in its own committee's report as the considered advice of the best representative and disinterested group of scientists and engineers it could assemble.

That concludes my statement, sir.

Senator HOLLINGS. So Dr. Paul, your first recommendation was to dispose of this dangerous substance at an Army establishment on land. Is that right?

Dr. PAUL. Yes, sir.

Senator HOLLINGS. Did you have an occasion to study the Department of the Interior letter of June 24, the report of the working committee as described by Mr. Meacham of the Department of the Interior?

Dr. PAUL. No; that was not transmitted to the committee. There was no reason for it to be.

Senator HOLLINGS. Independent of that, has the National Academy made its own judgment that to dispose of this material would be best done at an Army establishment on land, and barring that, then into the sea?

Dr. PAUL. Yes; that is correct.

Senator HOLLINGS. Did you learn later that the AEC—the Lawrence Radiation Laboratory rather, made a study and stated they could dispose of it within one of their sites of the Atomic Energy Commission? Are you familiar with that report?

Dr. PAUL. This all came to our attention about the same time that Congress received it. We did not receive any formal communication on that.

Senator HOLLINGS. Why did you put land, or give land disposal priority over ocean disposal?

Dr. PAUL. If it could be done it would solve the problem of transportation which is one of the things that was involved.

Senator HOLLINGS. Was there any other reason?

Dr. PAUL. No; I think not.

Senator HOLLINGS. You said in your statement, "* * * in which disposal hazards were discussed and recommendations made for each of the five distinguishable categories of materials involved." What were the five?

Dr. PAUL. One was the M-34 bomb clusters at Rocky Mountain Arsenal; 21,108 bomb clusters.

Second, was the mustard gas.

Third, were the coffins at issue here.

Fourth, were some containers water-filled steel containers that had been suspected of previously containing mustard gas and other possible agents. The Army wished to dispose of these because of the risk they were contaminated.

Fifth, was a stock of unserviceable riot-control agent, which had gone bad. It was unserviceable and the containers had been imbedded in concrete in 55-gallon drums that were expected to be disposed of by sea.

Senator HOLLINGS. Senator Cook?

Senator COOK. I must say, Mr. Paul, I have come to the conclusion that the Army uses a lot of concrete.

Senator HOLLINGS. They have a lot of it to use.

Senator COOK. The discharge of these coffins apparently baffled you. I noticed that the Gross committee really was the recommendation of your committee?

Dr. PAUL. Yes, sir.

Senator COOK. To study specifically the problem of disposing of these coffins?

Dr. PAUL. Yes, sir.

Senator COOK. So although in essence you are established to advise the Government in these regards, this one baffled you; didn't it?

Dr. PAUL. Yes, sir; the Army informed us that these things couldn't be demilitarized in any easy way. The problem of getting back at those rockets and doing anything with them was a very difficult one.

Senator COOK. If you have something, go ahead.

Senator HOLLINGS. The National Academy of Sciences, Dr. Paul, did you concern yourself at all with the cost of this?

Dr. PAUL. The cost of doing this?

Senator HOLLINGS. Of disposing of these materials?

Dr. PAUL. Of disposing?

Senator HOLLINGS. Yes, of these dangerous substances?

Dr. PAUL. I think in the discussion, rough costs were talked about. I believe the basic feeling was that cost was not an overriding factor, that the main concern was to ensure the greatest degree of safety.

Senator COOK. May I ask a question, Mr. Chairman?

Senator HOLLINGS. Yes, go ahead.

Senator COOK. I take it from the last sentence in the first full literal paragraph on page 2:

> The Academy committee recommended that the Army convene a group of technically qualified individuals including demolition experts, to consider whether a practically feasible way could be devised to dispose of these coffins on an Army establishment * * *

This really was your recommendation?

Dr. PAUL. Yes.

Senator COOK. "* * * failing that"—knowing that the Gross committee would report on this, but, "* * * fail that, two alterntives sites for disposal at sea were recommended for the Army's consideration."

At least you knew that there was a history of disposal at sea?

Dr. PAUL. Yes, sir.

Senator COOK. That if nothing could be done, this would be a last alternative in your mind?

Dr. PAUL. Yes, sir.

Senator COOK. You made it a last alternative to the extent that you made recommendations on four of the categories that you had been asked to study, that the fifth one established another committee of experts in the field of demolition and experts in the particular field to see whether they could do something, because in essence it really baffled you?

Dr. PAUL. Well, it was a little more than that. I think the feeling was that the risk entailed in a sea dump of these materials was less than that of the 21,108 bomb clusters at Rocky Mountain Arsenal, that was another matter.

Both because of the much larger quantity of material——

Senator COOK. Had the 21,108 bomb clusters in Rocky Mountain Arsenal been put in concrete?

Dr. PAUL. No.

Senator COOK. You didn't recommend that they be put in concrete; did you?

Dr. PAUL. No, sir.

Senator COOK. Have you ever made a recommendation that any type of hardware of this kind be placed in concrete containers?

Dr. PAUL. Oh, no, sir. We did not get into this at all until 1969 when we were asked.

Senator COOK. All right.

Thank you, Mr. Chairman.

Senator HOLLINGS. Dr. Paul, I am going to refer to the letter of Mr. Frederick Seitz, your President of the National Academy of Sciences, of June 25, addressed to John S. Foster, Director of the Office of Defense Research, and the accompanying report, and the language on page 13:

> We wish to suggest to the Department of Defense to adopt basically the same approach to chemical warfare agents and munitions that the AEC has outlined for radioactive waste from nuclear reactors. It should be assumed that all such agents and munitions will require eventual disposal and that dumping at sea should be avoided.

Therefore, systematic studies of optimum methods of other appropriate methods on military stations involving no hazards to general population and no pollution of the environment should be undertaken.

Appropriately large disposal facilities should be regarded as the requirement counterpart to existing stocks and planned manufacturing operations as a first step in this direction.

We suggest a construction of facilities for gradual detoxification of the remaining M–55 rockets.

This is dated June of last year.

Dr. PAUL. Yes, sir,

Senator HOLLINGS. 1969.

Dr. Paul, are you in a position to answer anything with respect to the currents from this particular site chosen, the currents going south toward the Caribbean area?

Dr. PAUL. No, no, I would not have any information there.

Senator HOLLINGS. How about the Gulf Stream? Dr. Cheek wanted to testify on another score, but is there anything else you wish to add?

Dr. PAUL. No, sir.

Senator HOLLINGS. Then we will recall Dr. Cheek.

Thank you very much, Dr. Paul, for your testimony.

STATEMENT OF DR. CONRAD H. CHEEK, CHEMICAL OCEANOGRAPHER, OCEAN SCIENCES DIVISION, U.S. NAVAL RESEARCH LABORATORY, WASHINGTON, D.C.

Dr. CHEEK. Thank you, Mr. Chairman.

Senator HOLLINGS. Dr. Cheek, after listening to some of the testimony this morning you wanted to clarify some points?

Dr. CHEEK. Yes, sir, Mr. Chairman, first let me express my appreciation for being given the opportunity to speak to some of the statements that have been made since our testimony, particularly in regard to those by Dr. Sanders.

Now in one case, Dr. Sanders agreed with our statement that the biological population in this area is sparse.

However, he made the claim that we were very wrong in regard to the great variety of organisms that were present. The record will show that we made no statement whatsoever concerning the variety and I question the ethics of this statement.

Furthermore, Dr. Sanders' statement is made on the basis of no data whatsoever. He has not examined anything in this area.

In regard to this agreed sparse population and the supposed great variety of which he speaks, let me point out that if we have a sparse population and great variety—great distribution in the variety, this would certainly imply that any one particular species would indeed be at very low population and therefore the ecological effect on the total of that species would be correspondingly minimal.

With regard to currents, I would suggest that Dr. Sanders is an ecologist and not an expert on current measurements. We are well aware that it is desirable to carry measurements over a longer period than we did, and I would like to make one correction.

The current data that we utilized for measurements were obtained from equipment left on site for 14 days. The ship returned to the area to pick up this current data after the survey had been completed.

The current data, sir, were not examined by an ecologist; they were examined by experts on deep ocean currents. It was a very good

current record which agreed with current values estimated on the basis of a previous series of salinity, temperature, and depth measurements that had been made in the general vicinity. These tests were made within a few miles of this area by scientists from GOFAR and Lamont Geological Laboratories, and I have their report here, sir. We feel that although our survey was minimal in respect to the length of time for current measurements, we utilized plenty of time for chemical measurement.

It does not take a long time to get oxygen, and fluoride, or salinity measurements in the area. We feel that the chemical data we obtained provide useful baseline information.

Also the photographs that we got were useful, we believe. It is the only basis that we have for comparison with future surveys of this area.

We are shocked and dismayed that the committee would ridicule our survey effort.

Senator HOLLINGS. Well, now, that is your conclusion about ridicule. We bring this out in the light of day. The fact of the matter is that scientists just did not think much of a 10-day test. That is the testimony of the witnesses, not this committee.

We are not marine biologists. But you still insist the 10 days was a good testing.

Dr. CHEEK. Yes, sir.

Senator HOLLINGS. I see. Getting back to the 1 percent remainder left, even you testified that if 1 percent of the gas from each one of the vaults were left, each one containing about 300 pounds of GB, multiplied by 418 vaults. One percent is left, that leaves about 1,300 pounds from different vaults, traveling at 4 miles-an-hour into the Gulf Stream.

What effect would that have going up toward England?

Dr. CHEEK. According to my testimony, let me make it clear: I stated that if all of the 135,000 pounds of material were released at once, within 10 days there would be only about 2 ounces remaining.

This is down by a factor of a million, and, sir, 5 days after that it would be down by about a factor of another thousand, that is, a total factor of a billion. Five days later still it would be down by a factor of a trillion. This would be at levels that are below detectability.

Senator HOLLINGS. How did you arrive at this August 1 date?

Dr. CHEEK. Sir, I did not participate in that aspect of the program.

Senator HOLLINGS. So you do not know whether August 1 is a deadline or not?

Dr. CHEEK. Sir, August 1 cannot be entertained as though it were a step function, that the day before everything is going to be all right and the day after that everything is going to be dangerous.

Chemical behavior does not occur in that fashion. It is very difficult to say just how long these encased rockets could be expected to stand around and not present a very definite and serious hazard.

Senator HOLLINGS. Don't you think——

Dr. CHEEK. I am not in a position really to speak to that, though August 1 as a cutoff date is a little difficult to rationalize.

Senator HOLLINGS. But I wonder, there should be some testing of some kind to determine the date?

Excuse me, Senator Cook, do you have anything?

Senator Cook. Well, Dr. Cheek, let's go back to your last statement about this August 1 date.

This committee has been stuck with an August 1 date. It has been the position of the Department of Defense that these rockets be disposed of immediately.

They notified the House committee yesterday that they could not delay notification that they gave to the Speaker of the House and President of the Senate.

Certainly they were relying on the report that this has now become a little more unstable and that immediate action has to be taken. It seems to me that specific testimony was given yesterday that at the request of several Congressmen that were there that no delay could be afforded and they could not stop this shipment. So for you to say that there wasn't anything magic about August 1, yet now to have the Defense Department totally and completely rely on it, seems a little inconsistent to me.

Dr. Cheek. Sir, I agree that this material should be removed and disposed of as soon as possible, but I want to get rid of the idea that some very pronounced change is going to occur as of one specific date.

I agree and I would certainly encourage the immediate disposal of this particular material. But it is difficult for anyone to say that it would really be very much worse, say, on September 1 compared to August 1. That is the point I am trying to make.

Senator Cook. Well, do you think it would have been all right by September 1?

Dr. Cheek. There is no way for me to tell that, sir.

Senator Cook. Because if it could have been all right by September 1 you could have taken the recommendation of the Lawrence study relative to existing holes at the Atomic Energy sites in Yucca Flats where they could have been disposed of between 41 and 45 weeks.

You see what bothers me, Doctor, is that I don't think there is any way that we can obviate the fact that the Defense Department has now made it an absolute imperative thing that this be moved on the date that they have set.

The testimony of the Under Secretary today states that these items were encased in concrete in the first half of 1968. But it now becomes a problem.

Well now, the act itself did not become law until November of 1969. Now why all of the delay at Anniston, Ala., or Lexington, Ky., knowing about their stability? Why did you let them sit there for well over a year, because they were encased in the first half of 1968?

Did it dawn on the Department that they were caught by the act of November 19, 1969, that they had to give notice and they had to go through a procedure?

Dr. Cheek. May I say again, sir, I had no participation in that aspect of it. I work for the Navy, and I am concerned only with the oceanographic aspect of it.

Senator Cook. I understand, it is a question that should not be propounded to you.

Dr. Cheek. This question would be best put to other persons.

Senator Hollings. As an oceanographer in the Navy, what marine biological studies were made in this area?

Dr. Cheek. I am not aware of any marine biological study made in the area. I might point out that we did have—and I do not call this a

marine biological study—we did have on board the ship during this brief survey two high school students, one of whom expressed some interest in marine biology.

He obtained one of the water samples and some sediment from the bottom and asked if he could look at them under the microscope which was onboard the ship, and we gave him permission to do so.

Now you can make your own judgment as to what his competence might have been for this purpose, but this is all the biological work that was done on the cruise.

Senator HOLLINGS. Come now, that is all the attention you gave to marine biology, was to carry on two high school students?

Dr. CHEEK. No, sir, please do not misunderstand me, Mr. Chairman. We did not make any efforts of our own, and we did not take any data or information from this young man. This was mostly a chemical and physical survey. It was not a biological survey.

The only evidence we have of biological population would be that from the photographs. We had hoped that by obtaining photographs of the bottom we could get some estimate of what the biological population would be, so that on future surveys after the dump we could make further surveys and photos of the bottom in order to get a comparison.

Unfortunately, or perhaps fortunately, the biological population on the bottom is so sparse that we don't feel that the amount of photography that we could do would give us a reasonable baseline; so again this is further evidence that there is very little biological matter there that would be destroyed by the nerve agent.

Senator HOLLINGS. So, no survey was ever done, but from the pictures, didn't you put all that information into a computer?

Dr. CHEEK. No, sir.

Senator HOLLINGS. The current information?

Dr. CHEEK. This was for current measurements.

Senator HOLLINGS. You put that into a computer?

Dr. CHEEK. Yes; that was put into the computer and we do have here an expert on current measurements who would be willing to testify. I would like to emphasize again, sir, that the current information that was obtained is entirely consistent with current values that have been estimated on the basis of salinity, temperature, and depth measurements in that particular area.

Again, even as Dr. Sanders said, in deep water in this area the situation is fairly stable. The findings in this case are entirely consistent with that viewpoint. We feel again, sir, that the information from our survey is entirely relevant and will be useful.

Senator COOK. Let me just ask you one question, Dr. Cheek, and I appreciate your coming in to defend the remarks, and I think they were well taken.

Dr. CHEEK. Thank you, sir.

Senator COOK. As a Navy oceanographer are you not delighted that this is the last exercise of this kind that you will have to participate in?

Dr. CHEEK. Sir, we feel we are in the service of the Defense Department and in one sense happy to see that our research efforts can be put to use.

Senator COOK. As I put it that is a good answer. But as an oceanographer by profession——

Dr. CHEEK. Yes, sir; as an oceanographer by profession I must say that in general I would object to putting things like this into the ocean but, I cannot compare——

Senator COOK. Thank you.

Dr. CHEEK. I cannot compare possibly endangering the sparse marine life at 16,000 feet to the possible endangering of people in Anniston, Ala., and Lexington, Ky.

Senator HOLLINGS. Do you know of any testimony that regards the danger to people in Alabama or Kentucky?

Dr. CHEEK. There are claims, sir, that anyone near this material would be endangered by its increasing instability. There are those who are worried about the train shipment, yes, that is right. I believe the enclosed statement was in response to a question which has been omitted.

Senator HOLLINGS. Well, that is another report. Let us get on with that. If you don't have anything further, we appreciate your comments, Dr. Cheek.

We will now hear from Mr. Frederick R. Tesche, Deputy Director of the Military Applications Section of the Atomic Energy Commission.

Mr. Tesche, would you come forward, please?

STATEMENT OF DR. FREDERICK R. TESCHE, DEPUTY DIRECTOR, DIVISION OF MILITARY APPLICATION, ATOMIC ENERGY COMMISSION; ACCOMPANIED BY COMDR. RONALD RICHTER

Dr. TESCHE. Thank you, Mr. Chairman.

Senator HOLLINGS. We understand you have been in hearings all day long.

Dr. TESCHE. Yes, sir.

May I introduce Comdr. Ronald Richter from the Division of Military Application.

Senator HOLLINGS. We are glad to have both of you here. I know you don't have a prepared statement but we wanted to include in the record at this hearing the feasibility study projects, the Lawrence Radiation Laboratory study, dated September 15, 1969. Are you familiar with that?

Dr. TESCHE. Yes, sir.

Senator HOLLINGS. Will you testify in your own words—well, we will take the entire study for the record and include it as part of the record.[1]

Senator HOLLINGS. Now you may refer to it as you wish and briefly summarize for us.

Dr. TESCHE. I do have a summary here, sir.

Senator HOLLINGS. You do have, very good.

Dr. TESCHE. The study concluded that while the gas could be reliably destroyed by an underground nuclear explosion a great deal more in-depth study was required prior to actually carrying out the project.

Aside from developing a detailed plan, the in-depth study would have to address the structural integrity of the containers, the state of explosive and chemical composition and stability, and a full safety evaluation when more information on gas characteristics became available to the Atomic Energy Commission.

[1] See p. 106.

These studies would take place while such things as downhole detector systems, emergency escape holes, and so forth, were being prepared.

The major points of concern to the Atomic Energy Commission were the safety implications, the interference with weapons development programs, and the public relations aspects.

We expected that the safety implications, which appeared formidable, would fully surface during the in-depth study of the project should the Army decide to pursue this method of disposal. If it developed that the measure of propellant instability predicted by the Army did in fact exist, this disposal method would be unacceptable to the Atomic Energy Commission, for vault emplacement requires personnel down-hole in close proximity to the vaults and any accident would probably result in a fatality.

I might digress for a moment to point out that it has been made known, I believe, that there is a hole in Yucca Flats and that in principle, it was available for this project but an auxiliary hole would also have had to be drilled adjacent to it for ventilation purposes and for rapid exit.

Interference with the weapons development program was judged to be unacceptable if Yucca Flats was chosen as a site, because better than 90 percent of our testing is carried out in this locale, and the transportation, storage, emplacement and destruction of this material would require a cessation of our testing activities for a period of approximately 14 weeks if the schedule were to be met.

Finally, the public relations aspect: These are quite adequately covered in the original version of the study plus the fact that the various reactions being displayed toward movement of the vaults would be the same if the material were moved to Nevada except that the Atomic Energy Commission would be in the middle. I think, in summary, the technical study was one done in candor and in intellectual honesty. I think the Commission on the other hand when it was apprised of this plan was not in favor of it.

Senator HOLLINGS. Well, Mr. Tesche, what we have and what we are really confronted with was that back in June of last year the Department of the Interior objected to the ocean disposal and recommended a land disposal approach.

Independently, the National Academy of Sciences, through the Kistiakowsky committee report also concurred in it, and then came the Lawrence Radiation Laboratory report saying they could do it.

I am referring specifically to the language in the schedule on top of page 4 where you have the following table and it summarizes the time and cost impact of the four different locations and options at Yucca Flats which is in NTS, what is that? Nuclear test?

Dr. TESCHE. Nevada Test Site.

Senator HOLLINGS. That is Yucca Flats, Nevada Test Site existing hole, that would take 41 to 45 weeks with a cost of $3.5 to $4 million;

Now, the next one—what is that?

Dr. TESCHE. Pahute Mesa.

Senator HOLLINGS. Pahute, that's a new hole there, and that would take 64 to 68 weeks and then other sites substantially more time with this language here.

If this project must be completed by August 1970, then an existing emplacement hole must be utilized. The only eixsting hole suitable in this event is in Yucca Flats.

The accomplishment of this project in Yucca Flats will cause an unacceptable amount of interference with other ongoing programs in NTS activities.

A possible alternative for meeting the August 1970 date is to transport the vaults to the Nevada Test Site before August 1970 and store them in a remote location, the Pahute Mesa, until facilities can be completed. A short move on the Nevada Test Site might be required before disposal.

So they recommended the feasibility of it there subject to the time schedule, subject to the interruption and subject to whether or not you wanted to use an existing hole or not? Isn't that the case, that they said back in September it could be done in as little time as 41 weeks which is about 10 months, which would have been by August 15?

Dr. TESCHE. The problem here as we view it is our uncertainty about the safety of the containers, and that we would simply have to close down activities associated with out testing programs, 90 percent of which are at Yucca Flats, because of worries about personnel safety.

Unless it could be absolutely demonstrated safe that concurrent activities could transpire——

Senator HOLLINGS. I think perhaps I have misread it then, but it seemed like you were talking about safety, and you have discussed the safety very thoroughly in this report. They have a hazards and safety evaluation section. They list them all.

It is hard to refer to these numbers on my copy, but it is four or five pages down where they talk about this.

They say to summarize preliminary hazards evaluations it is felt that the vaults can be emplaced in a safe manner under tight control operationally, assuming that further information does not indicate state of concern of decomposition of the propellants.

Dr. TESCHE. We are in the state now where we don't know the condition of the propellants.

Senator HOLLINGS. I am talking about a year ago, September of 1969, when you made this particular report. You didn't emphasize—in fact, the Government didn't get all that about safety. They reported in its Department of Army summary to all the various Departments. Alexis Johnson, Under Secretary of State, going to Russell Train, to the Secretary of Transportation, to the Surgeon General, to the science adviser at the White House, thereafter, on October 13, 1969, the Army was informed, even though this report was dated a month earlier, the Army was informed by representatives of the Atomic Energy Commission that the Commission had reviewed the feasibility study and decided that the vaults could be destroyed with an underground nuclear explosion, but not by August 1, 1970.

Further, that the AEC would prefer to not divert talent and resources now.

They weren't talking of safety there.

Further, that the Atomic Energy Commission would prefer not to divert talent and resources for this purpose since it would delay or

postpone action on regularly assigned test programs and, too, because of the strong probability of adverse publicity generated by this additional detonation.

So the thrust of what the Army received is twofold objections, one was the publicity and the other the diversion of talent.

Dr. TESCHE. Certainly, the question of publicity is quite correct. But the uncertainty of the condition of the propellant was known by us as part of our input information at the very start of the study. We were told that the August 1 date was the date which was estimated to be the time that the material became hazardous. So the necessity for emphasizing the safety of this operation was one of paramount consideration all through the study.

Let me give you an example, sir. In preparing the hole at Yucca Flats, that exists there today, to put the munitions in, one would have to excise a cavity some 50 by 50 by 50 feet or so, with a mining mechanism. It takes quite some time to excise a cavity down at a thousand feet or so. This would essentially call a halt to the normal AEC weapons development test program because of the possibility of shock breaking up the surface of the cavity that was being built down there, at the risk of further loss of time, and a possible hazard to people.

So the question of safety is threaded entirely through the study from its conception last year.

Senator HOLLINGS. Any work with radioactive materials is going to involve a safety factor. But throughout the report the opposite is true. These obsolete chemical munitions can be reliably destroyed by an underground nuclear explosion, and that is what they said back in September. That is what the Lawrence Radiation Laboratory said:

> This operation can be conducted with no undue or unusual onsite or offsite safety hazards.

And it goes on. In fact, three different sites have been considered. You have the Yucca Flats, the Pahute Mesa, and other locations. The primary difference is 1, time; 2, cost; 3, operational interference. They weren't emphasizing safety.

Although I agree safety is a factor, and a big factor in all of these factors because it always is, that is not the message that the entire Government got.

Dr. TESCHE. I think the Atomic Energy Commission makes the condition that if it was a feasible operation, subject to thorough evaluation of the safety problem, it could be done. One of the things being the stability of the explosives. So, seeing that the Atomic Energy Commission felt it could do the job means really that the Atomic Energy Commission can do the job provided the munitions and any other factors associated with this project can be demonstrated or can be shown to be safe.

Senator HOLLINGS. Well, sir, they went right down on scheduling and costs. They give possibly the most detailed report. And on the Yucca Flats existing hole, they give the time in weeks. They include the cost, the planning, the site selection, the site preparation, the 72-inch emplacement hole, the 36-inch secondary hole, mining mobilization, the decontamination facilities, the vault emplacement, the system on the ground, device emplacement, and they even added in weeks and costs. And they put in all the other things, even a lost time

delay factor, and still came up with 41 weeks, or 11 months, and we have an August 18 schedule, and this would have been done by August 15; in fact, with no lost time, it could have been done by June 1. It could have been done according to your Lawrence Radiation Laboratory report. Are you saying it couldn't have been done on account of safety? Is that your testimony now?

Dr. TESCHE. No, sir. I am saying that had all of the safety studies necessary demonstrated the stability of the munitions and the integrity of the vaults, and that all of the further studies involving the geology of the hole to determine that the hole could be created down there, if all of these things turned out positively, then the test could have been conducted at Yucca Flats, but with a severe impact on the Atomic Energy Commission weapons program.

I would like, if I could, sir, to read one paragraph concerning this very thing—and this is a requirement.

If these explosives have deteriorated to a point where handling of the vaults is hazardous, we would recommend against the suggestion that these munitions be disposed of in a different manner or manner which——

Senator HOLLINGS. I'm sorry. I can't hear you.

Dr. TESCHE. We would suggest that these munitions be disposed of in a manner which minimizes human handling, for example, sea dumping.

Senator HOLLINGS. All right. I will yield to Senator Cook.

Senator COOK. You keep referring to the public relations of the AEC.

Dr. TESCHE. Yes.

Senator COOK. I wish you would expand on this a little bit, because what really bothers me considerably is your talking about the fact that something could have occurred in Nevada.

Here we are moving this material a year later through areas where there is population and the only argument I hear is public relations aspects on the part of the Atomic Energy Commission.

During the course of this, somebody might get hurt. Well, somebody could get hurt or lose their lives in moving it through North Carolina. Somebody could lose their life in putting it on the vessel. Something could go wrong, somebody could lose their life driving it 200-odd miles out to sea.

You seem to be the only Department in this whole organization that has more power over the military because the military certainly had power over everybody else. They could disagree with the Interior Department. They could disagree with the Surgeon General. They could disagree with the National Academy of Sciences. They could disagree with everybody who wrote a report and said that it ought to be disposed of by an underground explosion. But you said no, and that was the end of it for you.

Dr. TESCHE. May I clarify? The Atomic Energy Commission did not say no. We provided a technical study to the Army at their request. We pointed out the difficulties involved. We explained to them the exhaustive safety studies that would have to be undertaken, particularly on the vaults and underground cavern, and so forth. We gave them a cost estimate.

Senator COOK. Are you saying, Mr. Tesche, to me, that if the Army had said, "That's the way we're going to do it," that that is the way it would have been done?

Dr. TESCHE. The Commission went on record as saying that they were very much opposed to this. But they agreed that we should make this study for the Army. The Commission has made it clear that they do not look upon this operation with any favor whatsoever, but we were asked by the Army and we agreed to provide this technical study to them, as well as we could.

Senator COOK. If the Defense Department had said to the Atomic Energy Commission, "This is the way these vaults are going to be disposed of," would you have had to comply?

Dr. TESCHE. I believe, sir, that the Atomic Energy Commission would have appealed this decision or this request to higher authority.

Senator COOK. Then you are saying that if you had been requested to dispose of these rockets you would have appealed this decision.

Dr. TESCHE. Yes.

Senator COOK. Because of the instability of the material, or because of the public relations aspects concerning the Atomic Energy Commission, or both?

Dr. TESCHE. The whole matter of safety—the instability of the chemicals, and the public relations aspects—yes, sir.

Senator COOK. I must say, Mr. Tesche, there is one other thing that rather bothers me, because it is stated in your report, that one of the reasons you didn't want to consider it, was that you felt that it was unacceptable to set back any of your timetables.

Now, I merely want to say to you that I expect in the operation of this whole thing that many people have set their timetables back, that many people have had to get themselves involved in this, and they probably would just as soon not have. Yet, they certainly went ahead and they assumed this responsibility. They assumed the burden of doing something that they thought was a most unpleasant task. and everybody has testified to the fact that this was not—Mr. Train said this was rather an unacceptable thing, but they were stuck with it. The Interior Department said if they had any other alternative, they wouldn't have done it. Everybody felt the most logical solution was disposal by an underground explosion but everybody then swallowed and took their licking, and were then prepared to dump it into the Atlantic Ocean. However, it could have been disposed of on a logical timetable determined by the Atomic Energy Commission. Yet the AEC decided their schedule would be disrupted and that it was going to hurt their public relations.

Dr. TESCHE. But, sir, in any underground test of any type that would be done, one of the most thorough reviews that we make is the review regarding the safety of the operation that we are going to conduct, not just for the few people around the site, but for the city of Las Vegas. The Atomic Energy Commission policy has always been to not even consider conducting experiments that do not satisfy certain safety criteria which are judged by a number of independent experts, university people, and so forth.

So, we consider safety to be of an extremely important——

Senator COOK. I am not saying that. In your report, you don't talk of the safety factor. In your report you even set up the vault for experimentation. It is all laid out here. How this can be done, the fact that you would only use one atomic explosion; you recommend that a dummy vault would be constructed to allow checkout procedure, verification, and crew training before emplacement of the vault.

Why in the world was all of this done if at the end of all of this work and effort you were going to say no from the very beginning? Why was all this time taken? Why was all of this effort wasted? Why was this total and complete study made when from the very beginning in your testimony, you didn't want to do it? You weren't going to do it, and if they asked you to do it, you would appeal to higher authority? Why didn't you say "No, we are not going to do all this research in the first place?"

Dr. TESCHE. We were asked by the Army to look at this on the recommendation of the National Academy of Sciences, so we went into this program to look at this project as we would for anyone else.

Senator COOK. I must say, Dr. Tesche, it's like my oldest daughter asking me to take her to the showroom to buy her a new car. I take her down there and I show her all the cars and we find one that she likes, and I look her in the eye and I tell her that "I am not going to buy you one anyway." You did all this work, all these computations, and all these studies, yet you weren't going to do it.

Senator HOLLINGS. Mr. Tesche, or your colleague, what disturbs me in the testimony is the comparison of sea disposal to a nuclear explosion in the AEC report:

No. 1, is this incorrect or correct, that the AEC was asked to study and make its report in comparison to sea dumping? Didn't the Army say that we were going to have this as an alternative to sea dumping? Do you deny that?

Dr. TESCHE. We made our study not as a comparative study with sea dumping whatsoever. We made our study focusing solely on the destruction of these munitions by nuclear device.

Senator HOLLINGS. One point at a time, now. On page 1, "Introduction and Summary," a statement of the problem: The Army is faced with public and congressional opposition to the dumping of obsolete chemical munitions into the ocean.

So there you consider the ocean, and at the bottom of the third paragraph it is indicated these munitions were incased in concrete and steel vaults in preparation for sea dumping. So we have sea dumping in mind when you start off?

Dr. TESCHE. Indeed we did. We knew that.

Senator HOLLINGS. With sea dumping in mind, and after a detailed study that goes on for a good 25 to 30 pages, detailing the hourly rate, the cost—and yours is the only one that allocated cost that I can find in all of these matters. You said at the bottom of the page, summary and conclusion, "these obsolete chemical munitions can be reliably destroyed by an underground nuclear explosion." This operation can also be conducted with—and I am quoting; please listen and you correct me if I am wrong—"This operation can also be conducted with no undue or unusual onsite and offsite safety hazards if the structural integrity of the steel shipping vaults can be assured through the time of emplacement in the hole. Planning and execution, however, must acknowledge the possibility of gas leakage."

Acknowledging that possibility, and all the other, you are taking the Army August 1 date, like everybody else presumably does? Having done that, you can say it can be done without any undue onsite or offsite safety hazard?

Dr. TESCHE. If the structural integrity of the steel shipment vaults can be assured.

Senator HOLLINGS. Right.

Dr. TESCHE. That is the big "if."

Senator HOLLINGS. Other than that, do you have any other "if's"?

Dr. TESCHE. If we do——

Senator HOLLINGS. So you want to add another "if," another "if" that the report doesn't add? What would that one be that you would want to add?

Dr. TESCHE. The continuation of the testing program were not to cause a collapse of the cavern that would have to be built at the bottom of the hole.

Senator HOLLINGS. You think this report did not consider that? Is that your testimony now—that the collapse of the cavern problem was not considered in this report I am reading from?

Dr. TESCHE. It is considered.

Senator HOLLINGS. I am sure it's considered. Tell me wherein you differ from this report of something that the report didn't cover. That is what I am trying to find out. If you agree, tell me you agree. That's all the committee would like to know.

Dr. TESCHE. I agree with the report.

Senator HOLLINGS. You agree with the report?

Dr. TESCHE. Yes, sir.

Senator HOLLINGS. All right. Then we are beginning to make a little progress. The fact is that they did say that it could be done in several ways allocating the time and all, and I think they said in one section on summary of sites where they recommended over the Yucca Flats site, the Pahute Mesa site, and I read the language there. Based solely upon operational interference considerations and minimizing the potential hazards to onsite personnel, it is strongly recommended that this project not be conducted at Yucca Flats. Based upon operational safety, time, and cost considerations, it is recommended that this project be considered for execution at Pahute Mesa rather than off the Nevada test site locations. Is that correct?

Dr. TESCHE. We recommended that if this operation was conducted at Pahute Mesa instead of Yucca that it would be better.

Senator HOLLINGS. And the Pahute approach entails the actual shipping of this material, the concrete vaults with the GB nerve agent, shipping that months ago, and having it temporarily stored until all these preparations, safety and otherwise, could have been made, isn't that true? Wouldn't that have been the procedure?

Commander RICHTER. If I may, I don't believe there was a firm shipping plan or coordination between Army and AEC on this point.

Senator HOLLINGS. I am not talking about a firmed up shipping plan, because you never did firm that up. But here in your report you have recommended storage until all these factors and all these precautions have been complied with. All of this material would have been out there now. Isn't that what this is?

Commander RICHTER. Yes, sir.

Senator HOLLINGS. The answer is yes.

Commander RICHTER. Senator Cook?

Senator COOK. Yes?

Commander RICHTER. A little while ago, you were speaking as if you understood that the Atomic Energy Commission had gone into this study with a preconceived notion of saying no to it. This is not

the way it was. We were contacted informally by the Army who said that they had a problem that they thought we could help them with. We went over to the Pentagon and had a conference with the Army. They outlined the problem to us. Hence, the statement of the problem in our feasibility study. We listened to what they had to say and we arranged conferences within a week at one of our laboratories which was tasked to do the feasibility study. The representative of the Department of the Army, the deputy manager of the Nevada operations office who runs the NTS, and two military officers—one was myself—went out to LRL, presented the problem to the laboratory people and told them that they were to look at this method of destruction purely and simply as a project they were to evaluate and provide us with a feasibility study. They were not to compare this with any other disposal method, or suggest any other method. This was the method that the Army had been asked to look at—and they in turn had asked us to study it for them. This was the basis on which LRL should evaluate this project.

Senator COOK. Let me enlarge a little on this: I have been in this business I guess long enough to know what feasibility studies are. But this is not a feasibility study. This is the next thing to an absolute construction plan.

Listen to this: The balance of the room will be excavated by top-slicing, removing all muck through the 72-inch shaft in a 2½ cubic yard bucket. In the event that unforeseen ground conditions exist and the roof is not stable, steel ring beams and column supports will be constructed. This work could add 25 to 30 percent of the time and cost to the mining phase.

Now, you were asked to do a feasibility study whether this could be done. You not only did a feasibility study as to whether it could be done, you outlined with diagrams here, showing the location of vault No. 43, vault No. 13, vault No. 89, and so forth.

Now, the point I am trying to make is that Mr. Tesche said that if they had been asked to do this, the Commission would have appealed to higher authority. Yet this report lays out the step-by-step construction with which to bring this thing to a conclusion.

Now, how much did their survey really cost? When you went to the Pentagon was the same cost allocated to this, or did you absorb this cost?

Commander RICHTER. It was absorbed.

Senator COOK. Did you absorb it?

Commander RICHTER. Yes, sir.

Senator COOK. Do you have any detail on your records that shows the cost of this report, showing the absolute destruction of these walls, brought to the very conclusion in this report?

You have to carry the cost factor somewhere. I don't think I could come out there and ask you to do a detailed study like this and then anticipate you to say, "Why, sure, the committee is a friend of ours; we will do this."

This had to take time. This took a great deal of work by engineers, and a lot of onsite work.

As the chairman just stated, a site on Yucca Flats was abandoned, and one at Pahute Mesa was selected as the more feasible one. So actually, onsite work had to take place, too.

What was the cost factor and the allocation of cost in this study? I mean, did they just sit around the room and say, "We don't want to do it at Yucca; it's far better to do it at Pahute Mesa?" Or what was the reasoning? How was it concluded?

Was it concluded by reason of engineers doing this, and a great deal of technical work, or what? They must have known they would run into muck, which is a heavy substance that they would have to get out with a bucket, because they laid out exactly how it would be handled. All I am saying is that you are saying this is a kind of an informal report that you gave to the Army, because they asked you if you would help them in a difficult situation.

I am saying that this is a plan and a program that absolutely presupposes bringing it to a conclusion. Now, do you disagree with me?

Dr. TESCHE. Sir, we were asked by the Army, just as Commander Richter has said, to look into the feasibility of carrying out this project. Now, we have our experts in Nevada and in the laboratory who were accustomed to this sort of a thing. Not destruction of munitions, but geologists, seismologists, and people that understand the operation there. We have extensive knowledge of the geology of Pahute Mesa and Yucca Flats.

Senator COOK. Did you send anybody to Anniston, Ala., and Lexington, Ky. to look at the vaults?

Dr. TESCHE. No, but we had a motion picture showing the casting of the munitions.

Senator COOK. Did you get all of the detailed information from the Army, or how they had been placed in the concrete, whether vertical or what? As a matter of fact, in here you say you had a system by which the shaft would be dropped so that you could put these vaults in proper upright position or quantitative positions in relation to the explosion, and so on and so forth.

Now, really and truly, are you saying to me, both of you, that this report represents no more than a feasibility study?

Commander RICHTER. Yes, sir. Before you can say yes, it is feasible to destroy it, you have to know what we will destroy. You have to know what temperatures you have to reach. You have to know what size nuclear device you will need to reach these temperatures out to the desired distances. You have to know if you can mine the cavity in the geologic media that is present. That the techniques are available to mine a cavity of the required size.

You have to have the material available or the facilities available for lowering a 6½ ton block of concrete into this hole.

Senator COOK. As a matter of fact, you not only have it out there, you spell it out, every piece of that equipment, in this so-called feasibility study. You spell out by letter and numerical number as to type of equipment that it can be done with.

Here is the way you place it; here is the way it is going to be done. This is the manner in which it will be done.

Commander RICHTER. Yes, sir; and in this—in the recommendations and within the report it states that while due to the short deadline, we would have to start on this right away if the Army chose this method of disposal and concurrent with this construction process, we would have to still conduct our structural analysis of the coffins or vaults that were built, and to investigate thoroughly the stability of the propellants of the rockets in these containers.

Senator COOK. All right.

Commander RICHTER. Third, that we had to get additional information on the characteristics of the gas before we could carry the project through to completion.

Senator COOK. I can only say, in conclusion, Mr. Chairman, then I will turn it back to you, that if the AEC thought they were getting out of a bad situation, they may have gotten out of it. I am not sure what the public reaction will be, and this is one of the things that bothered you in the first place, Dr. Tesche. I think there is a great concern in the country about not having disposed of this before, and not knowing what is going to happen now when you place 135,000 pounds of nerve gas at 16,000 feet depth.

If it had been disposed of at Pahute Mesa, at least you would know it was gone.

Senator HOLLINGS. You gentlemen can see the concern we have.

One more time, when you get the Department of the Interior over a year ago, in June 1969, recommending a land disposal program, and you get the National Academy of Sciences concurring in, the Kistiakowsky Report recommending the same thing, it should be done this way. And you folks come in and say it can be done, and go into it in a very detailed measure, pointing out the 10-gallon bucket and all that other stuff, you point out hours and days and everything else in this complete report, then through some neglect on the Army's part in not following through with it, and coming through now, saying that it will be dumped into the ocean; this is what concerns the Congress and the public. This is why we have to make it clear that when you come and attest to the report today, whether you are saying it cannot be done from a safety standpoint on land, if it can't, I am willing to learn of it, but you said it could back in September a year ago.

You see the point we are getting at?

Commander RICHTER. A full safety evaluation was never carried out, because we were never advised that we were to proceed any further. One of the recommendations from the study group was, if they had deteriorated to the point they were hazardous, then we can't handle it.

Senator HOLLINGS. I don't see how the gentleman can say he supports the report, when the report said that this operation can be conducted with no undue or unusual onsite and offsite safety hazard, and you tell me it was feasible.

Commander RICHTER. "If."

Dr. TESCHE. If the safety analysis worked out.

Senator HOLLINGS. If everything went as this report says; we have common sense enough to know that.

Commander RICHTER. But it is just——The next major paragraph goes into the recommendation.

Senator HOLLINGS. And the recommendations on down the line state they have three different sites, and then they come up with a choice of the best one. Do you think the Government got the wrong message in this "for official use only" interdepartmental memo all the way from the Department of State down to the science adviser, and the various Departments, including the White House, that the AEC had reviewed the feasibility study and decided the vault could be destroyed with an underground nuclear explosion, that the AEC would prefer to not divert talent and resources for this purpose, since

it would delay or postpone their regularly assigned test programs, and because of the strong possibility of adverse publicity?

Senator COOK. That's it.

Senator HOLLINGS. There it is.

Let me ask you if you know this—perhaps you don't, because this is out of the Surgeon General's report, but it refers to the Atomic Energy Commission. This morning the Surgeon General furnished this to the committee.

On August 7, 1969, the Army requested the Atomic Energy Commission to determine the feasibility and desirability—see, they use the term "feasibility"—and desirability of adopting the Gross committee recommendations with respect to nuclear destruction of concrete vaults.

The Lawrence Radiation Laboratory and the Nevada Operations Office of the U.S. Atomic Energy Commission submitted the results of the feasibility study to the Atomic Energy Commission. This study concluded that, as a practical matter, the obsolete chemical munitions could be reliably destroyed by an underground nuclear explosion.

However, additional studies were recommended. In the event the project was to be undertaken, the feasibility study further concluded that a long period of time would be required from project authorization through execution.

Subsequently—and this is my question, Dr. Tesche—subsequently the Army was informed by representatives of the Atomic Energy Commission that nuclear destruction was unsatisfactory.

Are you familiar with that, or was it given orally, or in writing, or just how?

Dr. TESCHE. We never told the Army that nuclear destruction was unsatisfactory. We had been given the August 1 date and as the result of our feasibility study, it became very clear that it would be quite unlikely that we would meet that August 1 date, even if all of the ensuing safety studies could have been made concurrent with the preparations.

Senator HOLLINGS. So, in verifying this, when it stated there that the Army was informed that nuclear destruction was unsatisfactory, informed by the Atomic Energy Commission, the thrust of that unsatisfactory finding really spawns from the target date of August 1, that you couldn't do it within that period of time?

Dr. TESCHE. Yes, sir.

Senator HOLLINGS. Anything else?

Senator COOK. This material is going to be moved through three or four States on a train. Everybody has testified to the fact that it is stable enough to move on a train. As a matter of fact, the Surgeon General stated that it was more stable than many other various deadly chemicals that are carried in tank trucks.

Would that degree of stability be satisfactory for you?

Dr. TESCHE. I couldn't answer that for the people in the Nevada Test Site, or the laboratory. They would want to assess the stability of that explosive themselves to make their own judgment as to whether they think that the vaults could be transported within the Nevada Test Site in view of seismic activity there and so on.

Senator COOK. All right.

Senator HOLLINGS. Thank you, Dr. Tesche. Do you wish to add anything further? Either of you?

Commander RICHTER. No, sir.

Dr. TESCHE. Thank you, Mr. Chairman.

Senator HOLLINGS. We very much appreciate your appearance here this afternoon on such short notice, too.

Our next witness will be General Stone.

STATEMENT OF BRIG. GEN. W. W. STONE, JR., DIRECTOR OF CHEMICAL AND NUCLEAR OPERATIONS, ASSISTANT CHIEF OF STAFF FOR FORCE DEVELOPMENT, DEPARTMENT OF THE ARMY

Senator HOLLINGS. General Stone was at the Army when it was decided it was not feasible to dispose of this gas by way of underground nuclear detonation.

General STONE. Sir, from the level at which I operated within the Army, which is at the Army staff level, rather than the Army Secretariat, there were several points about the AEC report which concerned us.

First of all, sir, we did accept the AEC's statement at the bottom of page 3 that to take one of the holes at Yucca Flats imposes an unacceptable interference with the AEC's program. This meant it would require about 15 months from the time the project authorization was given, the program funded and the full go-ahead given, through the event's execution.

Recognizing that we received this report at the end of September or early October, this then would take us to approximately January 1, 1971 for project execution.

We have fully accepted the findings of the Gross committee. The Gross committee, as you will recall, had reviewed very carefully what was known about the double-based propellant that was in the rockets in the concrete.

They felt the environment to which this propellant had been subjected for a year and a half to 2 years within these vaults had possibly made it sensitive. They concluded that beyond the point of August 1, 1970, they simply did not know enough about the propellant within that environment to be able to guarantee whether it was becoming more or less stable.

Assuming the worst possibility, that it was becoming more sensitive, in other words, less stable, they recommended that disposal be done by that date, which we accepted.

There is one aspect of the AEC's report which has given me considerable difficulty for a period of time. On page 10 of the updated version, the July 10, version, at the top of the second paragraph, middle of the page, it says:

> Assuming that further calculations and discussions with the Hercules-Radford personnel do not indicate decomposition characteristics of the double-based propellant that would significantly increase its sensitivity, it would appear the vaults can be handled safely consistent with the engineering plan.

This statement is directly contrary to a basic finding of the Gross committee which was based on their knowledge of the chemistry of this propellant that one simply could not, by virtue of study, calculation or experiments at that point in time, which was last summer—

the time of their first report—determine whether this material was safe beyond the period of August 1970 or not. And they had to, in fact, assume the worst.

Here the AEC's planners, who had written the feasibility study, were assuming that by calculation, study and testing they could make this determination in sufficient time to permit disposition of these items by an underground nuclear explosion.

Senator HOLLINGS. One of the witnesses earlier this monring, I understand, may have left an impression that all of the M–34 clusters would have been dumped in the original Operation CHASE in 1969. You want to make a clarifying statement about that? Tell us what Chase is.

General STONE. Operation CHASE, sir, is an operation which has been conducted repeatedly. It is an acronym for the words "cut holes and sink them." As we have stated, this has been the standard means for a number of years for the disposition of ammunition of all types, including chemical ammunition.

Senator HOLLINGS. That sounds like something the Vice President would use.

General, having directed that question, let us get to the August 1 date. The August 1, 1970 date, what tests were made in order to determine the August 1 date?

General STONE. Very few tests, sir. The problem is, of course, that although we have samples of the propellants which were manufactured in the same time frame, which was 1962 to 1966, and have them under various types of surveillance, which is the standard procedure for propellants and explosives of all types, they have not been subjected to the same environment as those in the vaults.

These rockets have been encased in concrete since early 1968 and possibly subjected to considerable pressure. The double-based propellants have the characteristic of very slow deterioration over a period of time. Part of this deterioration is the giving off of gases. Having been confined within concrete, this gas cannot escape, which is the case in normal storage in the open or in igloos, our conventional means for storage of these items.

Confining this gas within the concrete could significantly increase the pressure upon this propellant, causing it to deteriorate still further. Many of the modes of deterioration of these propellants are such as to increase the sensitivity to shock wherein they would actually go off.

Senator HOLLINGS. So the judgment was made really from experience, but no actual testing?

General STONE. That is correct, because we do not have any long-term surveillance of this type of propellant where it has been held under pressure, confining the gases which do come off slowly. Our problem with the AEC proposal here is that we simply could not duplicate the 2-year period in which this material has already been confined.

Senator HOLLINGS. And nobody wanted to have their name on record as saying it was safe after August 1?

General STONE. Exactly right, sir.

Senator HOLLINGS. That was a conservative estimate.

Back to the AEC report. Am I to understand that that 15 months made it impractical—I am looking at these schedules within the report.

Mine is about the ninth or 10th copy, but as Senator Cook pointed out, it has the hours, and dates, and times. There is no page number, but it is section IV, "Schedule and Costs", and it summarizes the time and cost estimates for executing this particular project.

They go into the various possible alternatives with the first one, the Yucca Flats new hole, the time 51 weeks at $3,415,000; and 41 weeks at the Yucca Flats existing hole, 41 weeks at $3,415,000, and so on down the line.

That is where we get the 15-month estimate?

General STONE. Yes, sir. The Army accepted the fact that to use a hole at Yucca, be it a new or existing hole, would create undue interference with the AEC program.

Senator HOLLINGS. What part of that program? Can you elaborate that for us?

General STONE. No, sir; I assume the bulk of it is in support of weapons development.

Senator HOLLINGS. Other testing. It would perhaps have been disrupted for a few months. Then the question is the judgment of whether it is worthwhile to have disruption of 2 or 3 months, 5 or 10 months, or going into the unknown at 16,000 feet in the middle of the ocean and causing the present hiatus.

Senator COOK. There is one point you brought up that is very interesting. If you heard the colloquy I had with the two gentlemen from AEC, they said this was no more than a preliminary plan. I am delighted with your testimony because it is from their submission to the military, particularly, "it would appear that the vaults can be handled safely consistent with the engineering plan."

Now, that means they not only did a preliminary study, but they did an engineering plan for you; is that correct?

General STONE. Not to the best of my knowledge. Sir, I believe what happened here is that the feasibility study is a rather standard format within the Atomic Energy Commission. They do, as you know, a number of underground tests per year. I believe you will find on inquiry that essentially this same type of feasibility study is prepared for essentially every shot or at least every new type of shot.

Senator COOK. I am not arguing about that. I think if they do a preliminary engineering plan as they state here, that this is consistent with the engineering plan. When they do it under those circumstances they know they are going to bring it to a state of fruition. This one they did for you simply because you asked for it. But the tenor of the testimony was they never intended to do it anyway, because if they had been requested to do it, they would have appealed to higher authorities. That is the only point I am trying to make.

I must say to you if this had been a feasible plan, and they said it was, it seems rather strange with the estimates, the weeks, and cost factors that are given to the Army, that the Army merely relied on the fact that it might in some way upset the present schedule.

For instance, all of this that has taken place in the movement of these things from Alabama and Kentucky has upset a lot of peoples' schedules, hasn't it?

General STONE. Yes, sir; but might I point out that it is approximately three times as far to Nevada as it is to the sea terminal.

Senator COOK. I agree with that.

Senator HOLLINGS. How much does this cost, General Stone? What we propose to do on August 18, how much does it cost the Government to dispose of this GB?

General STONE. I would have to supply that for the record. I do not have that with me. General Murray had it this morning, but I do not have it.

Senator HOLLINGS. Will you do that at your earliest convenience?

General STONE. I certainly will.

Senator COOK. Also there are 12,540 units that are encased in this concrete. Would you give us the original cost of producing these?

General STONE. We will have to supply that also for the record, sir.

(The following information was subsequently received for the record:)

COST DATA ON OPERATION CHASE (1970)

The projected cost of Operation CHASE (1970) is $705,000. The original cost of the M55 rockets being destroyed was approximately $1,530,000. The total cost of the 418 vaults was $275,000, including 418 vaults at $79,000, and embedding munitions in concrete at $196,000. In addition to the above, an exploratory study of alternate disposal methods conducted at Tooele Army Depot at the request of the Gross Committee cost $315,000.

Senator COOK. That is all right. I think it would be interesting to know what it cost to produce 12,540 rockets. They are never going to be used for any other purpose than to be put in the bottom of the ocean. I would like to know really and truly, if we could find some way, to get an estimated cost of what it cost to produce 418 concrete vaults to place them in.

Senator HOLLINGS. General, do you have an estimate of the remaining gas within the possession of the Army that will likewise be disposed of at some time? In other words, this is the dangerous amount of gas that we have on hand; this has been found to be in a dangerous state as the Under Secretary testified to earlier today, inferring that we have more stored at these same sites and that thereafter perhaps we are not going to encase these in concrete; we are going to demilitarize them on site. Can we get an estimate that is not classified?

General STONE. I am sorry, sir; we do not have any unclassified figures. We would be glad to supply them to you in a classified manner.

Senator HOLLINGS. That is all right.

Are you watching the other gas now?

General STONE. Sir, I am not sure we discussed this with this committee, but we have pointed out before that for all types of ammunition we have standard surveillance programs. Our munitions are inspected every few months, lot by lot, to discover those that are deteriorating, catching them before they give us any major problem. These are then disposed of in a variety of ways. For chemical ammunition, the standard procedure is now complete detoxification on land, no longer any sea disposal.

Senator HOLLINGS. You have these weekly checks, and yet you determined way back in 1968, and now all of a sudden in August 1970, there is a crisis. That is a long period of time.

Where was the hangup, at the top level in the Army or where?

General STONE. I am sorry, I missed the question.

Senator HOLLINGS. The point is you determined that these substances were dangerous and should be disposed of in the fall of 1968. And somehow or other all of these reports, on a crisis basis—the Department of State wasn't even asked until June and they had to

inform people just last week, the governments involved and everything else.

Where was the hangup and delay?

General STONE. Sir, these particular vaults were actually filled, that is the rockets were put into the concrete in the period April 1968 through March 1969. They were all put into concrete based on the then existing plan to include them in the large Operation CHASE planned for last summer, which was to go through Earle, N.J.

Senator HOLLINGS. And off the coast where we haven't found them yet?

General STONE. That is correct, sir.

Senator COOK. Why wasn't this concluded last summer?

General STONE. Sir, as you may recall there were several hearings conducted by the Congress, followed up by a request that the Army cease the execution of this operation, which was about to take place, until the National Academy of Sciences could study the problem. The National Academy of Sciences did review the proposed operation in some detail. They requested that no further sea dumps take place unless absolutely necessary. And they did point out that sea dumps might be necessary in the case of these particular vaults. We have now pursued and developed procedures whereby we can detoxify all of the items in that original shipment scheduled for last summer with with exception of these vaults.

Senator COOK. You said just a minute ago, General, that these vaults would have to travel a far shorter distance to get to the east coast of the United States.

Because of your testimony before this committee, you would have had no problem in your mind to have transported these to the Nevada flats, would you?

General STONE. Sir, we frankly do not know.

Senator COOK. The point I am trying so make——

General STONE. What sort of a problem?

Senator COOK. The point I am trying to make, General, is all of the testimony has been that these rockets will be far safer on this train than a tank car full of propane or something else as was testified to this morning. The point I am trying to make is we really can't make the distinction in distance—we are making the distinction in the manner of disposal, aren't we? But it would have been no more problem to the military to have moved it from Anniston, Ala. and Lexington, Ky. to the west than it is to move it from these two locations to the east coast; is it?

General STONE. Sir, a problem that I can foresee is that after the vaults were shipped to the Nevada test site, some problem might develop, such as the relatiyely remote possibility of the caving in of the roof of one of these chambers, in which the vaults were stored. Such an occurrence would increase still further the uncertainty with respect to the safety of these items and our ability to safely get them down the 1,600-foot shaft. Then we might have to conceive some means of again trying to get rid of the vaults on land.

Our problem with several of the propositions proposed by the Gross committee, which we did look at and investigate, was not whether they were feasible, but the question of the time frame, as is shown in the second version of the report. Several of these procedures

are feasible and can be done safely, but in order to preclude the remote chance that there could be a detonation and endanger nearby populations where the vaults exist would require several years to build the necessary structures and install the automated equipment within them. The same kind of proposition might occur at Nevada.

Senator COOK. But the AEC report did say that it could be done with safety. As a matter of fact, they even told you, with the use of an existing hole, it could be done within the framework of 41 to 45 weeks. Is that correct?

General STONE. That is in their report, sir.

Senator HOLLINGS. That is right. And that 41 to 45 weeks, these estimates assume a three-shift-per-day, 5-day-a-week schedule, they say, and the above time estimates can be accelerated if a 6-day-a-week schedule is adopted. So they could have done it in a much shorter time if they had gone into a 7-day construction schedule.

General STONE. Yes. I missed this point, sir.

Senator HOLLINGS. I mean just looking at the schedule and reading from their reports. Why didn't they, on that possible alternative, on page 4, talking about if the project must be completed by August 7, then they could go to the Yucca Flats, and a possible alternative, talking again about the August 1970 deadline, a possible alternative for meeting the August 1970 date is to transport the vaults from the Nevada testing site before August 1970 and store them in a remote location until the facilities can be completed, a short move on the Nevada testing site might then be required before disposal.

Why wasn't that done? This is back in September, a year ago.

General STONE. Yes, sir. This is the point I was addressing with Senator Cook. They are assuming it would be possible by scientific analysis and experiments to prove that these propellants have not in fact become more sensitive to detonation after August 1. The hazard of handling them still exists, even though the distances are much shorter.

Senator HOLLINGS. But you would have it out there, you could be testing it right along, watching it to make sure and you could have cut down on the 41 weeks or even the 51 weeks using a 7-day-a-week schedule and going right at it to get rid of it.

General STONE. Yes, sir.

Senator HOLLINGS. The impression is given that you made an ocean determination back in April 1968 by putting it in concrete and the Army was not going to change that.

General STONE. Sir, I do not believe we made any such determination. We were trying to look at all possibilities. I think if you look carefully at the second Gross report, you will see the very extensive experimentation performed with respect to some of these alternatives.

Senator HOLLINGS. In order to not make an ocean determination, you have determined to never put them in steel and concrete again, is that right?

General STONE. Yes, sir, not in concrete.

Senator COOK. Thank you, Mr. Chairman.

Senator HOLLINGS. One final question, General Stone.

This is from Under Secretary Beal's statement, on page 3:

> Last July we gave orders to insure that no more chemical munitions will be placed in concrete. We have taken every precaution to avoid the necessity of

future sea disposal of chemical munitions. Apart from this one disposal we believe is unavoidable, we do not anticipate any future sea disposal of such items. We believe we have the technology to implement methods of detoxification on land which will meet the highest standards of safety to people without danger to the environment.

That is a rather unqualified statement.

Are you sure you are not going into the ocean again with chemicals?

General STONE. Sir, we can foresee no occasion that can come up in the future where this would be necessary. We are taking steps now to fabricate and construct mobile equipment to disassemble any item we have in the stockpile.

Senator HOLLINGS. The established policy will be against sea disposal?

General STONE. Yes, sir, that already is the policy.

Senator HOLLINGS. When will those facilities be completed?

General STONE. We should have these in operation within 1 calendar year from now.

Senator HOLLINGS. Twelve months from now?

General STONE. Yes, sir.

Senator HOLLINGS. Would that be sufficient to take care of any other materials you have at any of the other sites?

General STONE. Over a period of time, yes, sir. We will probably require several sets of this equipment because it is bulky and hard to move.

Senator HOLLINGS. Will any set come due and owing, so to speak, ready for detoxification, before the 12-month period?

General STONE. Sir, we do have some material which is in standby now. For example, rockets of the same type, in lots which have been shifted to the unserviceable category, are now awaiting demilitarization. These will be among the earliest items handled by this equipment.

Senator HOLLINGS. It will be handled by this equipment?

General STONE. Yes, sir.

Senator HOLLINGS. Thank you.

We have no further——

Senator COOK. Just one question, general.

Do you see any recommendation on your part that this detoxification equipment should be permanent, or do you really feel that mobile equipment is satisfactory?

General STONE. We believe the mobile equipment will handle it by moving on a cycle of hitting each of the sites once a year or once every 2 years.

Senator HOLLINGS. We appreciate very much your returning this afternoon, your testimony. Thank you, sir. That will terminate the hearing on this particular subject.

The committee is adjourned.

(Whereupon, at 5:15 p.m., the committee was adjourned.)

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

(This information is referred to in Under Secretary Thaddeus R. R. Beal's statement.)

NATIONAL ACADEMY OF SCIENCES,
OFFICE OF THE PRESIDENT,
Washington, D.C., June 25, 1969.

Dr. JOHN S. FOSTER, Jr.,
Director, Office of Defense Research and Engineering, Department of Defense, Washington, D.C.

DEAR JOHNNY: I transmit to you herewith a report prepared by a committee I appointed on behalf of the National Academy of Sciences, in accordance with your request of May 14, to give technical advice on a plan developed by the Department of Defense and alternate plans, for the disposal of certain overage and surplus chemical warfare agents and munitions. The members of the committee were selected to bring a broad range of relevant expert scientific and engineering knowledge to bear on this matter, including chemistry, biology, toxicology, physiology, and oceanography, as well as practical experience in the manufacture, handling, transportation, and disposal of hazardous materials, including explosives and chemical warfare agents.

I believe you will agree with me that the committee should be commended for the intensive study they have been able to give to this complex problem, in the interest of public service, on such short notice. I am confident the unanimous conclusions they have reached represent the best judgment of the scientific and engineering community, and trust their recommendations will be helpful to you in deciding upon a course of action.

Sincerely yours,

FREDERICK SEITZ, *President*

DISPOSAL HAZARDS OF CERTAIN CHEMICAL WARFARE AGENTS AND MUNITIONS

(Prepared by an Ad Hoc Advisory Committee of the National Academy of Sciences)

This Committee was appointed by the President of the National Academy of Sciences in response to a request of May 14, 1969 from Dr. J. S. Foster, Jr., Director of Defense Research and Engineering, Department of Defense, for an assessment of hazards involved in the execution of "Operation CHASE" (and alternate plans) for the disposal of certain surplus chemical warfare stocks of the U.S. Army. Dr. Foster noted that, because of seasonal considerations, an early response would be most helpful.

This limitation on time precluded an exhaustive study by the Committee of all alternatives and factors involved. Prior to meeting, the Committee reviewed printed material submitted by the Department of Defense relating to Operation CHASE, and additional relevant material from a variety of other sources. Individual members of the Committee studied the records of pertinent hearings before the Subcommittee on International Organizations and Movements of the Committee on Foreign Affairs and the Subcommittee on Conservation and Natural Resources of the Committee on Government Operations of the U.S. House of Representatives, and consulted with a representative of the Colorado Committee for Environmental Information and with Mr. Louis Garona of Edgewood Arsenal. Various members visited Edgewood Arsenal, Rocky Mountain Arsenal, and Naval Ammunition Depot Earle (including a flight over the adjoining territory and the tracks of the Central Railroad of New Jersey to the city of Elizabeth). Personnel at these facilities were cordial and cooperative, and discussions with them were most helpful in providing the Committee with background information based upon experience in handling the agents and munitions concerned.

The committee met subsequently for two full days of briefings and executive sessions. Briefings, with responses to questions from the Committee, were given

on various aspects of Operation CHASE and alternate methods of disposal by the following personnel from the Department of Defense:

Army.—Mr. Samuel Berlin, Mr. Paul R. Chagnon, Mr. S. Eckhaus, Dr. Joseph Epstein, Mr. Norman G. Hansen, Mr. Robert Hurt, Mr. E. J. Jordan, and Col. John J. Osick.

Navy.—Mr. Frank Dunham, and Mr. Alfred Fernandes.

The following representatives of the Department of Defense, who also attended the meetings, responded to many queries from the Committee members:

Army.—Acting Assistant Secretary (R&D) Charles L. Poor, Brig. Gen. James A. Hebbeler, Dr. Van M. Sim, and Mr. R. K. Webster.

Navy.—Assistant Secretary (R&D) Robert A. Frosch and Dr. William P. Raney.

Messrs. W. C. Jennings of the Department of Transportation and T. P. McCormack of the Federal Aviation Administration responded to questions about railroad transportation and about flight patterns and regulations at the Denver airport. Officials representing other agencies of the federal government also were present.

The committee appreciates the cooperative attitude of all these individuals and the wealth of technical and other factual information that they provided.

CONCLUSIONS AND RECOMMENDATIONS

We are very much aware that continuing inaction will not reduce the hazards of eventual disposal of the chemicals and munitions intended for disposal in the 1969 Operation CHASE, and in some instances will increase them.

Furthermore we are aware that many activities of the federal government unavoidably involve some hazards to the personnel involved and also to private "bystanders". In this respect, government activities resemble those of private manufacturing and transportation organizations. We believe, however, that the government should set an example to private organizations and individuals of minimizing risks to humans and damage to the environment, even though this may complicate and make more costly its own operations. Therefore we recommend that Operation CHASE as originally conceived be modified as follows. Five types of materials are included in the plan:

I. AF M34 bomblet clusters containing GB, a "nerve gas."
II. Bulk containers of Mustard.
III. M55 rockets containing GB in concrete "coffins."
IV. Contaminated and water-filled bulk containers.
V. Drums containing cans of CS agent in concrete.

We recommend that disposal of these materials should be as follows:

I. A total of 21,108 M34 clusters, each containing 76 bomblets, each of which is loaded with 2.6 lb of GB (volatile liquid "nerve gas"), 0.55 lb of tetryl burster charge, and fuze, are stored now at Rocky Mountain Arsenal (RMA), the site of their manufacture some sixteen years ago.

Discussion: We consider the Army's plans for minimizing the hazards of possible GB leakage during railroad transportation, including prevention of accidents and provisions for treatment of injured people, to be well developed. However, we cannot exclude the remote possibility of a catastrophic explosion in connection with transportation of large numbers of M34 clusters. Conceivably a sniper's high-velocity bullet could initiate a burster charge, and tests have shown that this induces sympathetic detonation of several adjacent bomblets; or, the collision of a gasoline truck with the train on a grade crossing could start a fire that could detonate the contents of many clusters. Other possible hazards associated with rail transport could also release large amounts of GB from M34 clusters. This could cause casualties far beyond the capacity of the attendant medical staff to handle.

Moreover, the Navy's plans for loading and towing the CHASE ship to the disposal grounds and sinking it there cannot preclude the remote possibility of a collision at sea or some other major accident that could conceivably result in the release of large quantities of GB.

There is some possibility of a large detonation of M34 clusters upon sinking of the ship in the ocean. As already noted, limited sympathetic detonation in a cluster has been observed in a test in air. The better impedance match of water invites a massive sympathetic detonation should a bomblet detonate. We consider that this is a probable event upon the impact of the ship's hulk on ocean bottom (7,200 ft deep), which it reaches at a speed that has been estimated from 10 to 100 ft/sec. While the consequences are impossible to predict precisely, lethal contamination of several cubic miles of the ocean (spread near the bottom downstream from the

dump in a layer covering many square miles) for a period of many days likely, on the basis of calculations involving the rates of hydrolysis (and thus of detoxification) of GB, its convective diffusion, and expected (very slow) sea currents. With no massive detonation, GB would be gradually released upon progressive corrosion of its thin-walled steel containers. Calculations such as those above suggest contamination of a small fraction (0.1 to 0.01) of a cubic mile of sea water as a bottom layer near the dump, lasting a few to many months, depending on the corrosion rate. In either case live fish are likely to be attracted into the contaminated layer by dead animals. The effects of these events on the oceanic ecosphere cannot be estimated but could be very serious. We are not fully convinced that a massive detonation upon the upending of the sinking hulk while still near the surface can be wholly excluded. If this were to happen, of course, the results could hardly be less serious.

We have considered and rejected (as the Army did earlier) various ways of entombing the M34 clusters on dry land. In essence, real disposal would thereby merely be postponed, while the stage would be set for an accident or even a major catastrophe for a future generation of Americans, when the records of such entombing would have been lost and human activities not now thought of would have been undertaken.

The burying of the clusters in a deep cavern, followed by the explosion of a small nuclear device there, could incinerate and detoxify the clusters. However, the hazards involved in various stages of this operation and the time required for its completion make this an undesirable plan.

Over a period of many years, RMA personnel have disposed of more than 2,200 leaky M34 clusters by disassembling them and chemically destroying or salvaging the GB without "lost time" accidents.

Recommendation: We recommend, therefore, that the M34 clusters be disassembled and the withdrawn GB be destroyed chemically either by acid or alkaline hydrolysis. This procedure would result in waste materials without "nerve-gas" properties and not more hazardous than larger volumes of industrial waste that are routinely discharged elsewhere.

On balance, weighing various hazards, we recommend that this disassembly be undertaken at RMA because (i) the hazards arising from transportation by rail will be eliminated; (ii) RMA has an experienced staff that has already disassembled M34 clusters; (iii) RMA has facilities that can be fiarly rapidly expanded for the recommended operation. We consider the addition of waste waters from hydrolysis to the sealed pond on the grounds of RMA not to be an issue since it would be only a small increment of similar waste now in the pond. If this recommendation is adopted, however, we urge the Army to proceed as rapidly as possible with the implementation of the plan, which may take from 18 to 30 months. In the meantime, immediate measures should be taken to protect the stores of M34 clusters from lightning and excessive direct sunlight, and also to distribute them so as to minimize the effects of the unlikely event of an aircraft crashing on the stores.

If, for any reason, the disposal of M34 clusters cannot be carried out at RMA, we recommend that they be moved by rail to the Tooele Army Depot and there disposed of by disassembly and chemical destruction of GB, as above. Tooele is recommended because (i) it offers a shorter haul by rail from RMA through a less-populated area (with the major exception of the passage through a part of Denver); (ii) it is located in a sparsely populated region and has a large land area; (iii) the Army has transported to Tooele other munitions containing "nerve gas" so that, when the time comes for their disposal, the disposal facilities that will have to be constructed at Tooele for M34 clusters would make further railroad transportation unnecessary.

As noted earlier, the probability of a catastrophic railroad accident involving M34 clusters is very low, but not zero. To reduce it further we recommend that, in addition to safety measures already planned by the Army, positive steps be taken to close grade crossings in inhabited areas during the passage from RMA to Tooele of trains loaded with explosive munitions containing "nerve gases."

II. A total of 5,311 one-tone heavy steel containers (like those used commercially for chlorine) filled with Mustard liquid were to be disposed of in Operation CHASE, and are stored at the Rocky Mountain, Anniston, and Edgewood Army establishments. Another 7,332 such containers that were to be disposed of later are at Pine Bluff and Tooele.

Discussion: The transportation of these heavy steel containers by rail should be considered a hazardous operation subject to safety precautions practiced by the Army. However, we consider that such transportation of an almost non-

volatile liquid (Mustard H or HD) would involve virtually no hazards of a catastrophic accident because even a strong fire would not rupture the tanks and boil off the Mustard. Hence the safety and security plans adopted by the Army to deal with accidents resulting in minor leaks and even larger local contamination are adequate. Similarly we can conceive of no likely *catastrophic* accidents occurring during the towing of a CHASE ship to the disposal area.

In the past, various chemical warfare agents have been repeatedly disposed of in the oceans by the United States and other nations (see, for instance, House of Commons Parliamentary Debates, Weekly Hansard, No. 484, 25 March–31 March 1960). We have no information regarding possible deleterious effects of these operations on the ecosphere of the seas.

Most of the one-ton containers of Mustard would probably not rupture upon the bottom impact of the sinking CHASE ship. However, their brass valves (forming an electrochemical couple) would cause moderately rapid corrosion of the steel containers, so that large numbers of cylindrical shapes of solid Mustard weighing about a ton each would eventually be exposed to sea water on the bottom. Considering the very slow rate of solution of solid Mustard in sea water at 3.5°C, the rate of its hydrolysis (and hence detoxification), and the effects of dissolved Mustard on fresh-water fish, we believe that the ocean volume made lethal to fish would in all probability be extremely small, although some pollution would continue for years. We are concerned, however, about the effects of Mustard on the germ cells of fish and on unicellular and larval organisms, concerning which no quantitative data were available. Thus the effects of these large masses of Mustard on the oceanic ecosphere are not predictable.

Mustard is readily combustible and, in the past, about 3,000 tons of it have been destroyed by burning in a special furnace at the RMA. Some of the products of combustion are air pollutants of the same type as those released in some industrial and electric-power-generating activities, namely hydrogen chloride and sulfur dioxide, and none have properties of chemical warfare agents.

Recommendation: We recommend that the Mustard scheduled for disposal in CHASE (and about 6,600 tons more in the 7,332 containers still to be disposed of, as mentioned previously) be burned in government establishments where storage is safe and *local* air pollution from the resulting SO_2 and HCl is not a serious problem. This procedure was successfully followed at RMA in an incinerator having a heat dissipation capacity of about 17 $(10)^6$ Btu/hr. The products of combustion were dispersed into the air from a 200-ft chimney. Should maximum ground-level concentrations of pollutants prove to be excessive, a simple liquid scrubber should be added to the existing facilities and the effluent sent to the sealed lake. If for compelling reasons the disposal is at a site other than RMA, similar facilities are suggested, with thought being given, during design, to long-term use to incinerate other materials.

III. A total of 418 "coffins" containing M55 rockets are now at the Anniston (Alabama) and Blue Grass (Kentucky) Army establishments. The rockets are distributed evenly in solid blocks of concrete cast into heavy steel boxes with welded lids. Each such "coffin" weighs about 6.4 tons and contains 30 rockets. Each rocket contains 10.8 lb of GB liquid "nerve gas" and about 2.6 lb of Composition B burster charge, as well as rocket propellant and fuze. In previous CHASE operations during 1967 and 1968, 1,706 such "coffins" have been sunk in one location east of NAD Earle at a depth of 7,200 feet.

Discussion: The transportation of the "coffins" by rail should be treated as a hazardous operation, but we conclude that the probability of a catastrophic accident is essentially nil because (i) the "coffins" should survive the wreck of a slowly moving train (35 mph or less, according to Army plans); (ii) a fire would take a long time to heat the large concrete mass of a "coffin" to a temperature high enough to cause rocket explosion; (iii) a sniper's bullet could not penetrate to a rocket to cause explosion; and (iv) sympathetic propagation of the explosion of any one rocket is not likely.

As in the case of the one-ton Mustard containers, the probability of a catastrophic accident during the towing of a CHASE ship loaded with the "coffins" is vanishingly small.

We expect that most, if not all, of these "coffins" would survive intact throughout the sinking of the hulk. Upon the corrosion of the steel containers, sea water will penetrate concrete and corrode the thin aluminum bodies of the rockets, thus allowing GB to diffuse slowly to the outside. Some hydrolysis of GB will take place within the pores of concrete. Where alkaline pH due to concrete prevails, the products of hydrolysis will be polymeric. These and the gelatinous aluminum hydroxide of the corroded rocket bodies may seal the pores in concrete, slowing down diffu-

sion of GB. Hence the time interval after which "coffins" cease to be toxic cannot be estimated. The GB that escapes will be hydrolyzed gradually by sea water. The resulting toxicity of the sea should be highly localized.

The Army considers the demilitarization of M55 rockets now encased in concrete to be impractical.

Burying of the "coffins" on land or in lakes is inadvisable in our view, as well as in the Army's because they would probably retain their toxic contents long after the records of their disposition have been lost. The possibility of a serious (or even massive) accident involving human lives in some more or less distant future is thus not excluded.

Recommendation: We recommend that the Army convene a group of technically qualified individuals, including demolition experts (which we are not), to consider whether a practically feasible way could be devised to dispose of the "coffins" on an Army establishment. This method should be safe to neighboring population and positive in the sense that toxic and explosive contents of the "coffins" would be destroyed within a predictable time. As a group, however, we are unable to formulate a definite proposal that satisfies these conditions.

If the proposed study does not produce such a method (and assuming that what is now being recommended is consistent with the international obligations of the United States of America, a matter which we as a group cannot assess), we recommend that the 418 "coffins" be transported by rail (choosing routes minimizing proximity of population) to NAD Earle and, through Operation CHASE, sunk in the same disposal area (centered at 39°38′N, 71°0′W) where the other 1,706 "coffins" have already been dumped. The choice of this location is based on reasoning that the concrete blocks will remain on the bottom for a very long time after the loss of toxic ingredients, and it is preferable that all of them be in one location when, in some more or less distant future, technological operations at the depths involved (7,000 ft) will be common and the records of CHASE operations may have been lost. To accelerate the conversion of the additional "coffins" into inert blocks of concrete, we recommend brazing to each of the outer steel boxes several pieces of copper to form electrochemical couples for accelerated corrosion.

If it is decided not to use NAD Earle for Operation CHASE, we recommend reconsideration of the use of the Naval Weapons Station-Charleston, Charleston, South Carolina, since, if these recommendations are carried out, only one CHASE ship would be required, and the local personnel and facilities at Charleston may be found to be adequate for its safe loading and towing to sea. The use of Charleston would entail a less serious rail-transportation problem and the ship could be sunk in the dump area (29°20′N, 76°0′W) already designated on charts as used for "explosives, chemicals, and munitions," which is in a very deep ocean (about 15,000 ft) where disposal might be less undesirable.

IV. At Edgewood Arsenal (Maryland) are stored 2,325 one-ton steel containers that, at one time, contained some unknown contaminant, and have since been emptied and filled with water.

Discussion: These water-filled containers present relatively minor railroad and other transportation hazards, since such hazardous materials as GB and Mustard would already have been hydrolyzed for a long time by water-filling. On immersion in sea water, these containers should be corroded moderately rapidly because of their brass valves. Their leaking contents will serve as only a very minor local contaminant.

We have been informed that these containers be disposed of through commercial channels because the chemical nature of their contamination is unknown.

Recommendation: We recommend that, to ensure only insignificant content of toxic containers, these containers be drained and refilled with water at the Edgewood Arsenal, a procedure, we were told, that presents no serious problems. Thereupon, if they still cannot be disposed of through commercial channels, we recommend disposing of them through Operation CHASE.

V. Also located at Edgewood Arsenal are 86 drums of 55-gallon capacity filled with cast concrete in each of which has been embedded canisters containing 80 lb of a mixture of a solid riot-control agent CS and some pyrotechnic composition.

Discussion: We were informed that safe disposal of the contents of these drums at the Arsenal presents serious problems.

The rail transportation and ship towing of this material present no serious hazards, since explosive hazards are virtually nil and the agent is non-lethal. The thin-walled drums will be fairly rapidly corroded upon sinking to sea bottom. The CS agent is rapidly hydrolyzed by sea water and, therefore, whether or not the concrete blocks survive the bottom impact, contamination of the sea will be minor and transient.

Recommendation: Unless a procedure similar to the demolition procedure first recommended in Section III is developed, we recommend including in the same Operation CHASE procedure recommended as second choice in Section III the small additional tonnage here involved.

While the following comments are outside the terms of reference of the Committee, we wish to suggest to the Department of Defense that it adopt basically the same approach to chemical warfare agents and munitions that the Atomic Energy Commission has adopted toward radioactive waste products from nuclear reactors. It should be assumed that all such agents and munitions will require eventual disposal and that dumping at sea should be avoided. Therefore, a systematic study of optimal methods of disposal on appropriate military installations, involving no hazards to the general population and no pollution of the environment, should be undertaken. Appropriately large disposal facilities should be regarded as a required counterpart to existing stocks and planned manufacturing operations. As the first step in this direction, we suggest the construction of facilities for gradual demilitarization and detoxification of remaining M55 rockets.

AD HOC ADVISORY COMMITTEE

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Martin A. Paul, Staff Director.

DUKE UNIVERSITY,
Durham N.C., July 24, 1969.

MR. C. L. POOR,
Acting Assistant Secretary of Army (Research and Development), Office of the Assistant Secretary of the Army, Washington, D.C.

DEAR MR. POOR: I am enclosing herewith the report of the Group of Technically Qualified Individuals (hereinafter referred to as the Committee) appointed by you to investigate the disposal hazard of certain chemical munitions as recommended by the Ad Hoc Advisory Committee of the National Academy of Sciences appointed to review Army plans fordisposal of chemical agents and munitions.

Our Committee convened 8, **9,** and 10 July 1969. After intensive briefing by explosives and demolition experts from the Army and Navy and extensive discussion, the Committee reached unanimous agreement that the safest and most practical method of disposal of the concrete encased rockets was through incineration in an underground nuclear explosion. Such a procedure completely fulfills the recommendations set forth by the N.A.S. Committee and gives a definitive answer to the problem of disposal.

Sincerely yours,

PAUL GROSS,
Chairman, Professor of Chemistry Emeritus.

Report of the AD Hoc Committee To Investigate Disposal Hazards of Certain Chemical Munitions

Mission.—In accordance with a recommendation of an Ad Hoc Advisory Committee of the National Academy of Sciences, Mr. Charles L. Poor, Acting Assistant Secretary of the Army (Research and Development), by letter dated 3 July 1969 appointed a Committee which was convened on 8 July 1969. The mission of this Committee was to consider whether a practically feasible method could be devised to dispose of the M55 Rockets, with GB warheads, now encased in concrete "vaults" or "coffins" on an Army (or other Government) establishment. The method selected should be safe to neighboring population and positive in the sense that the toxic and explosive contents of the vaults would be destroyed as rapidly and safely as possible.

Briefing.—The Committee met over 8, 9, 10 July 1969 during which time a series of very informative briefings was presented by Army and Navy explosive and explosive ordnance disposal personnel; Appendix A comprises a list of those individuals who made presentations.

Description of Item.—Each vault consists of a ¼ inch steel plate receptacle approximately eight feet long, four feet wide, and three feet high containing 30 M55 area toxic rockets embedded in concrete; a cover of ¼ inch steel is welded in place as a top. The total weight amounts to 6.4 tons. The rockets are in a ready-to-fire condition (i.e., fuzed with booster and propellant attached). The vaults were constructed by applying about 2 inches of concrete to the bottom of the steel open-top box. Six M55 rockets with their individual fiberglass shipping and firing tubes were laid on the wet concrete. More concrete was added such that about 2 inches was on top of these rockets. The process was repeated until 5 layers of rockets were encased in the concrete with about 2 inches covering the top layer of rockets. The concrete was allowed to cure for a minimum of seven days; the ¼ inch steel lid was then welded on to seal the vaults. The orientation of the launching tubes containing the rockets and their exact location from the sides and ends of the vaults is not known. There are 418 of these vaults remaining—305 at the Anniston Army Depot in Alabama and 113 at the Blue Grass Army Depot in Kentucky. These vaults are between 12 and 18 months old and are presently stored outside in rows and layers in contact with each other. During 1967 and 1968, 1706 identical vaults were sunk in the Atlantic Ocean east of the Naval Ammunition Depot, Earle, New Jersey, at a depth of 7,200 feet.

Hazards Associated With the Vaults in the Present Condition.—Encasement of the 30 rockets in a single concrete vault coupled with the time delay in their disposal has created a potential hazard entirely out of proportion to that of the individual rockets as prepared. It is recognized that there were serious safety problems which led to the rockets' encasement in concerete and that the long time delay in their disposal was not envisioned. A potential hazard from a single rocket explosion may have been substantially increased by its encasement in the vault; the confinement could lead to a high order explosion. Indeed there is no positive assurance that further hazard could not result from the possible sympathetic detonation of adjacent rockets thus involving about 630 pounds of explosive (including the rocket motor) and 324 pounds of nerve agent GB. In the event of an entire vault's detonating, a minimum of 200 pounds of agent would be released, approximately 40 percent being consumed in the initial explosion. This would create an intolerable downwind hazard to the population in the area. Beyond this, there seems to be no evidence that a group of vaults in contact with each other could not be involved in a sympathetic explosive interaction. The consensus from evidence known of the storage life of these explosives and propellants under normal conditions is that the risk of accidental detonation of a single vault is currently very small. However, the risks may be either increasing or decreasing with time due to deterioration of the explosives and propellants or the infiltration of alien materials. These may include impurities known to be present in the original GB agent as well as the corroding materials arising from its decomposition. In the absence of precise information, it is necessary to assume that the hazard may be increasing slowly with time for it is known that the GB agent has already started leaking out of many of these warheads. To minimize the possible hazards, the following steps appear prudent:

(*a*) Immediately separate the vaults by at least three feet while in storage.

(*b*) Coat the exposed vaults with reflective paint.

(*c*) If these vaults are to be transported, a safe separation should be maintained between them in transit.

In view of the uncertainty of the safety associated with the vaults and the potentially increasing hazards which may result from continued storage, it is the

consensus of the group that the disposal of all 418 vaults must be completed no later than 1 August 1970. We are in essential agreement with the National Academy of Sciences Ad Hoc Committee that these vaults are safe to transport at least through 1 August 1970 in the sense that the probability of a serious mishap during carefully supervised transportation appears to be very small indeed.

Discussion.—During the briefings, a number of possible disposal methods for the vaults were presented and others were generated in the Executive Session. A listing of some of these procedures is presented in Appendix B. Although at least four methods appear to be technically feasible, the time necessary to devise definitive techniques and conduct experiments in the light of the above-described hazard to verify these procedures is considered excessive. Further, elaborate facilities might well be required in which to perform these operations. These facilities would have to contain both the effect of the 630-pound explosion and the agent released as a result of that explosion without endangering neighboring populations and personnel engaged in the disposal operations. With an all-out effort, it is estimated that in some cases approximately two years would be required to design and build such facilities and to develop the necessary procedures.

From a time-lapse vs. increasing potential hazard viewpoint of the various methods of disposal considered by this Committee, there appear to be only two practical procedures which will minimize possible extra hazard to man. The first method, and the one the Committee urges be vigorously pursued, involves the use of an underground detonation of a nuclear device to destroy completely all the vaults in a single explosion. The size of the nuclear device required would be relatively small. Disposal by this means could be incorporated in an on-going or scheduled test program. The results would be completely predictable with all the agent and explosive destroyed. No additional hazard will result from the inclusion of this material in the underground nuclear shot. If this procedure is not adopted as the Committee vigorously recommends, a less desirable method within the acceptable time frame is to sea dump these vaults in deeper water (15,000) feet than has been used heretofore if possible. If further sea dumpting of vaults is found to be inconsistent with the international obligations of the United States of America, a matter which we as a group cannot assess, it would be necessary to undertake a full, all-out investigation to demonstrate the feasibility of other methods listed in Appendix B.

Conclusion.—Because of the uncertainty of the safety associated with the vaults and the potentially increasing hazards which may result from continued storage, the disposal of all 418 vaults must be completed no later than 1 August 1970.

RECOMMENDATIONS

1. To minimize the possible hazards:
   (*a*) Immediately separate the vaults by at least three feet while in storage.
   (*b*) Coat the exposed vaults with a reflective paint.
   (*c*) If these vaults are to be transported, to maintain a safe separation between them in transit.
2. Dispose of all 418 vaults by 1 August 1970 by:
   (*a*) Use of a nuclear device to completely destroy them in one explosion.
   (*b*) If the above cannot be accomplished, to sea dump them in as deep water as possible.
3. Although it is outside the scope of this Committee's objectives, the following general recommendations are also submitted:
   (*a*) Munitions should not be encased in concrete because of the difficulty of disposing of them when obsolete.
   (*b*) The Army immediately undertake the design and construction of an adequate, safe disposal facility which will accommodate all chemical munitions. (Full consideration should be given to surplus ICBM launch facilities.)
   (*c*) Pending establishment of such a facility, stocks of obsolete or unserviceable chemical munitions be stored in adequate and safe locations or be disposed of in appropriate facilities.
   (*d*) Future munition designs should take into account the possible need for large scale disposal and, to the extent possible, incorporate features which will minimize the hazards associated with munition disassembly and agent disposal.

Appendix A—List of Presenters

Mr. Andrew W. Anderson, Process Engineer,
Weapons Development and Engineering Laboratory,
U.S. Army Edgewood Arsenal, Maryland.
Major R. L. Briggs, Army Chemical Liaison Officer,
Naval Explosive Ordnance Disposal Facility,
Indian Head, Maryland.
Lt. Howard Cartwright, Explosive Ordnance Officer,
Research and Development Department,
Naval Explosive Ordnance Disposal Facility,
Indian Head, Maryland.
Mr. Frank Crist, Chief, Ammunition Equipment Office,
Tooele Army Depot, Utah.
Dr. J. P. Picard, Chief, Propellant and Explosive Laboratory,
Feltman Research Laboratory,
U.S. Army Picatinny Arsenal, New Jersey.

Appendix B—Alternate Disposal Methods Explored by the Committee

(*a*) Using an underground detonation of a nuclear device, completely destroy all vaults in a single explosion. The results are predictable and complete. This will require an underground cavity of at least 1,600 cubic yards to contain the vaults.

(*b*) Sea dump the vaults in the "as is" condition, but explore encasing each vault with or without the top lid removed in an outer shell with sufficient void between the inner and outer casings to contain enough decontaminating solution to neutralize the GB in the vault. The material of the outer shell should be such that it would maintain its integrity for long periods of sea water exposure.

(*c*) Immersing the vaults in a solution, such as 28 percent HCl, disintegrate the concrete and expose the entire rocket to the solution which would dissolve the aluminum warhead skin and hydrolyze the GB agent. Controlled tests would be required to determine the effects of the selected solution on the various explosives involved. Also total dwell time would have to be determined. The overall feasibility of this procedure should be investigated to see whether the time required is adequate.

(*d*) Using appropriate facilities, the vault is suspended on end in a pool of solution, such as 28 percent HCl, to disintegrate about 4 to 7 inches of concrete thus exposing one end of the rocket launchers. Those rockets oriented such that the warhead end is exposed would be removed one at a time, the agent extracted and chemically neutralized in a caustic solution. If necessary, the vault would be reversed and the other end treated so that rockets with warheads oriented in that direction could be removed. The metal parts exposed to GB contamination would then be soaked in caustic and burned. The explosives would be handled by standard procedures. The rocketless vaults would also be caustic-soaked to neutralize any GB contamination and then disposed of. This procedure was denied top priority because it was reported that rockets have been found where the agent has escaped into the launching tubes and has run out onto the workmen who were engaged in disassembling the munition.

(*e*) In a suitable facility with provision for remote control, the vaults are oriented so that six rockets are in a vertical plane with the long axis of the rockets horizontal so that 10 holes can be bored with a commercially available diamond core drill such that each rocket is pierced in two places. At the warhead, the penetrations would be approximately midway between the fuze and igniter and, at the motor, midway between the igniter and nozzle. Such hole locations would insure penetration of each warhead regardless of orientation and attitude within the vault. This operation would be carried out by remote control under an agent decontaminating solution which would also be used as the drill coolant. The possibility of an explosion does exist since the drill would pass through both the explosive and propellant. Therefore a situation of potential danger would always be present.

(*f*) Utilizing ionizing radiation, effect the decomposition of the GB agent and dispose of the vault by above ground detonation or sea-burial. Since the hazard would be limited to the explosive alone, the rate and amount of energy required to perform this operation is unknown and a question would remain as to completeness of agent decomposition.

(*g*) Incinerate the entire vault. The GB agent will decompose at 800° F with one second dwell time; however, the propellant will probably "cook off" at a substantially lower temperature thus maintaining a condition of potential danger.

(*h*) Mechanically expose the ends of the rockets by boring into the vault with diamond drills. A possibility exists that the fuze located in the warhead may be penetrated. This fuze contains lead azide and styphnate. These materials being friction and heat sensitive could detonate thereby activating the entire rocket explosive train and possibly detonating the entire vault.

(*i*) Utilize a diamond edge saw blade to cut through the concrete vault attempting not to touch the detonator or composition B explosive in the warhead or the igniter located between the propellant and the warhead. Since the exact location of the rockets is unknown, the possibility of hitting the igniter is deemed to be an unacceptable risk.

(*j*) Utilize a high pressure water jet (300 gpm at 4–5000 psi) to broach the concrete. It is anticipated that a five to twelve inch wide cut could be made. The hazard associated with the possibility of the jet's hitting the warhead detonator and cutting it open is considered excessive.

(*k*) Utilize shaped charges to penetrate the ends of the vault thereby exposing the rocket ends. The possibility of initiating the detonator, explosive charge or propellant is considered too great.

(*l*) House the vault in a suitable enclosure capable of containing the explosion and immerse the vault in a suitable solution which can chemically neutralize the GB agent. The feasibility of using a surplus ICBM launch facility as a "suitable enclosure" should be explored. Through a suitable mechanism, to provide an atmosphere of ammonia over the decontaminating solution. The vaults would then be explosively detonated with a sufficiently large charge to disintegrate them. It would be necessary to demonstrate the completeness of disintegration of the vault and its contents and decomposition of all agent to make this method acceptable.

(*m*) Several variants of the above-described methods were also proposed, but these are not discussed here because of their similarity in principle.

COMMITTEE MEMBERSHIP

1. Dr. Paul M. Gross—Chairman, Munitions Command Advisory Committee, and Emeritus Professor of Chemistry, Duke University.
2. Dr. Eugene H. Eyster—Division Leader, Los Alamos Scientific Laboratory. Formerly, Chief, Explosives Division, Naval Ordnance Laboratory.
3. Dr. Ralph E. Fadum—Dean, College of Engineering, N.C. State University. Also Special Consultant to Office, Chief of Engineers.
4. Dr. Ralph E. Gibson—Professor of Biomedical Engineering, Johns Hopkins University, and Emeritus Director, Applied Physics Laboratory.
5. Dr. M. King Hubbert—Professor of Geology and Geophysics, Stanford University. Also Former Member Advisory Committee for the Disposal of Atomic Wastes.
6. Dr. V. J. Linnenbom—Superintendent Ocean Science and Engineering Division, Naval Research Laboratory, Formerly Head, Radiochemistry Section.
7. Dr. H. M. Parker—Staff Consultant, Pacific Northwest Laboratories, Battelle Memorial Institute and Director, National Council on Radiation Protection.

Feasibility Study—Lawrence Radiation Laboratory, Nevada Operations Office, U.S. Atomic Energy Commission

Project Harpin

I. INTRODUCTION AND SUMMARY

A. Statement of the Problem

The Army is faced with public and Congressional opposition to the dumping of obsolete chemical munitions into the ocean. Munitions containing a total of about 135,000 pounds of GB liquid "nerve gas" are yet to be disposed of. An alternative proposal under consideration is to decompose the agent and destroy the munitions within the ionizing heat and radiation of an underground nuclear detonation. This alternative is identified as Project HARPIN.

Based upon the recommendations of an ad hoc committee to the National Academy of Sciences, the Army has established August 1, 1970, as the deadline for disposal.

The toxic gas is contained in the warheads of approximately 12,540 M–55 toxic rockets—each rocket also contains a 19-pound propellant charge and

about a two-pound burster charge. These munitions were sealed in concrete-filled steel vaults (approximately 3⅓ feet by 4 feet by 7½ feet) in preparation for sea dumping.

This paper represents the combined judgments of LRL and NVOO regarding:

1. A preliminary hazards evaluation.
2. Engineering and construction feasibility.
3. Time and cost estimates.
4. Impact on the Weapons Test Program.

B. Summary and Conclusions

These obsolete chemical munitions can be reliably destroyed by an underground nuclear explosion. This operation can also be conducted with no undue or unusual onsite and offsite safety hazard if the structural integrity of the steel shipping vaults can be assured through the time of employment hole stemming. Event planning and execution, however, must acknowledge the possibility of gas leakage.

Three different sites have been evaluated for this experiment:

Yucca Flat, NTS
Pahute Mesa, NTS
Other locations within CONUS

The primary difference between the sites is: (1) time; (2) cost; and (3) operational interferences.

C. Recommendations

If the HARPIN concept is accepted as the means of GB disposal, it is recommended that the following additional reviews be performed before the AEC accepts ultimate responsibility for this project. These reviews can be accomplished concurrent with emplacement hole drilling and mining if the overall project time frame must be compressed.

1. A structural analysis be performed on the concrete-filled vaults to investigate their load-bearing ability in a vertical stacking configuration and to investigate the integrity of the gas seal welds on the steel vaults.

2. The stability of the explosives in the burster and propellant charges be verified. If these explosives have deteriorated to the point where handling of the vaults is hazardous, we will recommend against the adoption of HARPIN and suggest that these munitions be disposed of in a manner which minimizes human handling (i.e., sea dumping).

3. Obtain additional information regarding the characteristics, effects and handling of the GB gas, and prepare a final safety evaluation. These reviews will be in addition to the "normal" evaluations of all nuclear detonations.

These additional reviews will be completed in sufficient time to permit a "sea dump" if HARPIN is judged to be unacceptable.

If the project is authorized, it is recommended that it be conducted on Pahute Mesa, NTS. This location will reduce to acceptable levels the mutual interference problems between this project and other NVOO activities, and yet can utilize the existing NTS capability base. It is estimated that about 15 months will be required from project authorization to NVOO through event execution. This schedule is not consistent with the desired August 1970 disposal date.

The following table summarizes the time and cost impacts of four different location options.

[Dollars in thousands]

Location option	Time (weeks)	Estimate
Yucca, NTS—New Hole	51 to 55	3.5 to 4.0.
Yucca, NTS—Existing hole	41 to 45	Do.
Pahute, NTS—New hole	64 to 68	5.0 to 5.5.
Other Conus—New Hole	110 to 120	7.0 to 8.0.

If this project must be completed by August 1970, then an existing emplacement hole must be utilized. The only existing holes suitable for this event are in Yucca Flat. The accomplishment of this project in Yucca Flat will cause an unacceptable amount of interference with other ongoing NTS activities. A possible alternative for meeting the August 1970 date is to transport the vaults to the NTS before August 1970 and store them in a remote location (i.e., Pahute Mesa) until the HARPIN facility can be completed. A short move on the NTS might then be required before disposal.

II. TECHNICAL DESCRIPTION OF VAULTS AND ENCAPSULATED M–55 ROCKETS

The 418 vaults under discussion are constructed from ¼-inch-thick steel plates. The steel was manufactured in accordance with Federal Specification QQ–S–741B. The plates are Grade A–ASTM, designation A7–61T. The dimensions of the vaults are 7½ feet long, 4 feet wide, and 3 feet high. The vaults were assembled by double welding the seams. The weld seams of each vault with the exception of the lid are vacuum tested. This test data is not recorded and the test specification will be furnished at a later date. There are "I" beams (for lifting and stacking purposes) welded on the bottom of each vault. The "I" beams are 4 inches high and have a 4-inch-wide flange.

There are 30 M–55 area toxic rockets encapsulated in each vault. Each rocket is housed in its M–441 shipping and firing container. The rockets are imbedded in concrete in the vaults. The rockets were placed in the vaults in five layers of six rockets per layer. The first layer with the rockets equally spaced was laid on about two inches of concrete slurry placed on the bottom of the vault. Concrete slurry was then poured over the layer of six rockets until the layer was covered with concrete, then the second layer was emplaced. The remaining three layers were emplaced in the same manner. After the last slurry was poured, it was leveled to assure the lid could be fitted to the vault. There is no assurance that the rockets retained their positions in the vault as each layer was covered with slurry as successive layers were placed, or anytime prior to final set of the concrete. The lid was double seam welded on the vault after the concrete cured at least 28 days. There is no endwise orientation of the rockets recorded or known in the vaults. The 418 vaults are packed identically and weigh 6.4 tons each.

Background information relative to the characteristics of the rockets and GB was obtained from documents furnished to NVOO and LRL by the Department of Defense.

III. OPERATIONAL FACTORS

A. Need for a separate event

Project costs could be reduced (by cost sharing with the "host" event) if HARPIN is conducted as an "add-on" to another NTS event. We feel that this is an undesirable situation for the following reasons:

1. Only devices within a narrow yield range can be utilized for HARPIN. The yield must be in excess of 100 KT to assure destruction of the liquid GB (Appendix B contains LRL calculations regarding the required device yield). The upper yield limit is determined by the depth of the water table (1,800 feet in Yucca; 2,000 feet on Pahute). To facilitate mining activities, the HARPIN chamber should be above the water table. Based upon depth of burial, the maximum allowable yield for HARPIN would be 135 KT in Yucca and 185 KT on Pahute.
2. Most NTS events utilize developmental devices with a degree of uncertainty as to expected yield. HARPIN requires a guaranteed yield of at least 100 KT in order to assure, without question, that all of the chemical munitions are destroyed.
3. The NTS event schedule is very tenuous, with the actual event execution dependent upon the progress in the device development program. The actual execution of HARPIN as an add-on would be dependent upon progress in the event device development program.
4. Depending upon the purpose of the primary event, the inclusion of the HARPIN add-on may affect the primary experiment and degrade the value of the event.
5. The inclusion of a HARPIN add-on will cause serious interference problems with the preparations for the primary event. The presence of large amounts of high explosives and other hazardous materials within the Ground Zero complex will cause a severe disruption and delay in the normal event preparation activities.

For the above stated reasons, we feel that HARPIN should be conducted as a separate event.

B. Construction and Support

1. Event configuration

LRL has ascertained that the chemical munitions can be reliably destroyed in the proposed event configuration by a device yield of 100 KT.

The planned event configuration is a 39-foot by 40-foot by 56-foot-high chamber located at about the 1,600-foot level of a 72-inch-diameter cased vertical shaft. The shaft diameter is determined by the size of the vaults. The chamber dimensions are determined by the total volume of all vaults and a trade-off between: (1) a spherical chamber for the efficient utilization of the nuclear device; and (2) a

reasonably simple to construct and stable chamber and vault configuration. The chamber depth is determined by: (1) the locations of acceptable mining media; and (2) a depth of sufficient size to contain the nuclear detonation. Appendix A to this paper includes a sketch of the proposed downhole configuration.

A second 36-inch cased shaft is proposed to serve primarily as an emergency escape route and as a backup ventilation shaft. A cross drift will connect the 36-inch shaft to the main chamber.

In addition to normal utilities, the HARPIN facility may include: (1) downhole caustic showers for decontamination purposes; (2) an alcove in the cross drift for a "resident" medical team. A downhole monitoring system to detect gas leakage and a surface decontamination facility will also be required.

Some specialized equipment needed to handle the steel vaults must either be purchased or fabricated. Appendix A to this paper contains a more detailed construction plan.

Once the vaults are emplaced, the cross drift and the 36-inch access shaft will be stemmed. Following the removal of the surface mining equipment, the nuclear device will be emplaced in the normal manner, and the 72-inch shaft will be stemmed. No abnormal precautions appear to be necessary for event execution. Post shot drill back is not currently planned.

2. Evaluation of alternate sites

This project can be conducted at any one of three generalized locations:

(*a*) Pahute Mesa, NTS
(*b*) Yucca Flat, NTS
(*c*) Other CONUS locations.

Each of the three locations are discussed below:

a. Yucca Flat, NTS.—Yucca Flat is a broad alluvial valley with known chamberable media at depths in excess of 1,600 feet. The water table is located at about 1,800 feet, so the potential mining depths are water free. There are two existing 72-inch cased holes in Yucca Flat which can be used for this project, if necessary. The existing NTS construction and support capability base can be used for this project.

A significant operational interference problem will result if HARPIN is conducted in Yucca Flat. The two existing holes are located less than ½ mile from the Rainier Mesa Road in Area 2, a heavily traveled, major access route on Yucca Flat paralleled by primary power transmission lines. The holes are also located ¾ mile and 2 miles away, respectively, from the Area 2 contractor corporation yard. This yard is the work site and reporting location for 300 to 400 personnel daily.

The adjacent area (3 to 5 miles radius) is also the area where LRL conducts essentially all of its low to intermediate yield events on a continuing basis.

Depending on the final hazards evaluation of the HARPIN operations, a considerable area and immobile facilities could be denied the LRL test programs for a significant period of time. In addition, the Area 2 locations are subject to periodic ground shock which could be detrimental to the continued integrity of the downhole chamber.

b. Pahute Mesa (assume north end of Area 19).—Pahute Mesa is the location of medium to large underground nuclear tests. Dry chamberable geologic formations can be found down to depths of about 2,000 feet. The existing NTS construction and support capability can be used if this project is conducted at Pahute Mesa. A suitable hole for this project does not currently exist at Pahute Mesa.

Operations would be much more remote from existing facilities. The frequency of nuclear events is less in this area, although individual events are of higher yield. Separation from other sites is greater and the ground shock problem is usually decreased, although the more complex geology of Pahute Mesa makes shock prediction more difficult. The Pahute Mesa location would have a lesser impact on the weapons test program. The remote location will allow for onsite storage of large numbers of vaults prior to emplacement.

c. Other CONUS Locations.—A summary review of other possible HARPIN sites off the NTS but within the continental U.S. has been conducted. These sites were evaluated on the following criteria:

(1) Site suitable for a 100 KT underground detonation.
(2) Dry competent media for mining in the range of 1,500 feet to 2,000 feet deep.
(3) An adequate operational and logistics base for supporting this project.

The only known area which meets the above criteria is on the NTS. The Central Nevada STS meets item (1), but has a severe groundwater problem and would

require an increase in its base capability. Most of the areas which NVOO has evaluated for supplemental sites have high water tables. Little is known about the subsurface geology in those areas with apparently dry formations.

If HARPIN is to be conducted off the NTS, then a site selection program, including the drilling of exploratory holes, must be accomplished before work on the emplacement holes begin. A preliminary effects evaluation (including groundwater movement, seismic, offsite damage predictions, fallout, bienvironmental, etc.) must also be prepared before an offsite location can be confined. This effort will add at least six months and $500 K to the HARPIN project.

In addition to the hydrologic/geologic problems, none of the off-NTS sites have an adequate existing construction, logistical and M&O capability to support this project.

d. Summary of Sites.—Based solely upon operational interference considerations, and minimizing the potential hazards to onsite personnel, it is strongly recommended that HARPIN not be conducted in Yucca Flat.

Based upon operational, safety, time and cost considerations, it is recommended that HARPIN be considered for execution on Pahute Mesa rather than an off-NTS location.

C. Equipment

The availability of specialized and reliable equipment is necessary for the safe conduct of this project. Specialized equipment must be developed to remove the vaults from their shipping conveyance (presumably on a truck trailer in a horizontal position), raise to a vertical position for inspection, and transfer to the downhole hoists. Equipment must be developed to assist in the downhole handling of the vaults.

The downhole hoist and associated equipment must approach 100% reliability since any downhole accident with the vaults could have catastrophic results.

Certain equipment associated with the safe handling of the toxic munition (i.e., gas monitoring systems, protective clothing, decontamination equipment, etc.) should be made available by the Army for possible AEC use.

D. Hazards and Safety Evaluation

1. Description of hazards

The hazards analysis investigated four general areas of concern: (1) the material involved; (2) the mechanics of the firing and fusing system; (3) surface operations necessary for emplacement; and (4) downhole operations necessary for final emplacement. Most of the hazards analysis of the materials was completed by the High Explosives Chemistry Section at LRL. It should also be pointed out that this analysis is less thorough than normally desired because of the lack of samples of the actual material, late arrival of reports concerning the propellant, as well as the fact that the chemists have not discussed problems associated with aging and decomposition with knowledgeable personnel at Hercules-Radford on the double base propellants. Items considered in some detail were the Composition B used in the burster charge, the propellant contained in the rocket, the chemical agent GB, as well as the squibs and fuse components and igniter contained in the warhead. The item of most concern is the 19-plus pounds of propellant contained in each rocket. Particular concern in this area is due to the lack of available samples of the propellant at the time of assembling these rockets, the lack of detailed information on the decomposition behavior, and the unknown effects on the decomposition as a result of the rockets being placed inside the vaults and then being subjected to the heat of hydration of concrete followed by exposure to the sun for approximately a year.

Assuming that further calculations and discussions with the Hercules-Radford personnel do not indicate decomposition characteristics of the double base propellant that would significantly increase its sensitivity, it would appear that the vaults can be handled safely consistent with the engineering plan. Even though the lids were welded on initially, we would recommend that no further heat sources such as welding be applied to the vaults and that they not be subjected to any avoidable drops. The review indicated that the Composition B, squibs, or igniter should not represent a significant hazard during emplacement operations.

In evaluating the hazards associated with handling the chemical agent GB, it is felt that the vaults can be handled in a safe manner consistent with the engineering plan, assuming that the instruments used for detection are sensitive enough to provide adequate warning of a slow leaker in the hole. It would appear that the mechanisms of release for the GB are somewhat limited to either a slow leak from one or more of the vaults or a gross release as a result of an explosion of one

or more of the rockets. An explosion of one of the rockets will undoubtedly result in serious or fatal injury to those personnel at the bottom of the hole. With adequate warning of a slow leak, it is felt egress from the hole can be accomplished prior to serious injury. Adequate precautions such as necessary protective clothing will have to be a part of the operational safety plan if this proposal is approved.

To summarize this preliminary hazards evaluation, it is felt that the vaults can be emplaced in a safe manner under tight control operationally, assuming that further information does not indicate concern over the state of decomposition of the propellant.

2. Need for additional reviews

Should this technique of disposal still appear desirable after this initial review, it is recommended that the following actions be pursued prior to establishing this technique as the final means of disposal:

a. High Explosive Chemistry personnel from LRL participate in technical discussions with appropriate Hercules-Radford personnel on the double-base propellants and its associated firing and fusing systems.

b. Chemistry and Hazards Control personnel visit and discuss operational experience in connection with the GB detector. This review will include verification that the instrument detects presence of GB, and that it can be calibrated, that it is sensitive to a level below hazardous concentrations and that other operational aspects do not affect its use, especially in the downhole application of this operation. This review might include having one of the instruments sent to LRL for detailed evaluations. The same personnel should also visit the plant where this chemical agent is made, as well as Dugway Proving Ground, to discuss with the knowledgeable technical personnel their handling experience, how they decontaminate personnel or facilities, filtering techniques or scrubbers necessary for the removal of the GB from the atmosphere, their accident experience and their suggestions as to how to minimize potential problems associated with this operation.

c. Test organization personnel should give additional thought and plan possible alternatives if an uncontrolled slow leaker develops in the hole prior to completion of the emplacement operation, i.e., with only two rows of the array completed and only 180 of the vaults in place. What if, for example, the cage would drop in the hole and be brought to a stop by the safety dogs. The cage may then be frozen to the emplacement casing. Would the deceleration "g" loadings arm the warhead?

d. Additional calculations are needed to verify that the weight loading of upper levels of the vaults will not result in structural damage to the vaults in lower rows of the array.

e. Additional thought and effort need to be given to the safety of operations in the following areas:

(1) Receiving, monitoring and storage of material.
(2) Separation distances.
(3) Operational control in the immediate area.
(4) Surface operations.
(5) Downhole operations.
(6) Mechanics of release associated with (4) and (5).
(7) Decontamination.
(8) Monitoring and acceptable limits.
(9) Ventilation/filtering.
(10) Protective equipment/clothing.
(11) Standby medical/first aid support.
(12) Emergency Plan: (*a*) Downhole; (*b*) Surface.

E. AEC/DOD Responsibilities

It is recommended that the following outline the responsibilities of the AEC and of the DOD in the execution of HARPIN:

1. AEC responsibilities

a. Design and construct the HARPIN facilities located at the NTS.

b. Remove vaults from the DOD conveyance at the HARPIN site, and emplace downhole.

c. Onsite safety evaluation and implementation of onsite safety plans (some DOD support, i.e., decontamination team—may be required).

d. Evaluation and implementation of offsite safety plans arising from presence of vaults at the HARPIN site.

e. Design, procure and emplace nuclear device.

f. All safety effort related to nuclear phenomenology, including "normal" nuclear test review procedures (i.e., TEP review, effects evaluation, Panel of Consultants, etc.).

g. Event execution.

h. Miscellaneous and minor support to DOD personnel at the HARPIN site (i.e., feeding, housing, logistics, communications, etc. to same extent as available to AEC personnel).

2. DOD responsibilities

a. Deliver the vaults to the AEC at the HARPIN site on an AEC-designated delivery schedule.

b. Be responsible for safety-related activities until delivery to the HARPIN site.

c. Assist the AEC in the safety evaluation of the vaults.

d. Provide specialized equipment and personnel necessary for the safe handling of the toxic chemicals.

e. Coordinate all onsite movement of vaults with the AEC.

f. Provide the necessary funding to the AEC to cover the incremental costs of the project.

(Part IV, Schedule and Cost, continued on next page.)

The following table summarizes the time and cost estimates for executing Project HARPIN;

IV. SCHEDULE AND COST

[Dollar amounts in thousands]

	Yucca, new hole		Yucca, existing hole		Pahute, new hole		Other CONUS, new hole	
	Time (weeks)	Amount	Time (weeks)	Amount	Time (weeks)	Amount	Time (weeks)	Amount
Planning							4	
Site selection							26	$500
Site preparation	2	$80	2	$80	3	$150	6	200
72-inch emplacement hole	10	800		800	12	1,050	15	1,500
36-inch secondary hole	(5)	345	(5)	345	(7)	610	(9)	800
Mining mobilization	4	150	4	150	5	200	6	250
Mining	17	575	17	575	22	900	25	1,200
Decontamination and change facility	(4)	40	(4)	40	(6)	50	(6)	75
Vault emplacement	8	465	8	465	9	555	12	700
Stem underground	2	40	2	40	2	55	3	70
Demob. and mining equipment	2	50	2	50	2	70	3	100
Device emplacement	2	200	2	200	3	280	4	350
Safety		50		50		50		200
E.G. & G		100		100		100		200
A/E		220		220		320		500
Miscellaneous		300		300		550		800
Lost time/delays	4		4		6		6	
Total	51	3,415	41	3,415	64	4,940	110	7,445

NOTES

Parentheses indicate concurrent activity.

These estimates are preliminary and are based upon the aforementioned concept of project execution. Reasonable amounts of time and cost contingency are included in these estimates. The estimate for the "Other CONUS" location has the lowest level of confidence because of the limited number of organizations which participated in this study.

These estimates assume a 3-shift-per-day, 5-day-per-week schedule for most construction activities (drilling is a 3-shift, 7-day-per-week operation). The above time estimates can be accelerated if a 7-day-per-week construction schedule is adopted with some increase in cost.

These estimates do not include the cost of the nuclear device, which would represent only a small fraction of the total budgetary impact.

Appendix A—Engineering/Construction Plan

I. OBJECTIVE

The engineering/construction objectives of HARPIN are to emplace 418 vaults in a close configuration underground, 1,600 feet below the surface, leaving adequate space for emplacement of a nuclear device in the center of the emplaced mass. The vaults are steel boxes of ¼-inch plate, 3 feet by 4 feet by 7½ feet long with two 4-inch deep "I" beams welded lengthwise on the 4 foot by 7½-foot side. For handling purposes, the vaults are essentially concrete-filled, weighing 6.4 tons (say 13,000 pounds) each. The other contents of the vaults are described in Section II of this paper. There is no indication of endwise orientation of the contents.

The design parameters to attain the objective are to:

A. Develop a mined room at the bottom of a six-foot diameter cased hole.

B. Design a stable stacking configuration to keep the vaults within a 50-foot radius of the nuclear source.

C. Only one nuclear device may be used.

D. Personnel will not go underground after stacking of the vaults is complete for activities associated with device emplacement. Device emplacement will be from the surface using standard LRL downhole emplacement techniques modified with regard to safety considerations.

E. A second access shaft will be required as an emergency escapeway.

F. Welding will not normally be permitted on the coffins.

G. Postshot drill back is not currently planned.

Since a complete hazard evaluation has not been completed, the propopsal must be modified when special handling and safety requirements are defined.

II. METHOD

A. Mining

Several methods of handling/stacking the vaults were investigated and the one with least apparent construction problems meeting design parameters was chosen. It is shown on Attachment B. The underground chamber approaches a right circular cylinder of 42-inch diameter with a domed or conical roof. We believe that this is a stable configuration which can be mined at either Yucca Flat or Pahute Mesa.

We have been advised that mining hoist and headframes of adequate load capacity exist at the Nevada Test Site. Mining would begin by cutting the 72-inch casing at the acceptable depth and developing the roof structure of the room. It is assumed that the ground will be stable and can be supported with rock bolts, wire mesh and spreader plates—a common mining procedure. After the roof is completed, the cross drift to the other shaft will be driven, a shaft station established and the 36-inch casing opened up. At that time, the 36-inch shaft will go into use as a manway as well as an emergency exit, leaving the 72-inch shaft available as a "production" shaft exclusively. Ventilation systems will probably be installed in both shafts consistent with the safety requirement upon mining completion.

The balance of the room will be excavated by top slicing, removing all muck through the 72-inch shaft in a 2½ cubic yard bucket. Access from the cross drift to the main chamber will be by temporary ladder which will be removed as the several levels of vaults are emplaced.

In the event that unforeseen ground conditions exist and the roof is not stable, steel ring beams and column supports must be constructed. This work could add 25% to 30% of time and cost to the mining phase.

When the room is fully mined, a level concrete pad will be built to assume the anticipated floor loading. The six-foot diameter casing will remain in the room; it will be cut with a vertical slot on one side for its full height for access and egress. The casing itself could assume some of the roof support function if necessary. Note that the six-foot casing is offset about two feet from the center of the room to minimize the area not available for stacking components.

B. Vault Emplacement

The method of stacking the vaults is designed to minimize the handling required and to eliminate a requirement to lift the 6.4 ton mass underground. Facilities to fully lift and transport this weight underground would be costly, time consuming in their use and require substantial additional construction. There will be four levels of 92 vaults, plus one level of 50 vaults as shown in Attachments A and B.

Vaults would be outfitted with heavy duty casters on the small end. The casters should have wheels 12-inches in diameter by 3-inches wide to give adequate load distribution. Welding to the vaults is not recommended; therefore, the casters would be affixed with a clamp-on type of frame. The caster frame would also include a fitting to allow latching on an electric motor truck to facilitate handling. The "I" beams presently on the vaults should be left on to facilitate shipping and handling. Normal shipping and handling should keep the vaults in the horizontal position. They should not be set vertically until ready to be loaded for the downhole trip.

The muck bucket used in the six-foot hole will be replaced with a special cage designed to accept and secure one vault at a time in the vertical position for the downhole trip. The cage must be designed with a cross-head and safety dogs to

act on the six-foot diameter casing in the event of a slack or broken cable. Personnel will not ride with the vault.

A dummy vault would be constructed to allow equipment checkout, procedure verification and crew training before emplacement of the real vaults.

Presumably, the vaults will arrive or be stored onsite in the horizontal position. A tipple would be built to allow a vault to be laid in its bed and rotated to the vertical when loaded in the cage.

When a vault arrives downhole, it will be removed from the cage and a temporary outrigger frame with casters (training wheels) attached for increased stability. It will be rolled and pushed to its designated location using a small electric operated motor truck. The outrigger casters will be removed at the latest possible time. Vaults will be blocked in place with timber blocking to minimize later movement when loads of the upper layers are imposed. Blocking of the casters and between the floor and bottom of the vault will prevent or reduce deflections.

As the first level is being completed, a double layer of tongue and groove, 1-inch thick plywood will be laid on the top level. Joints will be staggered and the layers nailed together to form a complete diaphragm. The second level of vaults will be located on this plywood floor. If necessary, the floor will be shimmed with additional plywood to maintain a level surface. The vaults of this level will also be blocked to prevent lateral and vertical movement. It will probably be necessary to use skid plates in offloading from the cage to reduce wear on the plywood floor. These temporary plates can be moved from level to level as required.

The third, fourth and fifth levels are repetitive operations.

At the conclusion of vault emplacement, the cross drift to the 36-inch access shaft will be stemmed followed by stemming of the 36-inch shaft. Subsequently, all mining equipment will be demobilized.

The following engineering details require consideration and further design:

1. The reinforced concrete floor on the bottom of the chamber must be designed for an equivalent uniform floor loading of 5,400 pounds per square foot or 38 pounds per square inch, although this is distributed through the casters on the lowest level.
2. The caster frame assembly and the outrigger "training wheels" clamp-on gadget must be designed.
3. Struts will be required to block the vaults around the six-foot diameter shaft, once they are in final position.
4. When loading and unloading the vaults in the cage, elastic stretch of the hoisting rope will occur. To prevent a tipping situation from occurring, the cage must be outfitted with a positive lock to the headframe and shaft. This is especially important underground when the hoist cable is long.
5. A placement sequence underground should be worked out to minimize handling and jockeying of vaults, especially as a level attains completion.
6. A specific handling procedure and hardware must be designed to allow the vaults to be loaded into the cage at the ground surface.
7. This procedure has evolved with very little specific input as regards safety and hazards control. Changes to ventilation systems, underground personnel limits, safety stations, monitoring functions and operational limitations will be accommodated as these constraints are defined.

C. Device Emplacement and Stemming

It is assumed that operations associated with preparation of the nuclear device may be accomplished within 1,000 feet of the ground zero area. The appropriate device buildings and other appurtenant facilities, including power systems and signal systems, would be readied during the vault-loading period. The device would not be brought out until all vaults are secured underground. The normal LRL device checkout procedure would prevail. Limited diagnostic effort to verify device performance would require a minimum of diagnostic cables and associated equipment.

Emplacement would proceed after the normal system dry runs are completed. Emplacement would be made with a drill rig on a casing string or, if the explosive package is light enough, with a flatwire rope winch. These are standard NTS operating techniques. Standard stemming would follow emplacement completion. At this point, the nuclear explosive would be readied for expenditure consistent with any operational and weather limitations.

Postshot drill back is not planned.

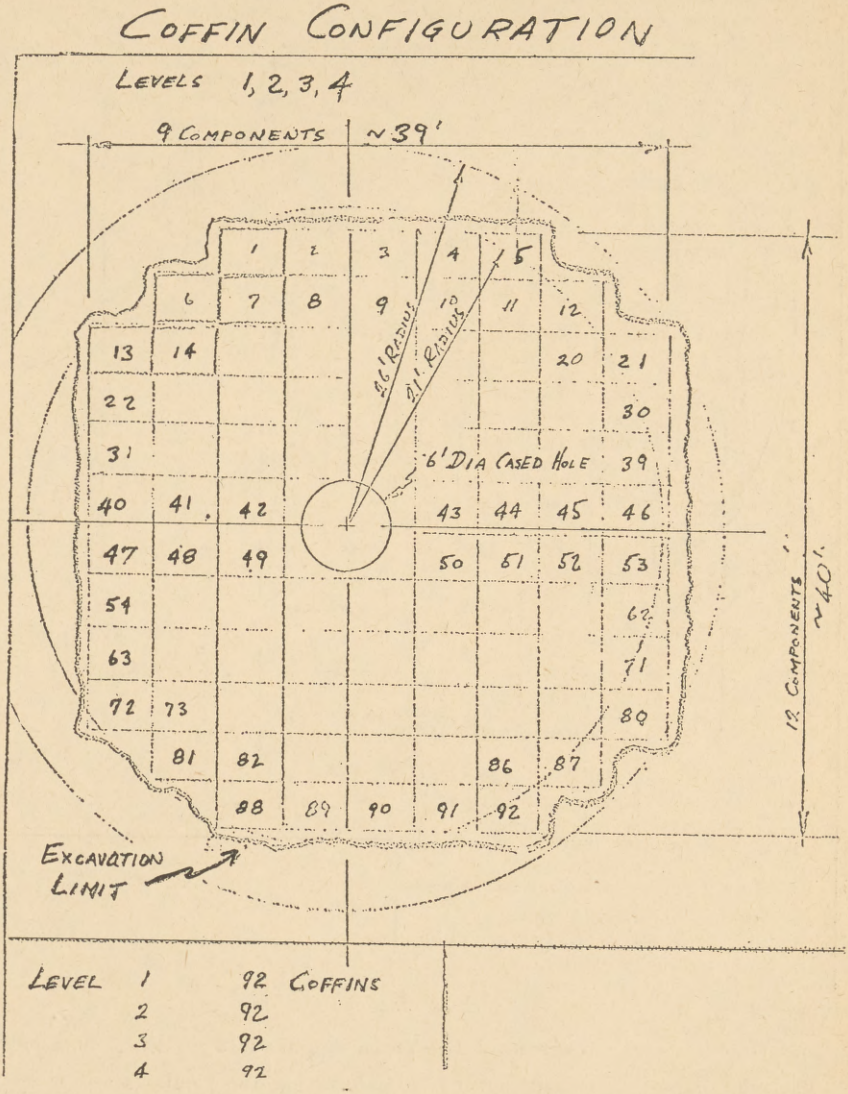

COFFIN CONFIGURATION
LEVELS 1, 2, 3, 4
9 COMPONENTS ~39'
16' RADIUS
21' RADIUS
6' DIA CASED HOLE
12 COMPONENTS ~40'
EXCAVATION LIMIT
LEVEL 1 92 COFFINS
2 92
3 92
4 92

Figure 1

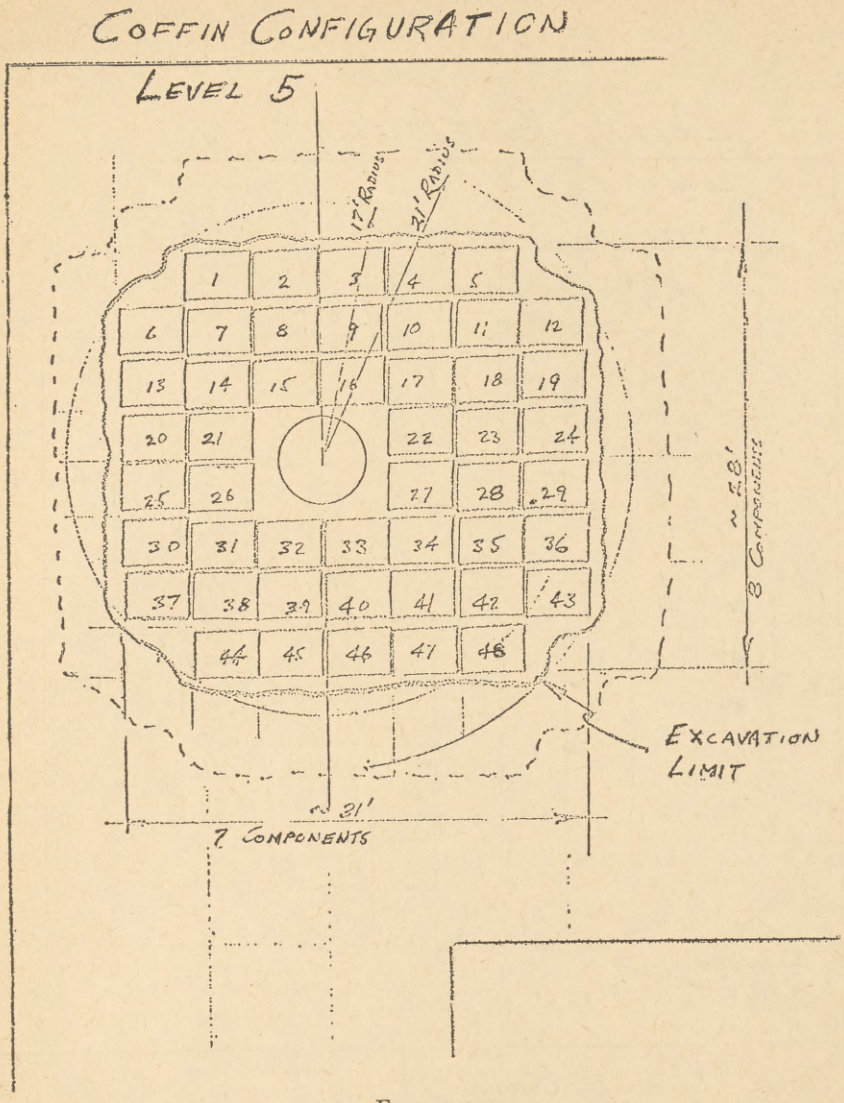


FIGURE 2

APPENDIX B—YIELD FOR HARPIN

The most important consideration is to assure that the yield of the device is large enough so that there will be no uncertainty about the destruction of the material. A detailed calculation of temperatures vs distance which included the attenuation of shock pressure due to the gaps between coffins and the other inhomogeneities in the stacked system would be very difficult. Therefore, we have calculated a simple system and must include a large factor of safety. Figure 1 gives the radius of vaporization and the radius at which material will reach 500°C as a function of yield for explosions in dry tuff. It is expected that the temperatures in a concrete medium would be fairly similar to those in tuff.

In the homogeneous tuff, 40 KT would be required to include the volume of interest (7 meters radius) within the radius of vaporization. Although GB will decompose in less than a minute at 500°C, it is more conservative to require the higher temperatures at the radius of vaporization. Using a radius of 10 meters

or 100 KT should be adequate to account for the inhomogeneities, spacing between blocks and other factors which would tend to reduce the shock pressure and thus the temperature.

U.S. Department of the Interior,
Office of the Secretary,
Washington, D.C., December 2, 1969.

Hon. Stanley R. Resor,
Secretary of the Army,
Washington, D.C.

Dear Mr. Resor: We are enclosing our report reviewing the Army's proposal to dump 418 coffins containing M55 GB rockets in the Atlantic Ocean. We concur with the following recommendations made by our Committee:

1. That the Department of the Interior reaffirm its opposition to the use of the ocean as a dumping ground for toxic materials.
2. That the Department of the Interior accept the dumping of these munitions in the ocean at the designated site as a necessary but undesirable expediency (see report for details).
3. That the ship used for disposal be instrumented to determine:
   (*a*) whether ship explodes and if so, at what depth.
   (*b*) precise location of ship on ocean floor.
4. That position of coffins dumped off New Jersey Coast be precisely charted.
5. That aerial determination of ocean surface temperature be made on both dumping sites on a monthly basis for one year.

Sincerely,

(Sgd) C. F. Layton.

(For Leslie L. Glasgow, *Assistant Secretary for Fish and Wildlife, Parks, and Marine Resources*).

Enclosure:

Second Report of the Department of the Interior—Working Group on Ocean Dumping of Chemical Munitions, November 13, 1969

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

1. We recommend that the Department of the Interior reaffirm its opposition to the use of the oceans as dumping grounds for toxic materials.
2. Because of the present hazards to human safety and to the aquatic and terrestrial environments posed by the remaining 418 coffins containing GB rockets, we recommend that the Department of the Interior accept the dumping of these munitions in the ocean at the marked dumping site centered at 29°20′N, 76°0′W as a necessary but undesirable expediency. Two conditions should be placed on this acceptance. The first condition is that Interior be assured that adequate consideration was given to destruction of the munitions by underground detonation of a nuclear device and that this method of disposal was rejected for valid reasons. The second condition is that Interior obtain assurance from the Army that this will be their last need for ocean disposal of material of such potential toxicity to marine resources.
3. We recommend that the ship used for disposal be instrumented so that explosions can be detected and the depth at which they occur determined.
4. We recommend that the ship used for disposal be instrumented so that its position on the bottom can be precisely located.
5. We recommend that the position of ships used previously for dumping identical coffins off New Jersey be located and precisely charted.
6. We recommend that aerial surveys of surface temperature of the two dumping sites be made on a monthly basis for at least one year to detect possible upwelling. The data from these surveys should be provided routinely to the Fish and Wildlife Service for analysis.

INTRODUCTION

The working group met on November 10, 1969, to consider the Army's proposal to dump obsolete rockets containing GB nerve agent in the Atlantic Ocean. These rockets are encased in concrete and steel "coffins" or vaults and are a part of the chemical munitions considered in our previous report of June 27, 1969. In that report we indicated that the possible damage to marine resources of dumping these "coffins" was considerably less than the damage which might be caused by dumping the M 34 GB cluster bombs, but the extent of this damage could not be accurately assessed. We, and the National Academy Committee, recommended that the Army seek alternate methods for their disposal.

Two major developments were considered at the current meeting of our working group. First, the report (dated July 25, 1969) of an Ad Hoc Committee of Technical Experts called together by the Army to investigate hazards involved in a variety of alternate methods of disposal of the rockets encased in concrete was available for review. Second, the site proposed by the Army for this disposal differs from the one previously considered by our group. In our meeting, we carefully reviewed the report of the Army's Ad Hoc Technical Committee, the information we were able to assemble on the oceanography of the new proposed site, and the information previously available to us on these munitions.

EVALUATIONS

We are still of the opinion that encasing such highly toxic material in concrete and steel and dumping it in the ocean is not a proper method for its disposal. We consider it inimical to human well-being and to the maintenance and enhancement of the marine environment to dump any poisonous materials into the ocean.

However, judging from the report of the Ad Hoc Committee of Technical Experts, the remaining 418 rockets represent an unacceptable hazard where they are now located and must be disposed of as soon as possible. According to the report of that Committee, encasement of the rockets in concrete and steel has created a situation so dangerous that time is of the essence in their disposal. That Committee, after considering a number of possible methods of disposal, recommended only two as feasible within a reasonably safe period. The first and most desirable method is complete destruction of all vaults by underground detonation of a nucelar device. The second and less disirable method is dumping them in the ocean in deep water (15,000 feet or more in depth).

According to the information available to our working group, the first and most desirable of these methods has been rejected. It appears, therefore, considering the present hazards to human safety and to the aquatic and terrestrial environment and the unavailability of alternate methods for disposal that the Department of the Interior has no choice but to accept ocean disposal of these hazardous materials as a ncecessary, though undesirable, expediency.

As scientists, devoted to the wise use, maintenance, and enhancement of the quality of the marine and aquatic environments and their resources, we agree wholeheartedly with the statement in Assistant Secretary Leslie L. Glasgow's memorandum of November 5, 1969, that

"Should Interior concur with this ocean disposal, we should obtain assurance from the Army that this will be the last need for ocean disposal of material of such potential toxicity to marine resources."

There remained then, for the working group to consider two items: The disposal site and the possibility of monitoring adverse effects on marine resources.

Concerning the site, we consulted with several recognized experts in oceanography and assembled and examined the available information. We drew up a balance sheet comparing the advantages and disadvantages of this site over the previously used site and some other site in deeper water. The site selected in our opinion is the least undesirable. It is in deeper water than the site previously used, where, from available information, marine life is sparser. Because of its greater depth, the site is less susceptible to technological use. It is on the seaward side of the Gulf Stream in a less productive area; the bottom currents are small (about 0.5 knot) so that toxic material eventually leaking from the containers should be confined to a rather small area; there is no evidence of upwelling at the site; and, finally, the site is already marked as a disposal area for explosives and chemicals.

We considered in some detail possible methods for monitoring the adverse effects on marine resources of dumping the remaining 418 coffins, as well as the effects from the previous 1706 dumped off New Jersey. We do not consider it practical to carry on a continuous monitoring program to measure the effects of these dumpings. If the coffins reach the bottom intact, there is no way of predicting how long it will take before they deteriorate and release their toxic contents.

We do feel, however, that certain actions and studies are desirable. First, the Navy and the Army should instrument the current CHASE ship to allow determination of whether explosions occur; and if so, at what depth. They should also instrument the ship so that its final position can be determined accurately. It is even more desirable to know the precise position of the previous chemical CHASE ships since they are in depths susceptible to exploration by current technology.

We further consider it desirable to conduct aerial surveys of sea surface temperatures in the two sites at monthly intervals for at least a year. These surveys

would detect possible upwelling. During such surveys, information about the distribution of surface swimming animals could be obtained and charted.

Members of the Working Group on Ocean Dumping of Chemical Munitions of the U.S. Department of the Interior.

Dr. George J. Ridgway (*Chairman*),
Bureau of Commercial Fisheries,
Dr. Lionel A. Walford,
Bureau of Sport Fisheries and Wildlife,
Mr. Walter J. Hunt,
Federal Water Pollution Control Administration.

Duke University,
Department of Chemistry,
Durham, N.C., May 15, 1970.

Office of the Assistant Secretary of the
Army for Research and Development,
The Pentagon, Washington, D.C.

Gentlemen: On 18 March 1970 the Army Research Office—Durham was requested by Office, Chief of Research and Development to review the progress being made at the Tooele Army Depot on implementing the recommendations of the Ad Hoc Committee to Investigate Disposal Hazards of Certain Chemical Munitions submitted to the Office of the Assistant Secretary of the Army for Research and Development on 25 July 1969.

Accordingly, a group of five technically competent individuals visited the Tooele Army Depot at Tooele, Utah on 9 April 1970 to study the experimental program designed to determine the safest and most practical method for the disposal of the vaults containing obsolete M55 rockets. The report appended hereto describes the findings of this group.

After reviewing the findings included within this report, I cannot urge you strongly enough to take immediate action to dispose of these munitions. While the individual components of this weapon have a reasonable storage life while in good condition, there is reason to believe that an element of instability is present that provides a potential of great danger particularly when one realizes what might happen if the contents of some of these vaults were released in their present storage areas so close to populated centers. Beyond these considerations there is the ever present danger of sabotage in storage and in transit.

Sincerely yours,

Paul M. Gross,
Professor of Chemistry & Chairman of Committee.

Follow-Up Report on Implementation of "Report of the Technical Group To Investigate Disposal Hazards of Certain Chemical Munitions," May 15, 1970

REFERENCES

1. Report of the Disposal Hazards of Certain Chemical Warfare Agents and Munitions prepared by an Ad Hoc Advisory Committee of the National Academy of Sciences (NAS)—Chairman, Dr. George B. Kistiakowsky, 25 June 1969
2. Report of the Ad Hoc Committee to Investigate Disposal Hazards of Certain Chemical Munitions—Chairman, Dr. Paul M. Gross, 25 July 1969
3. Test Report M55 Rocket Vault Study, May 1970
4. Operation Plan "CHASE", 29 December 1969

I. Background

Reference 1 describes the nature of the problem that was responsible for the appointment of an ad hoc committee to study ways and means of disposing of obsolete and deteriorating munitions having component materials injurious to health. This report made a number of recommendations directly responsive to the disposal of all munitions except the "coffins" containing M55 rockets presently being stored at the Anniston (Alabama) and Blue Grass (Kentucky) depots. This committee further recommend that, since it has no members that would qualify as demolition experts, the Army convene a group of technically qualified individuals who could study the problems involved in the safe disposition of the M55 rockets and make implementing recommendations.

Within this report were a number of conclusions that have been investigated by the Army and reported under reference 3. Among these are:

1. The "coffins" should survive the wreck of a slowly moving train (35 mph or less, according to Army plans);
2. A fire would take a long time to heat the large concrete mass of a "coffin" to a temperature high enough to cause rocket explosion;
3. A sniper's bullet could not penetrate to a rocket to cause explosion;
4. Sympathetic propagation of the explosion of any one rocket is not likely.

There is no evidence to disprove the first. The data presented in reference 3 under Incineration indicates that the time to deflagration or detonation of a rocket exposed to heat may not be as long as the second conclusion implies.

While reference 3 does not show that a sniper's bullet could cause explosion if fired into a vault, it does demonstrate that such a projectile is capable of penetrating the metal encased concrete vault and releasing agent from the warhead of one or more rockets. Also, the fact that a spent bullet was found within a warhead under the same conditions strongly suggests that, had it lodged in the motor, a deflagration or detonation might have ensued.

Finally, data taken from a number of experiments described in reference 3 shows that the sympathetic propagation of either a "deflagration" or "detonation" is certainly possible.

Reference 2 describes the deliberations of the committee of technically qualified individuals convened by the Army to implement the above described recommendation of the NAS committee concerning M55 rockets. The essence of its findings resides in two primary and alternate recommendations, four secondary and general recommendations and comments concerning nine methods for possible disposal of the rockets. No further consideration will be given to the four secondary recommendations in this report since they primarily address future possibilities rather than the immediate problem. The recommendations and suggestions of that committee are as follows:

"1. To minimize the possible hazards:

(*a*) Immediately separate the vaults by at least three feet while in storage.

(*b*) Coat the exposed vaults with a reflective paint.

(*c*) If these vaults are to be transported, to maintain a safe separation between them in transit.

2. Dispose of all 418 vaults by 1 August 1970 by:

(*a*) Use of a nuclear device to completely destroy them in one explosion.

(*b*) If the above cannot be accomplished, to sea dump them in as deep water as possible.

3. Although it is outside the scope of this Committee's objectives, the following general recommendations are also submitted:

(*a*) Munitions should not be encased in concrete because of the difficulty of disposing of them when obsolete.

(*b*) The Army immediately undertake the design and construction of an adequate, safe disposal facility which will accommodate all chemical munitions. (Full consideration should be given to surplus ICBM launch facilities.)

(*c*) Pending establishment of such a facility, stocks of obsolete or unserviceable chemical munitions be stored in adequate and safe locations or be disposed of in appropriate facilities.

(*d*) Future munition designs should take into account the possible need for large scale disposal and, to the extent possible, incorporate features which will minimize the hazards associated with munition disassembly and agent disposal.

Alternate Disposal Methods Explored (continuation of Reference 2).—(*a*) Using an underground detonation of a nuclear device, completely destroy all vaults in a single explosion. The results are predictable and complete. This will require an underground cavity of at least 1,600 cubic yards to contain the vaults.

(*b*) Sea dump the vaults in the "as is" condition, but explore encasing each vault with or without the top lid removed in an outer shell with sufficient void between the inner and outer casings to contain enough decontaminating solution to neutralize the GB in the vault. The material of the outer shell should be such that it would maintain its integrity for long periods of sea water exposure.

(*c*) Immersing the vaults in a solution, such as 28 percent hydrochloric acid (HCl), disintegrate the concrete and expose the entire rocket to the solution which would dissolve the metallic warhead skin and hydrolyze the GB agent. Controlled tests would be required to determine the effects of the selected solution on the various explosives involved. Also total dwell time would have to be determined. The overall feasibility of this procedure should be investigated to see whether the time required is adequate.

(*d*) Using appropriate facilities, the vault is suspended on end in a pool of solution, such as 28 percent HCl, to disintegrate about 4 to 7 inches of concrete thus exposing one end of the rocket launchers. Those rockets oriented such that the warhead end is exposed would be removed one at a time, the agent extracted and chemically neutralized in a caustic solution. If necessary, the vault would be reversed and the other end treated so that rockets with warheads oriented in that direction could be removed. The metal parts exposed to GB contamination would then be soaked in caustic and burned. The explosives would be handled by standard procedures. The rocketless vaults would also be caustic-soaked to neutralize any GB contamination and then disposed of. This procedure was denied top priority because it was reported that rockets have been found where the agent has escaped into the launching tubes and has run out onto the workmen who were engaged in disassembling the munition.

(*e*) In a suitable facility with provision for remote control, the vaults are oriented so that six rockets are in a vertical plane with the long axis of the rockets horizontal so that 10 holes can be bored with a commercially available diamond core drill such that each rocket is pierced in two places. At the warhead, the penetrations would be approximately midway between the fuze and igniter and, at the motor, midway between the igniter and nozzle. Such hole locations would insure penetration of each warhead regardless of orientation and attitude within the vault. This operation would be carried out by remote control under an agent decontaminating solution which would also be used as a drill coolant. The possibility of an explosion does exist since the drill would pass through both the explosive and propellant. Therefore a situation of potential danger would always be present.

(f) Utilizing ionizing radiation, effect the decomposition of the GB agent and dispose of the vault by above ground detonation or sea-burial. Since the hazard would be limited to the explosive alone, the rate and amount of energy required to perform this operation is unknown and a question would remain as to completeness of agent decomposition.

(*g*) Incinerate the entire vault. The GB agent will decompose at 800°F with one second dwell time; however, the propellant will probably "cook off" at a substantially lower temperature thus maintaining a condition of potential danger.

(*h*) Mechanically expose the ends of the rockets by boring into the vault with diamond drills. A possibility exists that the fuze located in the warhead may be penetrated. This fuze contains lead azide and styphnate. These materials being friction and heat sensitive could detonate thereby activating the entire rocket explosive train and possibly detonating the entire vault.

(*i*) Utilize a diamond edge saw blade to cut through the concrete vault attempting not to touch the detonator or composition B explosive in the warhead or the igniter located between the propellant and the warhead. Since the exact location of the rockets is unknown, the possibility of hitting the igniter is deemed to be an unacceptable risk.

(*j*) Utilize a high pressure water jet (300 gpm at 4–5000 psi) to broach the concrete. It is anticipated that a five to twelve inch wide cut could be made. The hazard associated with the possibility of the jet's hitting the warhead detonator and cutting it open is considered excessive.

(*k*) Utilize shaped charges to penetrate the ends of the vault thereby exposing the rocket ends. The possibility of initiating the detonator, explosive charge or propellant is considered too great.

(*l*) House the vault in a suitable enclosure capable of containing the explosion and immerse the vault in a suitable solution which can chemically neutralize the GB agent. The feasibility of using a surplus ICBM launch facility as a "suitable enclosure" should be explored. Through a suitable mechanism, to provide an atmosphere of ammonia over the decontaminating solution. The vaults would then be explosively detonated with a sufficiently large charge to disintegrate them. It would be necessary to demonstrate the completeness of disintegration of the vault and its contents and decomposition of all agent to make this method acceptable."

Interim Status of the Disposal Problem as of Late 1969.—Parts (*a*) and (*b*) of the first recommendation have already been implemented; nothing can be done on part (*c*) until a decision is made regarding the possiblities of transporting the vaults.

Part (*a*) of the second recommendation proved not to be feasible because of the unwillingness of the Atomic Energy Commission to provide the requisite facilities.

We are thus left with part (*b*) of recommendation 2 which requires that the vaults be taken to sea and dumped in the deepest water available. However, since

a number of alternatives had been suggested, there was a consensus that an experimental program should be initiated to insure that all of the alternates were unsafe or infeasible before a decision is made to sea dump.

Accordingly, on 17 July 1969 a letter was sent from the Acting Assistant Secretary of the Army for R & D to LTG A. W. Betts, Chief of Research and Development to initiate a test program designed to determine the feasibility of disarming and disposing of the vaults through one or more of the alternate procedures described in reference 2. The Ammunition Equipment Office at the Tooele Army Depot in Utah was directed to implement this testing program on 20 August 1969 and work was actually begun in October of that year; this is reference 3.

Description of Experimental Findings Cited in Reference 3.—The testing program described in detail in reference 3 comprised a series of experiments to determine if the M55 rockets embedded in the concrete vaults can be extracted and neutralized by August of 1970 and in a manner calculated to prevent endangering any individual regardless of whether he is an active participant in the program or is a member of the community contiguous to the test site. The various tests conducted at Tooele were made on coffins which were deliberately made to simulate those at Anniston and Blue Grass. The steel shells on the coffins were made to the same specification as to the originals and the concrete has approximately the same compressive strength. The rockets used in the testing were designated M61 and were identical to the M55 in the vaults at Anniston with the important exception that the 11 lbs. of active GB agent has been replaced by 10.6 lbs. of ethylene glycol. This substitution precluded the necessity of constructing elaborate and expensive facilities to insure safety from toxic effects during testing. A description of the separate testing programs follows:

1. Acid Immersion

This suggestion is concerned with the concept of suspending the vault in a pool of 28% HCl to disintegrate the concrete and expose the entire rocket; it would then dissolve the warhead skin and hydrolyze the GB agent. The success or failure of this suggestion will of course hinge primarily upon the rate of dissolution or degradation of the concrete by the acid. Actually these experiments will also relate directly to the next suggestion which involved immersing the end of a vault stripped of its steel casing into a solution of 28% HCl, not to dissolve the entire vault, but merely to degrade the concrete back from the end of the coffin to the point where the ends of the rocket launcher tubes are exposed thus enabling the caps to be taken off and the rockets to be manually removed. After preliminary laboratory tests, a vault was hung in a bath of 31% HCl in such a way that there was sufficient acid available to insure that 3 or 4 inches of the end of the vault were submerged.

It was found that after 29 hours of exposure to HCl approximately 3 pounds of aggregate had settled in the bottom of the acid tank and an additional 3 pounds could be scraped from the surface that was under attack by the acid. Consideration was given to the possibility of having the reaction of the acid on the concrete effected at a higher temperature recognizing that the reaction rate would approximately double for every 10° rise. However in view of the sensitivity of a rocket motor toward elevated temperatures it was decided that this was probable an an unsafe practice. Therefore, in view of the extremely slow rate of dissolution of concrete by the acid at ambient temperatures, it was decided that this method of either destroying the complete vault or of exposing the end of the rocket cases was completely infeasible. While this may not be true when the warhead is adjacent to the liquid, the random arrangement of the rockets demands that we assume the contiguity of at least one motor per vault near the immersed end of the "coffin".

2. Drill Tests

Based upon one of the recommendations in reference 2, a vault was oriented so that the plane containing five rockets was in a vertical position with the long axis of the rockets horizontal so that starting at the top, ten holes could be bored with diamond core gang drills such that each rocket would be pierced in two places, one being the warhead, the other being the motor, and in a position essentially central to each. This procedure was designed to insure that each warhead would be penetrated thus allowing the GB agent to escape where it could be neutralized.

A suitable vault was obtained containing rockets with ethylene glycol in the warheads and drilling was attempted from the top surface. The drill began to

bind as it went through one of the rockets and great concern was expressed that the heat generated by this procedure would be sufficient to ignite a motor and perhaps cause an uncontrolled deflagration or even detonation of the entire vault. Under these circumstances further drilling was stopped and a decision was reached that this particular method was infeasible for safety reasons.

3. Incineration method.

A suggestion was made in reference 2 to incinerate the entire vault It was noted that GB agent will decompose at 800°F with one second of dwell time and also that the propellant will probably "cook off" at a relatively low temperature. However, in view of the fact that the rockets are contained within a medium whose heat transfer is not too great, it was felt that one should look into the possibility of destroying the GB agent in this way.

Accordingly, a special incinerator oven, capable of achieving and maintaining predetermined temperatures for a 24 hour period, was designed and fabricated. It was originally conceived that three vaults would be utilized for the test, one each for the 150°C, 300°C, and 800°F temperature levels. Three hours after power was applied to the oven in the first test the controlled thermocouple reached the desired temperature of 150°. After a total elapsed time of 14 hours from the application of power, the first "detonation" (or deflagration) occurred. This was followed by six additional "detonations" over a three hour period. From these results it was obvious that incineration could not be used as a method for destroying the GB agent in that the rockets tended to deflagrate or detonate prior to any evidence of the decomposition of the warhead filler. Since several of the rockets in this test genetrated the walls of the oven wholly or in part certainly the test could not be considered to be a safe way of disposing of the munitions. Furthermore, the results of this test emphasize the magnitude of hazard existing from the ignition of rocket motors within the vault.

4. Core Drills

Another suggestion made involved the use of diamond drills to bore perpendicularly into the end of the vault thus exposing the ends of the rocket cases. It was recognized that a possibility existed that the fuze located in the warhead might be penetrated and might detonate thereby activating the entire rocket explosive train and possibly detonating the entire vault. Experiments showed that it indeed was possible to drill through the concrete to the end of the cases but that in numerous instances the drill hole was not lined up with the end of the rocket and additional cuts had to be made to fully expose the end of the rocket launching tube.

Once the rocket launcher tubes were exposed the end caps could be removed and the rockets withdrawn from the containers. While no evidence appeared in the tests that core drilling was unsafe in any way, a sufficiently large sample of drillings has not been made to provide, on a statistical basis, a reasonable level of confidence in the safety of the procedure. Also, the fact remains that it is a very time consuming process and it could not be considered as a feasible method of removing the rockets from the coffins.

5. Saw Test

In this test a diamond edge saw blade was used to cut through the concrete vault attempting not to touch the detonator or composition B explosive in the warhead or the igniter located between the propellant and the warhead. Prior to sawing the live test vault it was determined that a 2.38 inch cut could be made on the warhead end of the vault without having any effect on the explosives components in the fuze or warhead. In most cases this will not expose the end of the rocket container. The procedure employed involves making the first cut and then following it with a series of other shallow cuts; as fast as the end of a rocket container is exposed the cap is taken off and the rocket itself is manually removed. In this way, by limiting the cuts to 2 inches at a time, it is possible to expose the ends of all rocket containers and completely remove the rockets held therein. Experience has shown that once the cap is off of the rocket container, the removal of the rocket containing this simulated filler is a simple chore.

In order to be absolutely certain that the process was entirely safe, a saw cut was made directly across the top of vault so that the blade would pass through the motors of at least one rocket. In the first two cases the cut was made without any difficulty, however the third cut resulted in ignition of rocket propellant.

Accordingly, it was recognized that great care would have to be taken in the matter of removal of the concrete from the end of the vault to insure that the cuts were not of such distance from the face that they would intrude into the motor area and possibly be a source of danger. By using consecutive cuts and not trying to do the job all at one cutting, danger can be avoided. It has been found that by cutting transversely to a depth of 18.5 inches an entire cross sectional slab of concrete can be removed in two cuts and a cutting rate of approximately 2.25 inches per minute can be maintained. Under these circumstances and allowing for approximately 3 slabs to be removed in order to expose all of the rockets, the total time for exposing all rockets in a given vault would amount to a minimum of 4.25 hours. From a practical point of view it is obvious that much more time would be needed. However, this would appear to be the safest and most practical method of exposing the rockets that has been devised to date.

6. High Pressure Water Jet Test

This experiment was designed to determine if the ends of a vault, stripped of its metal facing, could be eroded enough by a high pressure fluid jet to expose the end caps within a time short enough to make the procedure practical. Attempts to use water as the working fluid disclosed that the rate of erosion was so slow that the method was impractical. However, when a suspension of 0.7 pound of sand per gallon of water at 300 gpm and 3000 psi was used as the eroding agent, the surface could be eroded to a depth of 6–7 inches in minimum time.

Unfortunately, it proved impossible to prevent penetration of the end caps and, where such entrance was effected, the sand became embedded between the outer wall of the rocket and the inner wall of its case. Under these circumstances, the rocket could not be removed. Accordingly, in spite of the safety and speed of this method, inability to free the rocket made it quite impractical.

7. Shaped Charge Tests

Two experiments were run using shaped charges. The first was for the purpose of determining whether or not shaped charges could be used to penetrate the ends of the vault thus exposing the container caps sufficiently so that they could be removed; the second involved the application of two large shaped charges to the exterior surface of the top of the vault to see whether or not the vault could be catastrophically ruptured in the depths of the ocean thus exposing the GB agent to the hydrolytic action of sea water much more rapidly than by corrosion and diffusion. In the first experiment, a test vault underwent radiographic inspection in order to approximate the location of its embedded rockets. This was necessary in order to know where to place the shape charges so as to insure that the jet resulting from detonation would be directed between the end caps of the rocket containers. Once this positioning was determined, 60 two inch conical shaped charges were placed 30 to each end of this test vault directly between the indicated positions of the rocket container caps. Each shaped charge was connected to a length of Primacord, the other end of which was inserted into a mass of composition C5 along with two M6 electric blasting caps to insure that all shaped charges would detonate simultaneously. Each shaped charge was designed to create a hole approximately .37 inch in diameter and 5.5 inches deep in mild steel. The gross weight of the charge was 205 grams.

When the shaped charges were activated the result was almost catastrophic. The vault was demolished and fragments of rockets and rocket case containers were widely scattered over the area, thus indicating that this particular method was neither practical nor feasible.

The second shaped charge experiment involved placing two shaped charges on top of the vault so that they would fire perpendicular to the longitudinal axis of the rockets. Each charge contained 412 grams of RDX and had an overall weight of 873 grams. When used with the standoff of 12 inches they were designed to create holes of 1.75 inches in diameter through 14 inches of mild steel. Detonation of the shaped charges caused one motor to ignite. The ignition of this motor caused the escaping gases to break the center of the aluminum end cap, fracture the concrete and force one end of the vault outwards breaking the welds around three sides. The shaped charge over the warhead end of the vault did little apparent damage and so it would appear that if this method were to be feasible there would have to be some assurance that the shaped charge did in fact ignite a motor, otherwise there is no evidence to indicate that the vault would be seriously ruptured except for the hole caused by the jet itself. In conclusion, one

could say that if this method were to be used to rupture vaults at the bottom of the ocean there is evidence to indicate that it is possible to open up the vault to thus theoretically increase the rate of hydrolysis and dissolution of the GB agent. However, at the same time, it must be recognized that what apparently did the most damage was the ignited rocket motor and secondarily we cannot be positive that the essentially unconfined action would be identical to that which occurred under the pressure of 7,000–15,000 ft. of water. Likewise, we have no way of knowing that, if the shaped charge did destroy the container, the released rockets might not surface and thus constitute a real hazard.

Finally, it was also recognized that perhaps there is no great virtue in rupturing the case at the bottom of the ocean but rather that the best interest would probably be served through a very slow and gradual erosion of the case in concrete with the attendant diffusion of the GB agent followed by hydrolysis.

In view of the chemical composition of concrete a question was raised as to whether it in itself might attack the GB agent in the presence of moisture. The obvious implication is that we have unknowingly embedded the agent in an automatic decontaminating environment. At the request of a member of the committee, experiments were initiated at Edgewood Arsenal to test the validity of this hypothesis. The complete results show that when 10 grams of the concrete being used at the Tooele Army Depot are pulverized and suspended in 100 cc of water, the resultant solution shows a pH of 12.2 clearly indicating its alkaline nature. On adding GB to this suspension, it was found that 24% of the GB had disappeared after 4 days. A second experiment made with three different sizes of concrete showed that the concentration of pure GB could be reduced from 87% to 10% when kept in contact with an equal weight of granulated concrete for as little as 11 days. This provides an additional safeguard to insure that a slow leakage of GB over the extensive time required for sea water to erode its way through steel and concrete should not seriously affect the ocean ecology.

8. Explosive and Chemical Neutralization of Vault

One other suggestion had been made in reference 2 which involved housing the vault in a suitable inclosure such as a surplus ICBM launch facility and immersing it in a solution capable of neutralizing the GB agent. The vaults would then be explosively detonated with a sufficiently large charge to completely disintegrate them thus allowing for the agent to come in contact with the neutralizing solution. However, a decision has been made that the vaults must be neutralized in their present location, or else trans-shipped to some coast line port for sea dump. Under these circumstances it was not felt necessary to explore this possibility any further.

Summary of Conclusion Reached by the Committee Meeting at Tooele Army Depot on 9 April 1970.—As a result of the experiments cited above, a number of conclusions can be drawn recognizing the ever present existence of hazard from toxicity and explosion due to accident:

(1) Of the methods explored for exposing the rocket containers so that the munition can be removed, the following were considered to be relatively safe from the hazard of accidental deflagration or detonation:

(*a*) High pressure water-sand jet.
(*b*) Core drilling at the ends of the vault
(*c*) High speed sawing at the ends of the vault
(*d*) Chemical attack

(2) Sand has a tendency to penetrate the rocket container and become wedged between the walls of the rocket and the container. This either prevents the rocket from being removed or would necessitate the use of extreme force which could result in the rupture of the warhead and the release of GB agent. This method therefore cannot be recommended.

(3) While there is no evidence to indicate that chemical attack on the concrete leading to its degradation is in any way hazardous, the reaction is so extremely slow under conditions needed to insure safety that the method is not considered to be practical.

(4) When either core drilling or sawing are pursued under normal safety constraints, it is quite possible to expose the container end caps. These can be removed and the simulated rocket extracted from its container. However, before viewing either of these methods as the ultimate answer, two other considerations must be recognized.

(*a*) Very sound evidence exists that the GB agent in many of the vaults under consideration has partially decomposed producing acidic residues which have so seriously corroded the metallic warheads that leakage has resulted.

At the same time the warhead walls have weakened and products of corrosion have effectively cemented the fragile shell to its container. Under these circumstances, it would appear almost impossible to extract a rocket even after it has been exposed without accepting the danger attendant to the release of residual GB agent. Concurrently, the acidic exudate could also penetrate the motor chamber and attack the propellant thus increasing its sensitivity and its tendency towrad violent decomposition.

(*b*) While every precaution has been taken to insure that the vaults presently in storage are safe, it must be realized that they do not have an indefinite storage life. This is particularly true if internal chemical attack is in process as described above. It is for this reason that the original report recommended that the Army dispose of these vaults by some acceptable method prior to 1 August 1970. The latest information indicates that the design, construction and activation of any facility capable of impleting any of the procedure cited above will require three-four years. This would appear to be far beyond the reasonable limits of storage safety. Whereas tentative data indicates that the GB agent that escapes into the concrete might be effectively decomposed and be rendered harmless over this period, the hazard associated with the deterioration of the propellant in the rocket motor is still very real. There is no evidence that time will reduce this hazard; indeed there is every reason to believe that the situation may grow progressively worse. The urgency of effecting early disposal of these vaults is accentuated by the recognition of the possibility of sabotage. The evidence described earlier that it is possible to penetrate a rocket encased in concrete and steel by a small arms projectile should keep us alert to the ever present danger of sabotage of these vaults in storage and perhaps to a lesser degree in transit.

In view of the experiments cited above, coupled with the continuing deterioration of the GB agent, resulting in an accelerating increase in hazard from extended storage, it is once more recommended that the procedures described in reference 4 (Operation Chase) be implemented so that the 418 vaults presently residing at the Anniston and Blue Grass Depots will be shipped with every possible precaution and without delay to a suitable ocean port and will be loaded on a surplus marine hulk which will then be towed to a suitable ocean depth and be scuttled.

ENVIRONMENTAL IMPACT STATEMENT FOR OPERATION CHASE (OCEAN DISPOSAL OF CONCRETE VAULTS CONTAINING CHEMICAL MUNITIONS)

In the fall of 1968, the Department of the Army determined that the disposal of certain chemical munitions and bulk agents was necessary to remove unserviceable material from our national deterrent stockpile. The proposed disposal plan called for these munitions and agents to be loaded on hulks which were to be taken under U.S. Coast Guard escort to a previously designated explosives dumping site beyond the continental shelf and sunk in the ocean.

On May 14, 1969, the National Academy of Sciences was requested on behalf of the Department of the Army to make an independent study of the contemplated chemical disposal plan. In response to this request, a panel of twelve distinguished experts drawn primarily from this country's leading industrial, educational and research institutions assembled in Washington to consider carefully the proposed chemical disposal plan. With respect to the chemical munitions contained in 418 concrete vaults overlaid with steel plates welded at the seams, the National Academy of Sciences recommended that the Army convene a committee of qualified experts to consider whether there is any practically feasible alternative to sea dumping. According to the Academy, this method should be safe to neighboring population and positive in the sense that toxic and explosive contents of the vaults could be destroyed within a predictable time. If such a method was not found, the Academy recommended that the Army proceed with ocean disposal of the vaults. (Ref. 1.)

In accordance with this recommendation, a committee of technically qualified non-Army experts, headed by Dr. Paul M. Gross, Professor Emeritus of Chemistry at Duke University, carefully considered alternative means of disposing of the concrete vaults. In its initial report of July 25, 1969, the Gross Committee recommended that all 418 vaults should be disposed of by "use of a nuclear device" or "if the above cannot be accomplished, to sea dump them in as deep water as possible." (Ref. 2). Subsequently, the Atomic Energy Commission advised that nuclear destruction is unsatisfactory.

After the alternative of nuclear destruction was found to be unsatisfactory, the Gross Committee requested that numerous experiments be conducted to

determine if any other alternative disposal method could be employed in lieu of ocean disposal. Following these efforts, the Gross Committee, in a follow-up report of May 15, 1970, recommended that the 418 vaults be shipped without delay to a suitable ocean port to be loaded on a surplus marine hulk which would be taken to a suitable ocean depth and scuttled. (Ref. 3).

The disposal area will be at 29°20′ N. 76°0′ W. which is designated on the charts as a munitions, explosives and chemicals disposal area. The proposed dumping area is approximately 220 nautical miles off the continental shelf. Its center lies approximately 160 nautical miles North/Northeast of the closest point of land (Powell Cay in the Bahama Islands) and is approximately 245 nautical miles East of the closest point of land in the United States (Cape Kennedy). This site, which is more than 16,000 feet below the ocean surface, was suggested by the National Academy of Sciences for a disposal operation through a southern port and concurred in by the Department of the Interior.

While every precaution has been taken to ensure that the vaults in storage are safe, the Gross Committee recommended that, because of the eventual deterioration of the rocket propellant, the vaults be disposed of in the ocean "without delay." Because of this potential hazard and the absence of a reasonably feasible alternative to sea disposal, the Army has accepted the recommendation of the Gross Committee.

1. The Environmental Impact of the Proposed Action

The eventual environmental impact of the proposed action will be due to the ultimate release of nerve agent contained in the munitions probably after the concrete vaults reach the ocean bottom. (With the exception of one munition, the munitions in the vaults contain GB agent. That other munition contains only about 10.5 pounds of VX agent.) Release of the agent will contaminate a volume of water at the ocean bottom. The maximum adverse environmental impact would be the temporary contamination of approximately 1 cubic mile of water at the bottom. (Ref. 6). However, this would occur only if all of the vaults rupture simultaneously, which is extremely unlikely. It is more likely that the contaminated volumes will be much smaller, especially if there is the expected slow release of the agent at the ocean bottom.

Most, and probably all, of the vaults should reach the ocean bottom intact. Corrosion of the vaults' steel plates and welded seams will begin at this time. Several other situations, all of which will contribute to an accelerated rate of destruction of the GB, will also probably occur. If the vaults should rupture, because of the positive pressure, quantities of water will be drawn into the munitions' compartments containing the GB. The hydrolysis rate of GB under these conditions could be very rapid. (Refs. 4 and 5.) In addition, if the concrete remains somewhat intact, as it is expected to do, GB passing through it will be rapidly destroyed due to the high alkalinity of a leached solution of concrete (pH 12.2). Eventually, what remains of the unreacted GB will diffuse into the ocean.

Consequently, when the welded seams and bodies of the M–55 rockets, which comprise all but four of the munitions in the vaults, are eventually penetrated, a significant amount of the GB originally contained in the rockets will have been hydrolyzed or reduced in strength. (In addition to the rockets, there are three 155 mm. projectiles and one M–23 mine in the vaults.) Upon penetration, the products of the hydrolysis and the remaining unhydrolyzed GB will slowly diffuse to the outside (Ref. 1), and when finally released into the ocean, will be hydrolyzed and/or diluted to physiological ineffectiveness (Ref. 4). These processes will occur at great depths because of the slow vertical mixing rate from 16,000 feet. In addition, since the bottom current and lateral diffusion rate at the disposal site are so low, toxic material released from the vaults should be highly localized. (Refs. 1 and 6.)

The behavior of GB agent in ocean water has been carefully studied in a detailed paper delivered by Dr. Joseph Epstein and Mr. James D. Wood to a panel of distinguished experts appointed by the National Academy of Sciences to study the ocean disposal of chemical munitions. (Ref. 4). The study concluded that if 960 tons of GB were released into ocean water continuously and uniformly over a 12-month period, only 0.017 cubic miles of the water would contain a GB concentration of at least 0.01 parts per million. Since the total amount of chemical agent involved in this operation is substantially smaller (66 tons) and will probably be released over a longer period of time, the volume which will be contaminated by its gradual release should be significantly less than the volume determined by the study.

Only if a number of vaults and the rockets within them crack simultaneously will there be a substantial amount of GB released into the ocean at one time. (The study attached as Reference 6 indicates the volume of water which would be contaminated as a result of the immediate release of the 66 tons of GB.) However, this is unlikely because most, and probably all, of the vaults should survive intact throughout the sinking of the hulk in which they will be located and remain uncracked after settling on the ocean bottom. In addition, the probability that an explosion of one or more rockets could be initiated inside a vault and cause it to rupture is "extremely remote." (Ref. 7.).

The munition not containing GB, which is referred to on page 3, is an M–23 mine containing only about 10.5 pounds of VX nerve agent. The hydrolysis of VX produces a variety of products, one of which is about ⅓ as toxic as VX as measured by oral toxicity to rats. About ⅓ of the total VX is transformed into this product so that on the basis of oral toxicity, about ⅑ of the original toxicity remains after complete hydrolysis. And this product will eventually be diluted to non-toxic levels. The toxicity to marine species of this latter compound is not known. However, it is believed that it will not be very toxic; VX itself at the pH of sea water is not very toxic to fish (LCt_{50} estimated at 4° C to be about 50,000 mg min/m³).

The proposed ocean disposal may also affect the limited marine animal life in the disposal area. Marine life is sparse at the disposal site because of the site's great depth and its location on the seaward side of the Gulf Stream in an area with little vegetation. Due to the site's lower productivity and great depth and its present designation on navigational charts as a munitions, explosives and chemicals dumping area, the site is less susceptible to future commercial or technological use than other parts of the ocean bottom. With respect to commercial fishing, the site is much deeper than any sites at which fish are caught for human consumption. In addition, the animal species at this depth are scavengers which are not utilized as a food source for man.

2. Any Adverse Environmental Effects Which Cannot be Avoided Should The Proposal be Implemented

The only unavoidable adverse environmental effects of the ocean disposal are the temporary contamination of water in the immediate vicinity of the disposal site and the possible poisoning of some of the sparse marine animal life in the same area, both of which are referred to in Section 1.

3. Alternatives to the Proposed Action

The following studies of alternatives to the proposed ocean disposal were conducted.

A. *National Academy of Sciences' Report.*—As noted above, the Ad Hoc Advisory Committee of the National Academy of Sciences carefully reviewed an earlier plan for ocean disposal of the concrete vaults and recommended that:

(1) The Army convene a committee of qualified experts to determine if there is any feasible alternative to ocean dumping.

(2) If this committee concludes that no reasonable alternative exists, the Army should proceed with ocean disposal. (Ref. 1).

B. *Initial Report of the Gross Committees.*—As is also noted above, the Gross Committee was convened in accordance with the National Academy of Sciences' recommendation. The Committee recommended in its initial report that:

(1) The vaults should be disposed of by nuclear destruction.

(2) If this cannot be accomplished, the vaults should be dumped in the ocean in as deep water as possible. (Ref. 2).

C. *Atomic Energy Commission Study.*—On August 7, 1969 the Army requested the Atomic Energy Commission to determine the feasibility and desirability of adopting the Gross Committee recommendation with respect to nuclear destruction of the concrete vaults. The Lawrence Radiation Laboratory and the Nevada Operations Office of the U.S. Atomic Energy Commission submitted the results of a feasibility study to the AEC. This study concluded that, as a practical matter, the obsolete chemical munitions could be reliably destroyed by an underground nuclear explosion. However, additional studies were recommended in the event the project was to be undertaken. The feasibility study further concluded that a long period of time would be required from project authorization through execution.

Subsequently, the Army was informed by representatives of the Atomic Energy Commission that nuclear destruction was unsatisfactory.

D. *Department of Interior Study.*—After reviewing the initial Gross Committee Report, the Department of Interior working group on ocean dumping of chemical munitions completed a report on November 13, 1969. (Ref. 8). In preparing this report, the group also studied the oceanography of the proposed disposal site. This group had in June 1969 considered the earlier chemical CHASE operation and, like the National Academy of Sciences, had recommended against ocean disposal of chemical munitions in general. It had also recommended further study of the disposition of the concrete vaults.

In its November 13 report, the Department of Interior working group concluded that because of the present hazards to human safety and the aquatic and terrestrial environment in addition to the unavailability of a feasible alternative method of disposal, ocean disposal of these hazardous materials was necessary. With respect to the proposed new disposal site, the group concluded from available information that it is in deeper water and is less susceptible to technological use than other previously used sites and that marine life at the site is sparser. In addition, the group found that the site is on the seaward side of the Gulf Stream in a less productive area; the bottom currents at the site are minimal so that toxic material eventually leaking from the containers should be confined to a rather small area; there is no evidence of any upheaval at the site; and the site is already marked on navigation charts as a munitions, explosives and chemicals dumping area.

At the request of the Department of the Interior, instruments will be attached to the hulk used in the disposal operation to monitor its descent and to indicate the location at which it settles on the ocean floor. In addition, the Department of the Interior and the Department of the Navy are working out appropriate oceanographic tests to be conducted in the disposal area.

E. *Follow-up Report of the Gross Committee.*—After the Gross Committee's first alternative of underground detonation of a nuclear device to destroy all vaults was found to be infeasible, a further study was conducted at the Committee's request to determine if any of the other alternative disposal methods proposed in its original report could be employed in lieu of ocean disposal. After reviewing these studies, which revealed no feasible alternative, the Committee recommended that the 418 vaults be shipped "without delay to a suitable ocean port to be loaded on a surplus marine hulk which would be towed to a suitable ocean depth and scuttled. (Ref. 3)

4. The Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

In view of the remote possibility that the disposal site will be used for commercial or technological purposes (see Section 1) and of the temporary adverse environment effects of the ocean disposal action (see Section 2), this action should have little or no effect on the maintenance and enhancement of long term productivity.

5. Any Irreversible and Irretrievable Commitments of Resources Which Would be Involved in the Proposed Action Should it be Implemented

No irreversible and irretrievable commitments of resources will result from the ocean disposal action.

LIST OF REFERENCES

Ref. 1: Report of the Ad Hoc Advisory Committee of the National Academy of Sciences (June 25, 1969).

Ref. 2: Initial Report of the Gross Committee (July 25, 1969).

Ref. 3: Follow-up Report of the Gross Committee (May 15, 1970).

Ref. 4: "The Properties of GB and H in Sea Water" by Dr. Joseph Epstein and Mr. James D. Wood.

Ref. 5: "Study of Effect of Concrete on GB Stability" by Analytical Chemical Department, Chemical Research Laboratories (April 30, 1970).

Ref. 6: Report on Estimated Contamination Possible from Sea Water Explosion of the Concrete Vaults, prepared by personnel at Edgewood Arsenal (November 28, 1969).

Ref. 7: Memorandum by F. H. Crist concerning the Probability of Initiating a Detonation of Entombed M55 Rockets (June 15, 1970).

Ref. 8: Second Report of the United States Department of the Interior Working Group on Ocean Dumping of Chemical Munitions (November 13, 1969).

U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF THE SECRETARY,
July 23, 1970.

Hon. J. RONALD FOX,
Assistant Secretary of the Army,
(Installations and Logistics), Washington, D.C.

DEAR MR. FOX: This is to advise you that we have reviewed the draft of "Environmental Impact Statement for Operation CHASE," as requested in your July 2 letter to Secretary Hickel. We concur in the statement, as revised and agreed upon by members of our respective staffs during meetings held on July 17 and 21, 1970.

Sincerely yours,

LESLIE L. GLASGOW,
Assistant Secretary for Fish and Wildlife and Parks.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
SURGEON GENERAL OF THE PUBLIC HEALTH SERVICE,
Washington, D.C., June 16, 1970.

Hon. J. RONALD FOX,
Assistant Secretary of the Army,
(Installations and Logistics),
Washington, D.C.

DEAR DR. FOX: Pursuant to your letter of 2 July 1970 requesting our review of the draft environmental impact statement for Operation CHASE, we submit the following comments:

1. The Operational Plan should be attached to the environmental impact statement as a reference.

2. A more definitive description of the geographical location and known ecological characteristics of the disposal site would be desirable.

3. The draft impact statement fails to mention two potentially significant factors:

(*a*) Other munitions, explosives and chemicals previously dumped at this disposal site and the estimated condition of this material, and

(*b*) The impact of the CHASE propellant and explosive materials on the marine environment.

It would be desirable to initiate and maintain a perpetual inventory and monitoring of the disposal site.

4. We agree in principle with one of the conclusions of the Department of Interior Working Group's Second Report, November 13, 1969; namely, there is no choice but to accept ocean disposal of these hazardous materials as a necessary, though undesirable, expediency. This conclusion was reached after considering present hazards to human safety and to terrestrial environments and the unavailability of alternate methods of disposal.

5. We concur with the recommendations of the Gross Committee and the National Academy of Sciences that alternative disposal methods for chemical munitions and agents be developed which will have a minimum impact on the environment.

I appreciate the opportunity of reviewing this statement and assure you that this office is available to assist you in the development of new approaches to disposal problems.

Sincerely yours,

JESSE L. STEINFELD,
Surgeon General.

A. STUDY ON EFFECT OF CONCRETE ON GB STABILITY

(By Analytical Chemistry Department, Chemical Research Laboratory, Research Laboratories, 30 April, 1970)

At the request of the Chemical Research Laboratory (CPL), experiments were instituted to determine the effect of concrete on GB. The concrete submitted by CPL represented "cores" of the material which had been used to encase M–55, GB rockets. The question to be answered was the potential effectiveness of the concrete as a decontaminant and neutralizer for GB.

Three concrete samples weighing 11.35 gm to 11.82 gm were placed into separate containers with GB of 87% purity (after neutralization with tributylamine and stabilization with a 2.3% excess of diisopropyl carbodiimide). The GB under these conditions represented the type of agent actually contained in the rockets. One experiment was represented by a single, irregularly shaped lump of concrete; the second, by several irregular medium-sized lumps; and the third, by irregularly shaped particles of a granular nature. In each container a weight of GB roughly equivalent to that of the concrete was sufficient to cover the solid. The same sample of GB, but without concrete, was maintained as a control. The purity of GB from the liquid phase of each container, as determined over fixed time periods, is shown in the table that follows.

PURITY OF GB IN CONTAINERS, AS PERCENT BY WEIGHT

Sample number	Size of concrete particle	Elapsed time, hours						Free acid [1] (percent)	$t_{1/2}$ obs hours
		0÷2	22	94	118	166	262		
1	Large	87.1	87.0	57.3	48.7	43.5	24.5	45.7	160.0
2	Medium	86.4	87.0	49.4	37.2	35.4	20.7	55.5	110.0
3	Granular	86.6	86.6	23.1	17.9	17.0	9.6	73.9	50.0
4	Control	86.5	87.4	89.0		[2] 84.5	[2] 75.9		

[1] Acid formed on hydrolysis of GB calculated as isopropyl methylphosphonic acid.
[2] Decrease in GB purity due to moisture from atmosphere and handling.

Concrete samples of the same aggregate sizes as were used in the GB decomposition studies were placed in 100 ml portions of freshly boiled, and cooled distilled water and soaked over 48 hours. The pH of the resulting solutions was between 12.1–12.2, regardless of the particle size. The basicity of the concrete as observed in the aqueous medium would appear indicative that the concrete might be a source for neutralization of acid formed on hydrolysis of GB. However, the increase in acidity (lack of buffering) as observed during the GB stability studies would indicate that decomposition of the agent is due to water contained in the concrete rather than the basicity of the concrete. As the surface to volume contact of concrete to GB is increased (as with smaller particles of concrete), more hydrated water (structurally bound to concrete) becomes available to the agent and the rate of hydrolysis increases.

The above-mentioned data do not preclude the catalytic effect of hydrolytically formed phosphonic acid on the continued decomposition of GB, since catalysis is an important part of the decomposition mechanism of the agent under these relatively undiluted conditions.

B. Estimated Contamination Possible From Underwater Explosion of Vaults

1. Edgewood Arsenal was requested to estimate the extent of contamination if all M55 rocket vaults currently held for disposal were to simultaneously explode underwater. Depths of 1,000, 2,000, 7,000 and 15,000 feet were specified for evaluation. The vaults consist of 30 each GB-filled M55 rockets encased in concrete within a hermetically sealed (welded) steel box. Table 1 contains a summary of the amounts of material involved in the proposed disposal operation.

Table 1.—*Material for disposal*

Number of coffins	418
Number of rockets	12,540
Tons of GB (10.51b/rocket)	66
Tons of Propellant (19.3 lbs/rocket)	121
Tons of Explosive (2.6 lbs/rocket)	17

2. It was assumed that during the explosion all of the agent GB would be released into the water and that all the propellant would be counted as explosive material.

3. Other data required for this analysis have been drawn from several sources. The initial volume of the explosive source was calculated from data supplied by the White Oaks Naval Ordnance Laboratories. The decay rate of GB in sea water was based upon Edgewood Arsenal data (detailed discussion of GB decay appears in reference c). Representative current and temperature profiles were drawn from the files of the National Oceanographic Data Center.

4. Calculations were made (based on the transport and diffusion model discussed in reference c) of the volumes in which the Ct=5,000 mg min/cu m (equivalent to

the LCt_{50} for small fresh water fish) and 50 mg min/cu m. The latter Ct value is included to provide a value with a large safety margin. Table 2 contains a summary of the information used in the calculations.

TABLE 2.—SUMMARY OF PARAMETERS [1]

Depth, feet	Initial volume, feet			Current velocity, knots	Temperature, C°
	Length	Width	Height		
1,000	170	170	380	1.5	12.0
2,000	130	130	210	.2	5.0
2,000	90	90	90	.15	3.5
15,000	70	70	60	.01	3.5

[1] Other parameters are detailed in reference c except for the 15,000 depth. For this depth the decay rate is 0.83×10^{-3} min^{1}, the lateral diffusion rate is $56 \times x^{1.15}$ and vertical diffusion rate is $20 \times x^{1/2}$ where x is the distance from the source in meters.

5. Tables 3 and 4 show the volumes of water which will have concentrations of at least 5,000 and 50 mg m/cu m respectively for a GB release at 1,000, 2,000, 7,000 and 15,000 ft below the surface.

TABLE 3.—VOLUME OF CONTAMINATED WATER

[Ct=5,000 mg—min/cu m]

Depth (feet)	Maximum dimensions, Km			Total volume cu miles
	Length	Width	Height	
1,000	32	0.46	0.18	0.62
2,000	16	2.67	.12	1.23
7,000	18	4.20	.60	1.10
15,000	3	1.80	.23	.03

TABLE 4.—VOLUME OF CONTAMINATED WATER

[Ct=50 mg min/cu m]

Depth (feet)	Maximum dimensions Km			Total volume cu miles
	Length	Width	Height	
1,000	79	2.6	0.25	12.2
2,000	40	9.6	.15	14.2
7,000	32	13.2	.74	7.5
15,000	4	3.4	.34	.1

15 JUNE 1970

C. PROBABILITY OF INITIATING A DETONATION OF ENTOMBED M55 ROCKETS

DEPARTMENT OF THE ARMY,
Office of the Assistant Secretary,
Washington, D.C.
(Attn: Assistant for Research, Dr. K. C. Emerson.)

1. Results of many tests conducted by this office indicate that the probability of initiating a detonation in either the warhead or motor of entombed M55 rockets is extremely remote. Specific test results germain to this conclusion are as follows:

(*a*) Tests conducted on 19 January 1970 prove that penetration of a bullet through the steel and concrete case into the burster charge is very probable. Comp B by design, substantiated by many tests, is not initiated by rifle bullets. Sensitive lead charges required to initiate the burster are well protected by the mass and geometry of fuze and packing material. These sensitive lead charges are also oriented out of alignment in the firing train and could not be expected to propagate a burster detonation even if they were initiated.

(*b*) The detonation of 50 lbs of 75% strength dynamite in juxtaposition with the warhead end of a vault proved ineffective in propagating a detonation during tests conducted on 19 January 1970.

c. One shaped charge functioned on the longitudinal axis and 22½ inches from a vault end is believed to have penetrated several warheads and no detonation occurred. Concomitantly a motor simultaneously inititated by another shaped charge on the opposite end of the vault vented through the container lid, the concrete encasement and caused over 10 lineal feet of weld along the vault end perimeter to fail. Significantly the motor burned with no detonation or propagation to other rockets.

d. Further proof that the motor when inititated will vent through container end cap, concrete encasement and welded steel shell rather than detonate due to confinement is obtained from the propagation test conducted 30 October 1969. Here again a motor initiated electrically, through a prearranged circuit, failed to propagate adjacent rockets.

e. Only motors fired during the incineration tests conducted 10–11 February 1970. None of the seven motors that were ignited detonated but rather vented through their container lids and concrete encasement to burn as in the other tests.

2. Copies of final report concerning all vault tests is being printed and will be available for mailing on 30 June 1970.

For the Commander:

F. H. Crist,
Chemical Ammunition Equipment Office.

D. Properties of GB and H in Seawater

(By Joseph Epstein and James D. Wood)

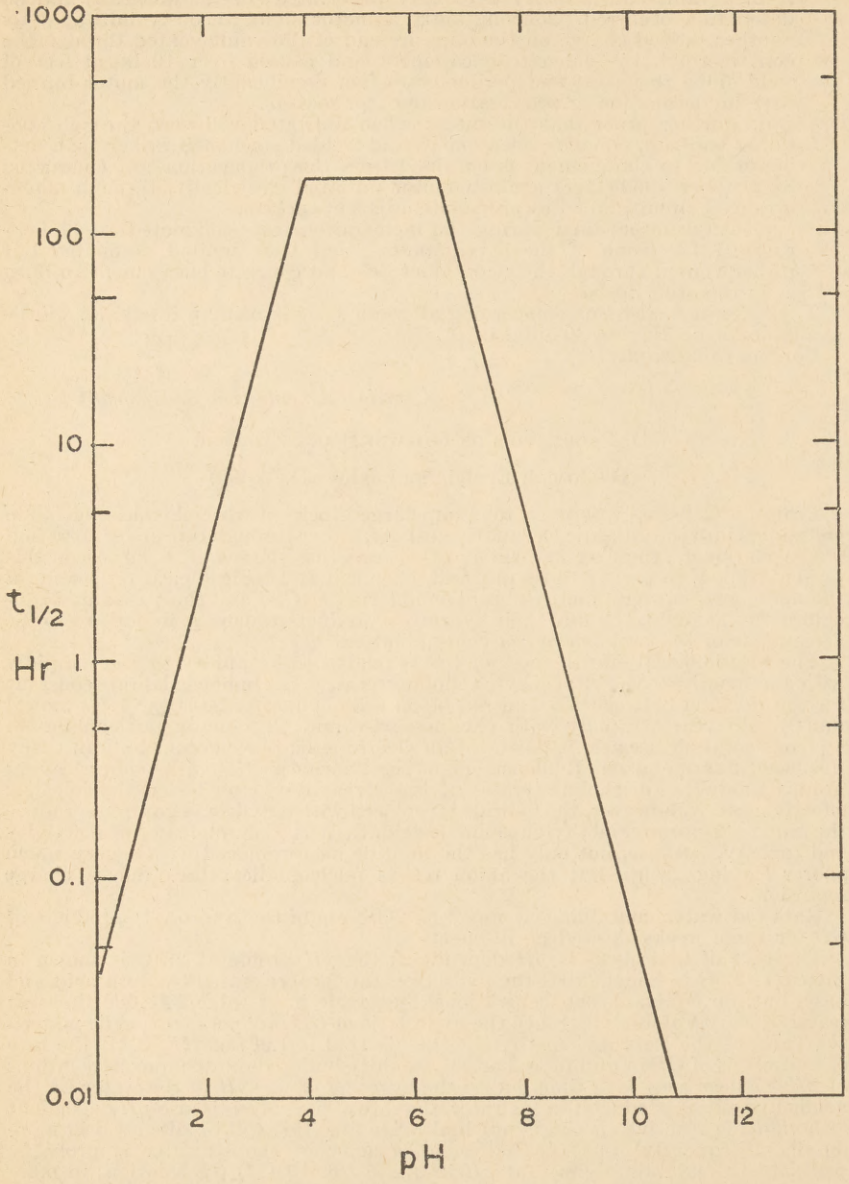
Project "CHASE" proposes to dump large stocks of toxic chemical agents in containers into the Atlantic Ocean. Eventually, either through rupture or corrosion of the containers, these agents will find their way into the sea. The purpose of this presentation is to review those physical, chemical and toxicological properties of the nerve gas isopropyl methylphosphonofluoridate (*GB*) and the vesicant, bis(β-chloroethyl) sulfide, (*H*) and their hydrolysis products which are important to the assessment of the problem of sea contamination.

The physiological effectiveness of *GB* is related to its ability to react rapidly with and inactivate the vital enzyme cholinesterase. (The bimolecular rate constant for the reaction between *GB* and red blood cell cholinesterase is ca. 10^7 δ mole^{-1} min^{-1}). *GB* reacts rapidly with cholinesterase and with many nucleophiles in aqueous solution because it possesses an electrophilic phosphorous and an easily displaced fluorine atom. Replacement of the fluorine in *GB* with poorer leaving groups produces anticholinesterases of lower reactivity and lesser physiological effectiveness. If, however, the fluoride is replaced with a hydroxyl group to produce the anion of isopropyl methylphosphonic acid, there is a complete loss of reactivity and toxicity, because, not only has the fluoride been replaced with a very much poorer leaving group, but the anion resists nucleophilic attack due to charge repulsion.

Rats fed water containing as much as 200 ppm of the hydrolysis products of *GB* for three weeks showed no ill effects.(1)

The rate of hydrolysis is *pH* dependent; the *pH* profile at 25°C is shown in Figure 1.(2) It is evident that the hydrolysis rate is accelerated by both acid and base, but, for equivalent concentrations, hydroxide ion is about 10,000 times as reactive as hydronium ion. Since the hydrolysis of *GB* produces two acidic materials, (pK_a of the isopropyl methylphosphonic acid is 1.96; of *HF*, 3.14) the rate of hydrolysis of *GB* in unbuffered or only slightly buffered dilute aqueous solutions of $pH \geq 7$ decreases with time due to the lowering of the *pH* of the water by the acidic hydrolysis products. In seawater, the rate of hydrolysis is also *pH* dependent although the reactive species is not hydroxide ion (this will be discussed in more detail subsequently) but the buffering capacity of the seawater is probably sufficient to maintain a constant *pH* in dilute (*ca.* $10^{-4}M$) *GB* solution; in more concentrated solutions, such as might be expected if a large quantity of agent were to be released into the sea in a short period of time, it is likely that the buffering materials would be overwhelmed and that there would be regions of low *pH* in the vicinity of the *GB* release. Under conditions of very rapid release of large quantities of *GB* followed by diffusion and dilution of the *GB*, it is thought that the pattern of hydrolysis will be very complicated—rapid at first, slowing down as the *pH* is lowered, speeding up as the *pH* is lowered further, slowing again as the *pH* rises due to dilution and passes through the range of minimum hydrolysis rate and then speeding up as the *pH* rises to the ocean *pH* where the decomposition then proceeds according to first-order kinetics.

FIGURE 1



The factors affecting the rate of displacement of fluoride ion from *GB* in aqueous medium are several, of which two are of importance in explaining the reactivity of seawater. First, it has been observed that in a series of related nucleophiles there is increase in reactivity with increasing basicity of the nucleophile. Graphically, a semi-log plot of the bimolecular rate constants vs the pK_a's of the conjugate acids of the nucleophiles is linear with a positive slope. Secondly, within a series of related nucleophiles, positively charged anions have higher bimolecular rate

constants than anions of the same series of the same basicity. (3)(4)(5) The effect of introduction of a cationic group into a weak acid is to lower its pK_a and, by ionization, produce a relatively higher concentration of the reactive nucliophile whose intrinsic reactivity with *GB* is similar to that of the uncharged nucleophile. Since the observed rate is dependent upon both the bimolecular rate constant and the concentration of the reactive species, one observes a high reactivity with nucleophiles containing cationic groups where the *pH* of the reacting medium is such as to take advantage of the pK_a change brought about by introduction of the cation.

Because of its high basicity, hydroxide ion is a very potent nucleophile, but at the *pH* of ocean water, it exists in low concentrations. The metal-hydroxo complexes which may be viewed as positively charged hydroxide ions, are present in relatively high concentrations. These are produced by dissociation of the hydrated metal ions.

$$M(H_2O)_n^{Z} \rightleftharpoons M(OH)^{Z-1}(H_2O)_{n-1} + H^+$$

Table I gives slopes and intercepts for a number of different nucleophiles for the equation

$$\log k_2\ (l\ \text{mole}^{-1}\text{min}^{-1}) = \alpha pK_a + C \text{ at } 25°C$$

TABLE I.—SLOPES (α) AND INTERCEPTS (C) IN DISPLACEMENT REACTION OF ISOPROPYL METHYLPHOSPHONOFLUORIDATE IN AQUEOUS SOLUTION

Nucleophiles (conjugate bases of)	α	C	*log k_2 for pK_a=9*
Hydrated aldehydes	0.46	−2.95	1.15 (25° C.)
Phenols	.59	−4.17	1.13 (25° C.)
Keto-oximes	.64	−3.25	2.53 (30° C.)
Pyrogallols	.76	−3.70	3.12 (25° C.)
Catechols	.81	−4.88	2.38 (25° C.)
Hydroxamic acids	.80	−3.87	3.35 (30° C.)

TABLE II.—*pK_a values and bimolecular rate constants ($l\ mole^{-1}\ min^{-1}$) for reaction of metal-hydroxo complexes and GB at 25° C*[1]

Metal ion	pK_a	log k_2
Cu^{2+}	8	4.08
Mn^{2+}	10.6	3.82
Mg^{2+}	11.4	3.41

[1] See the following equation:

$$M(H_2O)_x^{Z} \rightleftharpoons (HO)M(H_2O)_{x-1}^{Z-1} + H^+$$

Note: The last column gives the log of the bimolecular rate constant for a nucleophile of each class whose conjugate acid has a pK_a=9. For comparison, Table II gives the rate constants of several metal-hydroxo ions at 25°C (6)(7). The metal-hydroxo complexes are among the most reactive nucleophiles known for displacement of F^- from *GB*. They are even more active than hydroxide ion (log k_2=3.3). The higher reactivity shown by metal-hydroxo complexes is attributed to catalysis by the metal portion of the complex (acid-catalysis).

Yet, in neutral or even slightly alkaline solution, the concentration of the complex could be small due either to a low ionization constant of the hydrated metal ion or to the ease of formation of the insoluble dihydroxy compound or or polymerization products. To demonstrate the effectiveness of metal ion, however, the half-life of *GB* in water at *pH* 6.5 and 25°C is approximately 175 hours; the half-life of *GB* in the same water, but containing 1 ppm of Cu^{++}, is 2 hours.

Based upon the preceding discussion, the ions present in seawater which might be expected to contribute to the hydrolysis rate are metal-hydroxo ions, (especially those of magnesium and calcium since they exist in relatively high concentrations), hydroxide ions, bicarbonate and carbonate anions, The latter two can be neglected because of their relatively low basicities and concentrations.

Much of the data on hydrolysis of *GB* was obtained at low ionic strengths, i.e. 0.1, and in most cases the effect of ionic strength on the reaction rate has not been established. In seawater (ionic strength 0.7) the activities for the free ions of the major components have been listed as: (8) $A_{Na+}=0.356$; $A_{Mg++}=0.0169$; $A_{Ca++}=0.00264$; $A_{K+}=0.0063$; $A_{SO_4--}=1.79\times10^{-3}$; $A_{HCO_3-}=9.47\times10^{-4}$; $A_{CO_3--}=4.7\times10^{-6}$. The activity coefficient of Mg^{++} in seawater (5.3×10^{-2} *M*) is therefore 0.32 whereas in studies made on the reaction of *GB* in solutions containing magnesium ion (7), the activity coefficient was 0.67 ($\mu=0.03$).

As a first approximation, then, it is speculated that the first order rate of decomposition of *GB* in seawater, assuming constant *pH*, can be estimated from the equation:

$$k_{obs}=k_2\cdot\frac{K_a\cdot C_o}{[H^+]\cdot K_a}+k_2'\cdot\frac{K_a'\cdot C_o'}{[H^+]\cdot K_a}+k_2''\cdot\frac{K_w}{[H^+]}$$

where k^2 and $k/_2'$ are the bimolecular rate constants for the hydroxo-complexes of magnesium and calcium respectively and k_2'' is the bimolecular rate constant for the reaction with the hydroxide ion; K_a and K_a' are the ionization constants for the two ions (9) at 25°C ($pK_a=11.4$ and 12.7), and C_o and C_o' are their activities in seawater ($Mg^{++}=0.0169$ and $Ca^{++}=0.00264$). The values of k_2 and k_2' at 25°C, at unit activities, are 3.9×10^3 and 3.4×10^3 l mole^{-1}min^{-1}.

For prediction of rates at lower temperatures, it was assumed that the temperature dependence of k_2 and k_2' (not available) is the same as that of k_2''; (10) and that of K_a and K_2' is the same as that of K_w.

A comparison of the predicted with experimentally determined values is shown in Table III. The agreement between the calculated and found values at the temperatures of 15 and 25°C is very good; at 0.2°C, the predicted value is too high by a factor of approximately two. In view of the assumptions and the long extrapolation, this is not too surprising. It might be pointed out that had the assumption been made that the Arrhenius activation energy is 1.0 to 1.5 kcal less for the metal-hydroxo complex than for the hydroxide ion reaction the predicted value at 0.2°C would have been extremely close to the observed one; however, at 15°C the predicted value would be about 1.5 times that of the observed value.

TABLE III.—COMPARISON OF PREDICTED WITH EXPERIMENTALLY FOUND HALF-LIVES

Temp., ° C.	pH	$t_{1/2}$, minutes	
		Calc'd	Found
25	7.6	61.2	58.1 0.3 [1]
	7.9	30.7	25 3 [2]
15	7.7	167.0	159 2 [1]
0.2	7.7	28.8 (hrs)	15.9 0.1 [1] (hrs)

[1] 2 determinations.
[2] 4 determinations.

Two investigations have been conducted on the toxic effect of *GB* on freshwater fish. (11)(12) One studied the response of three species of fish to *GB*; the other determined the effects of certain environmental factors on the response of fish to *GB*. The tests were run at constant temperature and at *pH* 6.5 (pH of minimum hydrolysis rate of *GB*). The fish were exposed to concentrations of *GB* ranging from approximately 10 *ppb* to 50 *ppm*. The time for 50% of the test animals to succumb was recorded. The results are shown in Table IV.

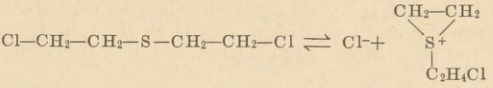
It is obvious that the *LCt*50 value for any species at either of the two temperatures is not a constant, nor is this to be expected. At low concentrations, the animal detoxification rate becomes important. At very high concentrations, other mechanisms of death production are probably rate-controlling. Between the ranges of concentration of 0.1 to 1 *ppm*, the *LCt*50 for the three species is approximately 5 *mg* min/*l*. Also, there is approximately a two-fold difference in the *LCt*50 figure at 24° C and 12° C. In the second study, the oxygen concentration in the water was found to have a pronounced effect on the T50; the higher the dissolved oxygen concentration, the larger the T50. The findings are explained on the basis that the fish need smaller volumes of water if the oxygen concentration is high and hence are subjected to less of the toxic agent.

TABLE IV.—EFFECT OF TEMPERATURE ON TOXICITY OF GB TO FISH

Fish species	Conc. GB p.p.m.	24°C T50 min	24°C LCt50 mg min/l	12°C T50 min	12°C LCt50 mg min/l
Sunfish	50	0.95	47.5	1.55	77.5
	10	1.65	16.5	3.4	34.0
	1.0	5.8	5.8	14.0	14.0
	0.1	35	3.5	120	12.0
	0.01	320	3.2	2,400	24.0
Goldfish	50	1.5	75	2.3	115.0
	10	2.2	22	4.2	42.0
	1	7.5	7.5	19.0	19.0
	0.1	52	5.2	170	17.0
	0.01	2,000	20	10,000	100.0
Minnows	50	0.8	40	1.3	65.0
	10	1.25	12.5	2.7	27.0
	1.0	3.25	3.5	11.0	11.0
	0.1	26	2.6	80	8.0
	0.01	360	36	1,700	17.0

In contrast to the effect of various ions and *pH* on the hydrolysis of *GB*, the hydrolysis rate of mustard gas (9) is *pH* independent and no effect has been noted of the effect of metals (Ag^{+}, Cu^{++}, Mn^{++}, Ni^{++}, Fe^{+++}) on the hydrolysis rate of *H*. The hydrolysis of *H* in dilute solution proceeds by two steps:

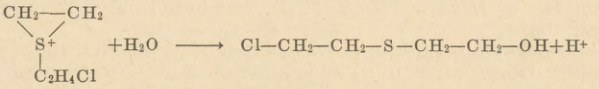
a) An ionization



Step 1

and

b) A reaction between the sulfonium ion and water



Step 2

Both the parent mustard and the sulfonium ion are physiologically active; the half-mustard is very much less reactive. Relative to mustard the half-mustard rapidly undergoes ionization and subsequent reaction with water to form the non-toxic thiodiglycol.

The rate is controlled by ionization (Step 1). Since the ionization is an equilibrium and highly dependent upon the chloride ion concentration, the rate of hydrolysis of *H* in seawater is very much less than that in distilled water. Data on the first order rate constants of *H* in distilled water and seawater at different temperatures are shown in Table V. It is estimated by extrapolation of the data to $T = 3.5°$ C, that the $t_{1/2}$ of dissolved *H* will be of the order of 2.5 days.

TABLE V.—EFFECT OF TEMPERATURE ON HYDROLYSIS RATE OF H

	T, °C	R_x, min^{-1}	$t_{1/2}$, min
Distilled water	0.6	4.4×10^{-3}	158.0
	10.0	1.2×10^{-2}	57.8
	20.0	4.7×10^{-2}	14.7
	30.0	2.1×10^{-1}	3.3
	12.5	2.1×10^{-2}	32.2
	14.5	2.8×10^{-2}	24.8
Seawater	25.0	1.2×10^{-2}	60.0
	30.0	2.8×10^{-2}	25.0

Note: Data from Summary Technical Report of Division 9, NDRC.[13] Rate in distilled water about 15 times that in seawater. Solubility=ca 0.6 g/l (600 ppm).

It is pertinent to point out that *H* has specific of 1.27 at 25° C, freezing point of 14° C (at 200 atmospheres, the pressure at 7200 ft, it may be expected to be even higher) and hence would be expected to solidify at the temperature of the bottom of the ocean. If the solid were to be exposed to the sea water, there would be a gradual solution of the *H* and the half-life of the *H* which dissolved would be approximately 2.5 days.

The rate of dissolution of solid *H* at 3° to 5° C in a simulated seawater moving at approximately 0.15 knots has been determined to be approximately 3×10^{-7} g/cm²/sec. (0.05 lb/ft²/day). The exposed surface of "frozen" mustard from a corroded or ruptured one-ton cylinder can be assumed to be about 40 ft². Thus, initially, 2 lb of *H* will be dissolved per day per cylinder. An average dissolution rate of 0.025 lb/ft²/day can be assumed to calculate the time to dissolve the total contents of a cylinder. For a ton of *H*, this would be about 5 years.

In experiments on fish 14 at 2 *ppm H*, 22 of 30 bluegills died within the thirty day observation period. No fish died at 1 *ppm* nor in the control tests; all fish died at 5 ppm or higher. Bluegills died as a consequence of two separable effects as indicated by bimodal curves with maxima at about 1.5 and 10 days when rate of death was plotted against time. At 25 to 200 *ppm H*, fish died as a result of a rapid-action effect of H (possibly its vesicant action) whereas the fish in concentrations of 2 to 25 *ppm* died as a consequence of a slow-action effect (perhaps the systemic poisoning effect of the *H*).

The following approximate threshold concentrations were found at which various aquatic species died within the thirty day period: 2 *ppm*: for bluegills, red-eared sunfish, and black bullheads; less than 5 *ppm* for guppies and bullfrogs; greater than 5 *ppm* for large mouth black bass; and 10 *ppm* for crayfish.

Levinstein *H* was slightly less lethal than refined *H* at 2 and 10 *ppm;* at 200 *ppm*, however, Levinstein *H* killed bluegills in significantly less time (possibly due to the lethal effect of some by-product in the Levinstein *H* which reached a threshold concentration only in the high dosage but had more rapid action than the *H*).

The toxicity of the principal hydrolysis product of H, thiodiglycol (*TG*), was found to be negligible. *TG* in concentrations up to 1000 *ppm* failed to kill bluegills within a observation period of forty-two days. A secondary hydrolysis product, the sulfonium salt of *H* with *TG* (*H* 2*TG*), was lethal only at concentrations of 1000 *ppm* and above.

Thus, if the stocks dumped into the ocean reach the bottom, the *H* would freeze and remain in a frozen state until such time as it was exposed to seawater. It would then dissolve, the quantity being a function of the surface area exposed (0.05 lb/ft²/day). That which dissolves would be decomposed into harmless materials at a rate of approximately 0.3 day^{-1}. GB exposed to the seawater will dissolve rapidly and hydrolyze at a rate dependent upon the *pH* and the temperature. For *pH* 7.6 and $t=3.5°C$, the rate would be approximately 0.05 hr^{-1} at the bottom of the ocean. It is pertinent to point out at this time, that, according to marine biologists, the animal species that exist at these depths in the ocean are scavengers, and that they do not contribute to the human food supply (except perhaps very, very indirectly).

To assist the committee in its assessment of the hazards that could result from dissolution of the agents into the seawater, calculations have been made of the volumes of contamination that would be obtained if the total of the *GB* were a) released at the bottom of the ocean continuously over different time periods ranging from one month to a year and b) released instantaneously at different depths of the ocean (the latter case is considered extremely unlikely). Contamination of the seawater by *H* to hazardous levels is considered to be very improbable because of its low dissolution rate. A fully exposed cylinder of "frozen" *H* has an area of approximately 4×10^4 *cm*². The time of contact of seawater flowing at 0.15 knots over the length of the cylinder is 25 seconds. Hence the total amount of *H* dissolved in one pass over the total surface is approximately 0.3 *g*. Assuming that this quantity will be contained in approximately 10^3 *l* (40 ft³), the *peak* concentration (at the source) will be only 0.3 *ppm*. Small species of fish live indefinitely at concentrations as high as 1 ppm.

For calculations using *GB*, the mathematical model used is one for atmospheric diffusion originally proposed by Sutton, but revised to include diffusion parameters suggested by Dr. Akira Okubo(15) of the Chesapeake Bay Institute, The Johns Hopkins University, who has recently completed a study "On the Prediction of the Probable Distribution of Concentration from Hypothetical Radioactive Sources in the Continental Slope off the East Coast of the U.S." The mathematical statement of this model is:

$$D(x, y, z, t) = \frac{Q}{4\pi\sigma_y\sigma_x\overline{U}} \exp\left[-\left[\frac{y^2}{2\sigma_y{}^2}\,\frac{z^2}{2\sigma_z{}^2}\,\frac{kx}{\overline{U}}\right]\right]\left[1-\operatorname{erf}\left[\frac{x-\overline{U}t}{\sqrt{2\sigma_x}}\right]\right]$$

where

D is the concentration-time product in mg min/m³
x, y, z, t are the space and time coordinates in meters and minutes
$\overline{U}$ is the mean transport velocity in m/min
k is the first order hydrolysis rate in min^{-1}
$\sigma_x, \sigma_y, \sigma_z$ are parameters dependent on x to incorporate diffusion in m
Q is the source size in mg

If t is set to infinity for total effects this equation becomes:

$$D(x, y, z) = \frac{Q}{2\pi\sigma_y\sigma_z\overline{U}} \exp\left[-\left[\frac{y^2}{2\sigma_y{}^2}+\frac{z^2}{2\sigma_z{}^2}+\frac{kx}{\overline{U}}\right]\right]$$

For the situation involving release over a period of time, the source strengths were taken as the total quantity of *GB* (960 tons) divided by the time of release so that solution of the equation gave concentration profiles; for the case of instantaneous release, presumably by explosion, initial concentrations of *GB* were calculated from the total quantity of *GB* and an estimate of the volumes that the *GB* would be released into at different depths of explosion. The volumes were estimated by personnel of the Naval Ordnance Laboratory, White Oak, Md. The calculations in the latter case were based upon a volume source. Since the mathematical model is for a point source, it was necessary to calculate virtual points x_{oy} and x_{oz} which would produce the initial size of the toxic cloud when $x=0$.

Empirical values for the diffusion parameters in point source calculations σ_y and σ_z were obtained using Okubo's relationships:

$$\sigma_y = at^{1.15}$$
$$\sigma_z = (2k_z t)^{0.5}$$

where a=proportionality constant and k_z is the diffusion coefficient and is depth dependent. For the volume source,

$$\sigma_y = c(x+x_{oy})^{1.15}$$
$$\sigma_z = \beta(x+x_{ov})^{0.5} \text{ where } \beta = \sqrt{\frac{2k_z}{\overline{U}}}$$

The iuitial σ_y and σ_z values were taken to be one-fourth of the initial width and height of the toxic volume respectively.

The hydrolysis rates at the *pH* and the temperature of the seawater were estimated from the data given previously. Ocean currents at various depths were obtained from the National Oceanographic Data Center. Calculations were made of volumes in which the $Ct=5000$ *mg* min/m³ (equivalent to $Ct=5$ *mg* min/*l* the *LC*50 value for small freshwater fish at 24°C) and 50 *mg* min/m³, the instantaneous release situations and for volumes containing concentrations in excess of 0.01 *ppm* in the continuous release cases. Table VI gives a summary of the parameters used in the calculations.

TABLE VI—SUMMARY OF PARAMETERS

Depth feet	Volume			GB decay rate	$\sigma_y{}^d$	$\sigma_z{}^d$
	Length feet	Width feet	Height feet	$min^{-1}\times10^3$	$M\times10^{-2}$	$M\times10^{-2}$
1,000	180	180	350	2.36	0.1714×1.15	$0.161\times\frac{1}{2}$
2,000	130	130	210	0.98	1.739×1.15	$0.441\times\frac{1}{2}$
7,000	100	100	100	0.81	2.421×1.15	$5.09\times\frac{1}{2}$

(a) Current velocity=1.5 knots; t=12° C.
(b) Current velocity=0.2 knots; t=5° C.
(c) Current velocity=0.15 knots; t=3.5° C.
(d) x=$\overline{U}$t.

Tables VII and VIII show the volumes of water which will have a) $Ct \geq 5000$ *mg* min/m³ and b) ≥ 50 *mg* min/m³ for *GB* release at 1000 ft, 2000 ft, and 7000 ft. Table IX shows the volumes containing concentrations ≥ 0.01 *ppm* if all the *GB* were released continuously and uniformly over periods of 1, 3, 6, and 12 months.

TABLE VII.—VOLUMES OF CONTAMINATED SEAWATER FROM AN EXPLOSION

[Ct=5,000 mg min/m³]

Depth, feet	Maximum dimensions			Total volume, cubic miles
	Length, mx10⁻³	Width, mx10⁻³	Height, m	
1,000	77	1.5	206	5.7
2,000	30	6.3	154	7.0
7,000	28	8.6	70	4.0

TABLE VIII.—VOLUMES OF CONTAMINATED SEAWATER FROM AN EXPLOSION

[Ct=50 mg min/m³]

Depth, feet	Maximum dimensions			Total volume, cubic miles
	Length, mx10⁻³	Width, mx10⁻³	Height, m	
1,000	150	4.5	288	46.6
2,000	58	15.4	176	37.7
7,000	49	20.0	84	19.8

TABLE IX.—CONTAMINATION FROM SLOW RELEASE OF GB—MAXIMUM CONCENTRATION=0.01 P.P.M.

Time of release (month)	Contamination volume			Total volume (cubic miles)
	Length mx10⁻³	Width m	Height m	
12	6.2	960	12	0.017
6	7.8	1,330	14	.035
3	9.7	1,800	16	.067
1	13.0	2,700	18	.15

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