THE RADIOLOGICAL CLEANUP OF ENEWETAK ATOLL

DEFENSE NUCLEAR AGENCY

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Washington, D.C. 1981

To the People of Enewetak who sacrificed so much on behalf of the peace of the world and the security of free men everywhere;

To the memory of the six U.S. servicemen who lost their lives at Enewetak Atoll during the cleanup; and,

To the thousands of individuals whose unswerving commitment to the people of Enewetak and sustained support to the Department of Defense over the eight years of the project made possible the remarkable success of this great humanitarian effort.

FOREWORD

For 8 years, from 1972 until 1980, the United States planned and carried out the radiological cleanup, rehabilitation, and resettlement of Enewetak Atoll in the Marshall Islands. This project represented the fulfillment of a long-standing moral commitment to the People of Enewetak. The cleanup itself, executed by the Department of Defense (DOD), was an extensive effort, involving a Joint Task Force staff and numerous Army, Navy, and Air Force units and personnel. The rehabilitation and resettlement project, carried out by the Department of the Interior concurrently with the cleanup, added complexity to the task and required the closest coordination — as did the important involvement of the Department of Energy (DOE), responsible for radiological characterization and certification. The combined effort cost about $100 million and required an on-atoll task force numbering almost 1,000 people for 3 years, 1977-1980. No radiological cleanup operation of this scope and complexity has ever before been attempted by the United States.

This documentary records, from the perspective of DOD, the background, decisions, actions, and results of this major national and international effort. Every attempt has been made to record issues as they developed, and to show the results, good and bad, of specific decisions, oversights, etc. Because this documentary may have considerable importance in the future, and because specific needs for data cannot be foreseen with accuracy, every attempt has been made to record in some detail all major facets of the operation and to reference key documents. Throughout the research, collection, and writing, four major types of potential users have been kept in mind. The documentary is designed:

— First, to provide a historical document which records with accuracy this major event in the history of Enewetak Atoll, the Marshall Islands, the Trust Territory of the Pacific Islands, Micronesia, the Pacific Basin, and the United States. To serve this end, the documentary addresses political, legal, administrative, and social issues; and it attempts to put the cleanup in perspective in terms of the prior history of Enewetak Atoll, World War II, the nuclear testing period, and the United Nations Trusteeship.

— Second, to provide a definitive record of the radiological contamination of the Atoll. It addresses the origins of the contamination on a shot-by-shot basis; the types, concentrations, and locations of contamination prior to the cleanup; the radiological cleanup decisions and their rationale; the cleanup processes themselves; and the resulting radiological situation, island-by-island. It is believed that this type of data will be useful over the coming decades as living patterns on the Atoll change, new radiological surveys are taken, improved health physics understanding becomes available, and new risk-benefit decisions are made. For this purpose this documentary will supplement the more technical data published by DOE.

— Third, to provide a detailed record of the radiological exposure of the cleanup forces themselves. As years pass, it will become increasingly important to the cleanup participants, to the U.S. Government, and to health physicists and radiation biologists, to have a meticulously accurate record of the radiological safety policies and procedures; an overview of personnel assignment practices; and a careful summarization of air sampler readings, film badge and thermoluminescent dosimeter exposures, bioassay samples, etc.

— Fourth, to provide a useful guide for subsequent radiological cleanup efforts elsewhere. It seems likely that there will be future requirements for radiological cleanup of extensive areas which present complex contamination problems. Since the Enewetak cleanup was a bellwether effort of its kind, the many lessons learned should provide useful guidance for those who will plan and execute future efforts. Information such as this is quickly lost if not permanently recorded.

In developing this documentary, every effort has been made to be accurate, balanced, and objective. However, since issues can appear in somewhat different light when viewed from different organizational perspectives, the reader should keep in mind that the authors generally have a DOD affiliation.

R. R. Monroe

August 1980

ROBERT R. MONROE
Vice Admiral, U.S. Navy
Director, Defense Nuclear Agency

PREFACE

Field Command, Defense Nuclear Agency has prepared this documentary to provide the general reader a narrative history of the radiological cleanup of Enewetak Atoll and to provide the interested researcher a description of the procedures used to support and accomplish the radiological cleanup. It is intended to present a balanced, objective review of the mistakes made and lessons learned, as well as the many successes achieved during the project. Much of the knowledge and experience gained during the project would be applicable to any military operation in the harsh environment of a tropical atoll, and the radiological cleanup experience represents an invaluable national asset in the Atomic Age. It is the aim of this documentary to record that experience while it is readily available. To complete the description of the United States effort to restore the atoll, the last chapter includes an account of the Rehabilitation Program which was conducted by the Department of the Interior concurrently with the cleanup project.

This report was compiled from historical documents stored in the Enewetak Radiological Cleanup repository at the Defense Nuclear Agency's Field Command in Albuquerque, New Mexico. The bibliographical notes, which are identified by superscripts within the text, are intended to provide future researchers with a guide to documents containing additional data regarding subject matter of the text as well as sources for the text itself.

The compilers have endeavored to arrange events by topics and operational categories as well as in chronological order. As a result, there is some overlapping of chronology between the chapters and sections. To facilitate continuity for the general reader, brief summary paragraphs have been included where appropriate, with the hope that the researcher will overlook these occasional redundancies.

In the use of names, the preference of the group being named has been followed. In Marshallese, the prefix "dri-" means "people of." Thus, "dri-Enewetak" means the people of Enewetak Island in particular, as well as the people of Enewetak Atoll as a whole. The people of Enjebi Island refer to themselves as "dri-Enjebi" in distinguishing themselves from the other people of the atoll, but as "dri-Enewetak" when referring to all the people of the atoll.

In referring to the operational element of the Defense Nuclear Agency (DNA), the term "Field Command" is commonly used for "Field Command, Defense Nuclear Agency" in actual practice and in this documentary. During the period covered by this report, the organization originally known as the Atomic Energy Commission (AEC) has been reorganized and renamed twice. On 1 January 1975, it became the Energy

Research and Development Administration (ERDA); and, on 1 October 1977, it became part of the Department of Energy (DOE). This organization is referred to in this documentary by the name in effect at the time of the event being described.

This report was compiled by members of the Field Command staff with the assistance of Headquarters, DNA; Headquarters Joint Task Group; and other personnel who were involved in the cleanup of Enewetak Atoll. The principal authors were Colonel Robert L. Peters, Director of Enewetak Operations at Field Command for over 2 years of the project, and Mr. David L. Wilson, Chief of Logistics Services Division and one of the principal planners at Field Command from the project's inception. The viewpoint represented is intended to be that of the Defense Nuclear Agency alone, and not necessarily that of the other agencies involved.

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CHAPTER 1

DESCRIPTION AND HISTORY 1526 - 1972

GEOGRAPHY

Enewetak Atoll is a small ring of islands approximately 2,500 miles west of Hawaii at latitude 11° 21′ N and longitude 162° 21′ E (Figure 1-1). It is the only surface feature of one of the three chains of islands known as the

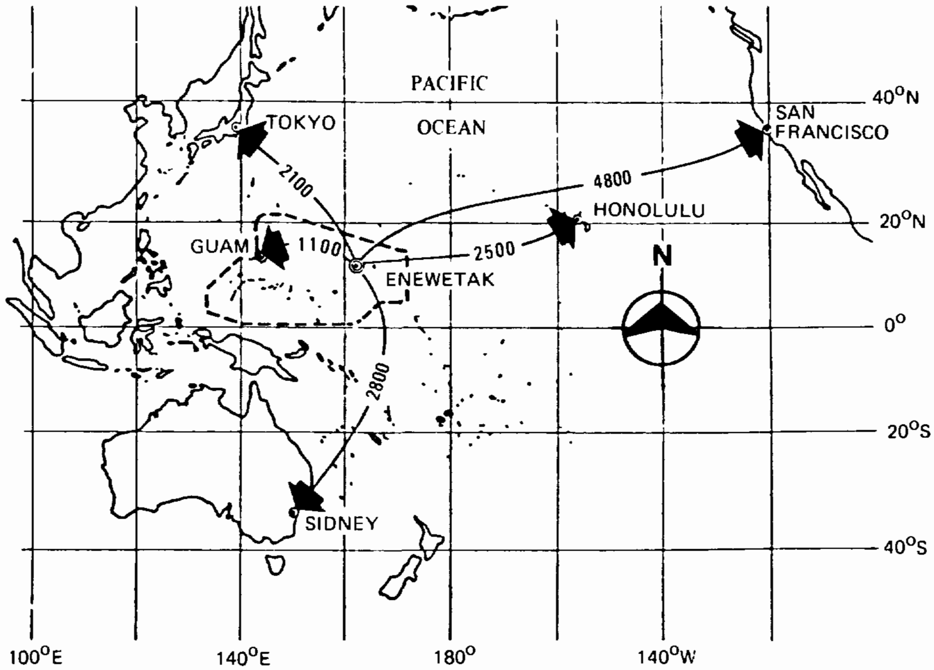


FIGURE 1-1. GREAT CIRCLE DISTANCES FROM ENEWETAK ATOLL.

Marshall Islands Group (Figure 1-2). The range of undersea mountains which form this chain was not identified as such until 1950. Prior to that, Enewetak was considered part of the Ralik or "Sunset" chain. The Ratak or "Sunrise" chain is the easternmost of the Marshall Islands Group (Figure 1-3).[1]

Enewetak Atoll contains some 40 named islands, two coral heads large enough to have been named by the dri-Enewetak, a number of small unnamed islets, and long stretches of submerged reefs (Figure 1-4). During the nuclear test period, the major islands were assigned "site" names by U.S. Government personnel. The northern islands were

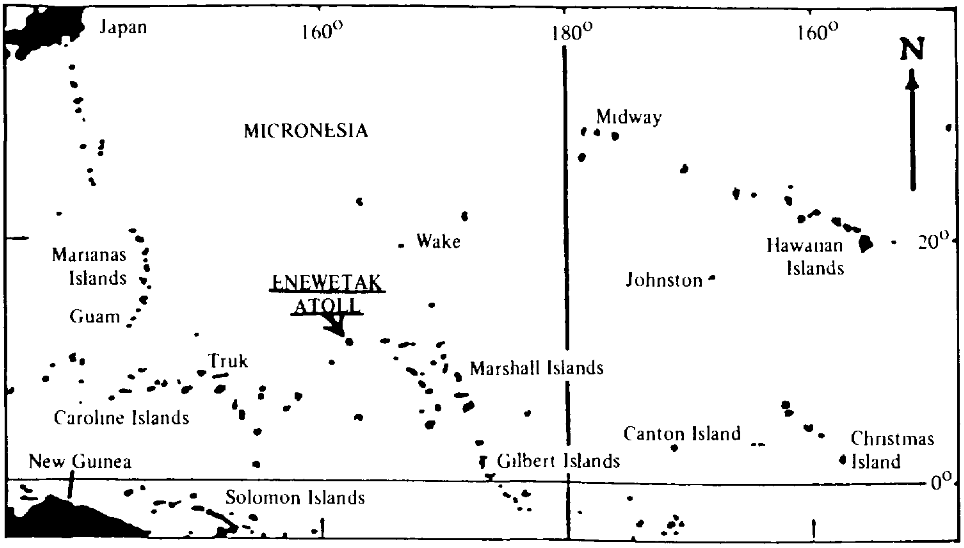


FIGURE 1-2. LOCATION OF THE MARSHALL ISLANDS IN THE WESTERN PACIFIC.

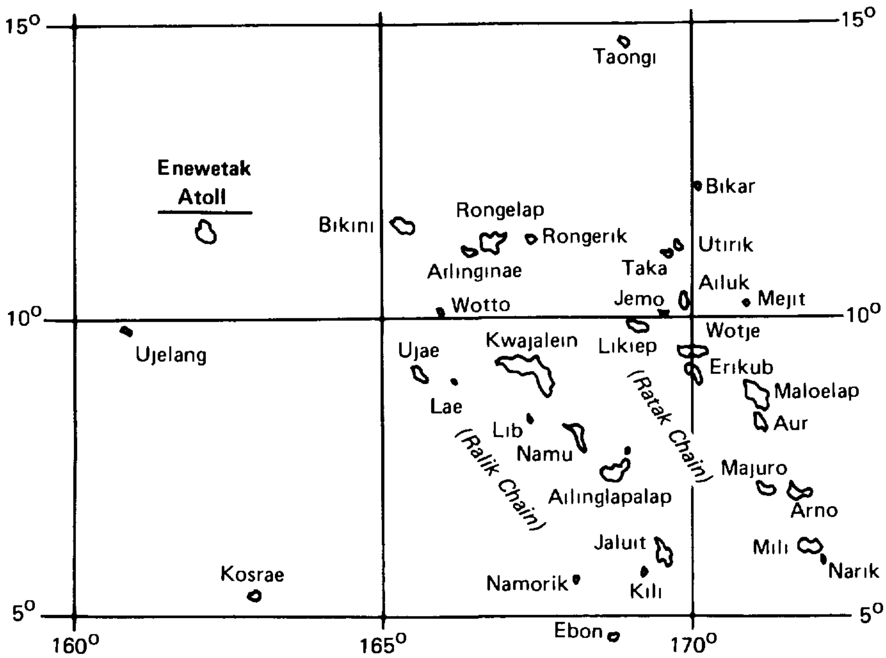
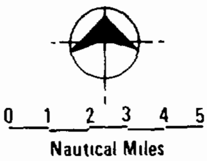


FIGURE 1-3. LOCATION OF ENEWETAK ATOLL IN THE MARSHALL ISLANDS.



	Enjebi	Lojwa	Japtan	Medren	Enewetak
Enjebi		6	17	17	20
Lojwa	6		12	13	16
Japtan	17	12		2	6
Medren	17	13	2		5
Enewetak	20	16	6	5	

MILEAGE TABLE
(Nautical Miles From Dock to Dock)

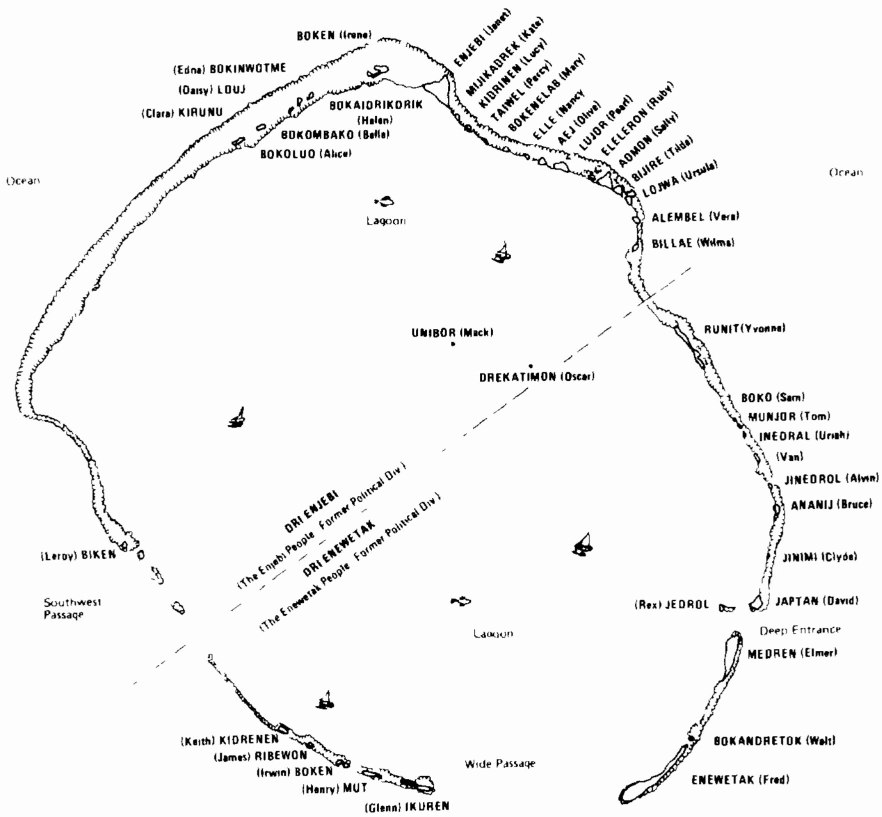


FIGURE 1-4. ISLANDS OF ENEWETAK ATOLL.

assigned female names in alphabetical order beginning with "Alice" and continuing clockwise through "Yvonne." The southern islands were assigned male names beginning with "Alvin" and continuing clockwise through "Leroy." Subsequently, additional site names were assigned to smaller islands and other features, disrupting the original order of assignment. The site names are shown in parentheses in Figure 1-4. The spelling used for the island names is that adopted in 1974 by the U.S. Board of Geographical Names as best representing the pronunciations of the dri-Enewetak.

The atoll is approximately 23 by 17 statute miles with the long axis running northwest to southeast. The land surface area totals 1,761 acres or 2-3/4 square miles (Figure 1-5). The lagoon has an area of approximately 388 square miles. Its depth averages 160 feet with a maximum of approximately 200 feet.[2,3] There are three entrances to the lagoon: the east channel or Deep Entrance, 180 feet deep, lying between Medren (Elmer) and Japtan (David); the Wide Passage in the south, 6 miles in width; and a 24-foot deep channel called the Southwest Passage. Figures 1-6 through 1-16 provide a pictorial introduction to the islands of the atoll.

GEOLOGY

Enewetak Atoll was formed by the growth of coral reefs on an extinct volcano (Figure 1-17). Coral reefs, and subsequently atolls themselves, consist of limestone which is produced by coral animals (coelenterate polyps), coralline algae, and shelled animals. These living organisms require warm, agitated water and strong sunlight to stay alive. This is particularly important to the coral animal forms since they are attached and can only get food which drifts to them. Corals and other reef builders, including algae, produce limy skeletons which, along with coral rubble, sand and other sedimentary material, are bound together in a rock-like mass by the limy secretions of the coralline algae. This continuous production of limy skeletons and binding by the algae results in the formation and growth of the coral reefs.[4]

The rate of growth of coral reefs is relatively faster on the ocean side of the volcanic mass than on the lagoon side because of more nutrition and aeration in the wind-driven water[5] Coral may grow vertically at an average rate of one millimeter per year. The rate and direction of growth varies with water depth and ceases completely when the coral is exposed by variances in relative sea level. Such variances are associated with the lowering of ocean levels during periods of glaciation. Thus, the growth rate and morphology are affected alternately by the submersion and subaerial exposure of the reef. Once the coral colonies reach the surface or are

SITE	ACRES*	HECTARES**
Enewetak (Fred)	322	130
Enjebi (Janet)	291	118
Medren (Elmer)	220	89
Aomon (Sally)	99	40
Runit (Yvonne)	91	37
Japtan (David)	79	32
Lujor (Pearl)	54	22
Bijire (Tilda)	52	21
Ikuren (Glenn)	41	17
Lojwa (Ursula)	40	16
Aej (Olive)	40	16
Mut (Henry)	40	16
Boken (Irene)	40	16
Alembel (Vera)	38	15
Bokombako (Belle)	31	12
Boken (Irwin)	29	12
Ananij (Bruce)	25	10
Kidrenen (Keith)	24	10
Bokoluo (Alice)	22	9
Louj (Daisy)	21	9
Kidrinen (Lucy)	20	8
Ribewon (James)	19	8
Mijikadrek (Kate)	16	6
Billae (Wilma)	14	6
Biken (Leroy)	14	5
Bokenelab (Mary)	12	5
Elle (Nancy)	11	4
Bokinwotme (Edna)	10	4
Kirunu (Clara)	7	3
Van	7	3
Jedrol (Rex)	5	2
Bokaidrikdrik (Helen)	5	2
Taiwel (Percy)	5	2
Eleleron (Ruby)	4	2
Inedral (Uriah)	4	2
Jinimi (Clyde)	3	1
Jinedrol (Alvin)	2	1
Munjor (Tom)	2	1
Boko (Sam)	1	.5
Bokandretok (Walt)	1	.5
TOTAL 40 Sites — 76,700,000 Sq. FT. (2.75 Square Miles)	1,761 Acres	713 Hectares

*1 Acre = 43,560 Sq. Ft. = .405 Hectares
**1 Hectare = 107,639 Sq. Ft. = 2.47 Acres

FIGURE 1-5. APPROXIMATE LAND AREAS, ENEWETAK ATOLL.

FIGURE 1-6. ENEWETAK (FRED) AND BOKANDRETOK (WALT).

FIGURE 1-7. MEDREN (ELMER) AND JAPTAN (DAVID).

FIGURE 1-8. JINIMI (CLYDE), ANANIJ (BRUCE), JINEDROL (ALVIN), VAN (NO MARSHALLESE NAME), INEDRAL (URIAH), MUNJOR (TOM), AND BOKO (SAM).

FIGURE 1-9. RUNIT (YVONNE).

FIGURE 1-10. BILLAE (WILMA) AND ALEMBEL (VERA).

FIGURE 1-11. LOJWA (URSULA), BIJIRE (TILDA), AOMON (SALLY), ELELERON (RUBY), LUJOR (PEARL), AEJ (OLIVE), AND ELLE (NANCY).

FIGURE 1-12. BOKENELAB (MARY), TAIWEL (PERCY), KIDRINEN (LUCY), MIJIKADREK (KATE), AND ENJEBI (JANET).

FIGURE 1-13. BOKEN (IRENE) AND BOKAIDRIKDRIK (HELEN).

FIGURE 1-14. BOKINWOTME (EDNA), LOUJ (DAISY), BOKOMBAKO (BELLE), KIRUNU (CLARA), AND BOKOLUO (ALICE).

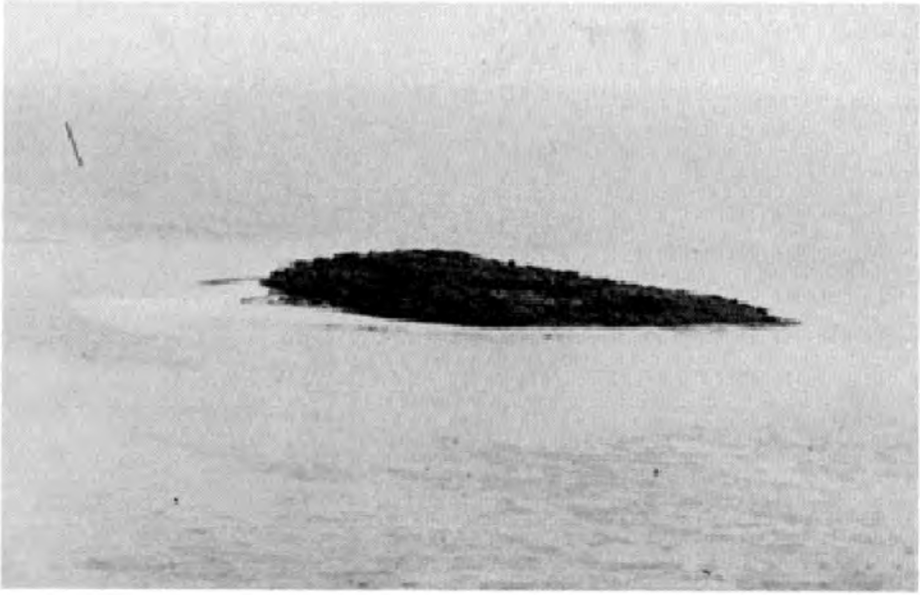


FIGURE 1-15. BIKEN (LEROY).

FIGURE 1-16. KIDRENEN (KEITH), RIBEWON (JAMES), BOKEN (IRWIN), MUT (HENRY), AND IKUREN (GLENN).

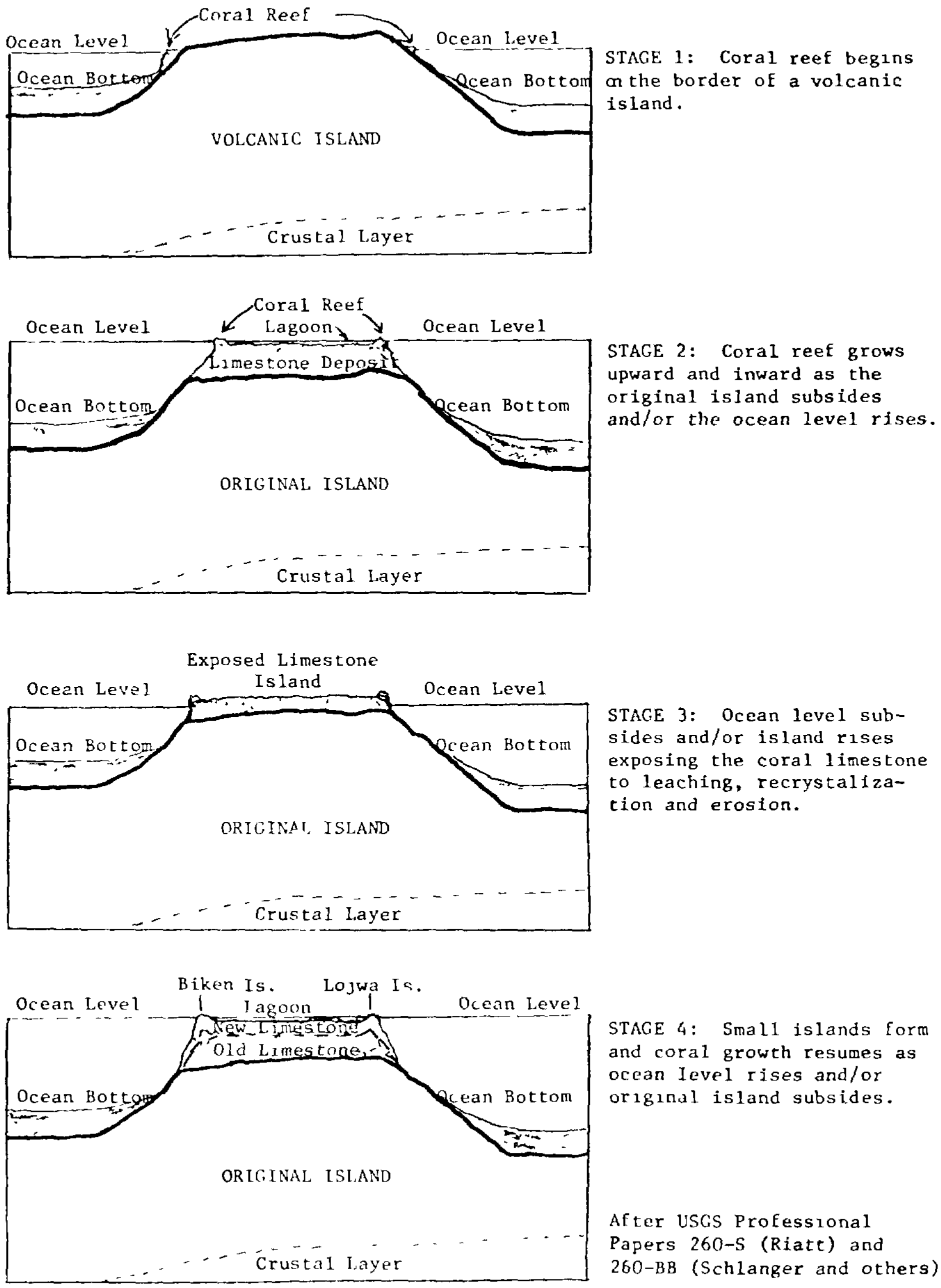


FIGURE 1-17. EVOLUTION OF ENEWETAK ATOLL.

exposed, lateral growth is promoted. Erosion of the coral and cementation of the resulting sediments also affect the formation and geology of the atoll. Enewetak Atoll has been forming for at least 43 million years, resulting in a 4,500-foot stratification of reef-derived carbonate deposits.

Several drilling programs have been conducted to determine the subsurface composition and deposition of Enewetak Atoll. The Atomic Energy Commission (AEC) and Los Alamos Scientific Laboratory drilled 33 holes less than 200 feet deep during 1950-51. The U.S. Geological Survey (USGS) drilled three deep holes, two to the basalt (volcanic rock base), during 1951-52.[6] An additional 174 shallow core holes were drilled in support of Defense Nuclear Agency (DNA) programs[7] to understand the near subsurface geology (less than 300-foot depth) of the atoll in 1972-73.

Based on results of the USGS and DNA drilling programs, the subsurface geology of the atoll is found to be both laterally and vertically variable. In general, the ocean-side reef consists of well cemented limestone, whereas the backreef and lagoon sediments consist of uncemented coralline sands and gravels derived from the ocean reef organisms and the many patch and pinnacle reefs in the lagoon. Holes drilled near the ocean reef edge penetrated predominately moderate to well cemented sediments, whereas holes near the lagoon penetrated predominately uncemented to poorly cemented sediments. This correlation between surface and subsurface distribution of rock types is indicative of little lateral shifting of the reef and associated deposited environment during the past few million years.

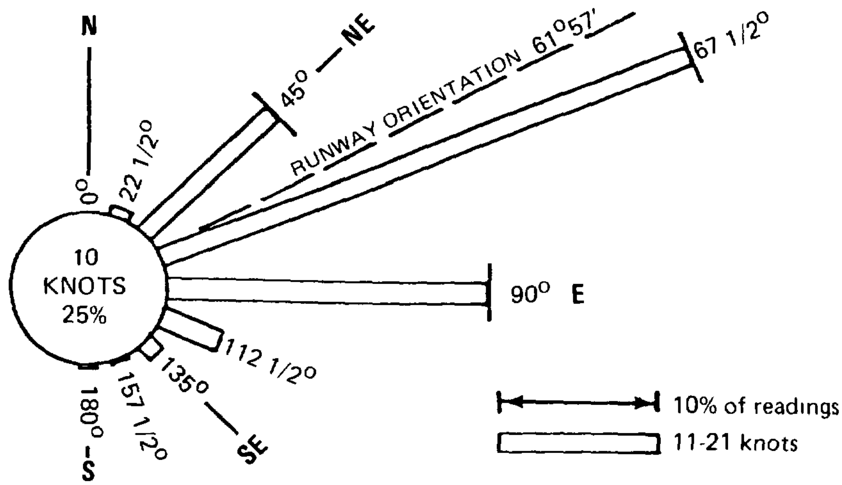
A generalized geologic profile beneath the islands is as follows: unconsolidated coralline sands and gravels between the island surface and the intertidal zone; within the intertidal zone, a layer of well cemented coralline beachrock from a few inches to 8 to 10 feet thick is found. Recent coralline sands and gravels exist between the beachrock and 45-foot depth, whereas an alternating sequence of cemented and uncemented coralline sands and gravels exist to 600 feet.[8] Between 600 and 1,000 feet the sediments again are composed of uncemented coralline sands and gravels, and between 1,000 and 1,200 feet cemented coralline sands and gravels are encountered. Beneath 1,200 feet and to the top of the basalt, the sediments are predominately uncemented coralline sands and gravels with occasional cemented layers.

CLIMATE

Enewetak's climate is of the tropical marine type with temperatures ranging from 71°F to 94°F and humidity in the 73 to 80 percent range.

There is much cumulous cloud cover, a moderate rainfall of 57 inches mean annually, and fairly constant northeasternly trade winds of 0 to 30 knots. A wind rose is shown in Figure 1-18.

Most depressions, tropical storms, or typhoons occur in the months of September through December, although they are possible at any time of year. Typhoons are not common but do occur, resulting at times in severe damage.[9]



Note Wind directions (given in degrees) are along vectors and from outer end toward the center

25% of all wind velocity readings are at 10 knots or less

Percentage of readings of velocities of 11-21 knots are indicated by length of vector, e g 35% of the time, winds of 11-21 knots will blow from ENE (67½°)

FIGURE 1-18. ANNUAL AVERAGE WIND DIRECTION AND VELOCITY.

HYDROLOGY

Enewetak Atoll must rely upon rainfall as its only source of fresh water. As the soil is extremely porous, drainage of rainwater by downward percolation takes place rapidly. The percolated water interfaces with the marine groundwater that has infiltrated through the porous rock from the sea and lagoon. Fresh water, when poured on an open body of salt water, spreads rapidly over the surface of the denser salt water and the two become thoroughly mixed through current and wave action. Porous rock, such as that found under the islands of Enewetak, imposes an obstacle to this rapid spread and restricts the mixing. On a roughly round-shaped island of uniform permeability, the body of fresh water floating upon the salt water assumes a lenticular or lens-shaped cross section, the edges of which are about at the edges of the island. These lenses serve as a secondary source of potable though brackish water during dry periods when rainwater reservoirs are nearing exhaustion. Figure 1-19 is a chart of mean monthly rainfall showing the potential water deficit of the dry period of the year.[10]

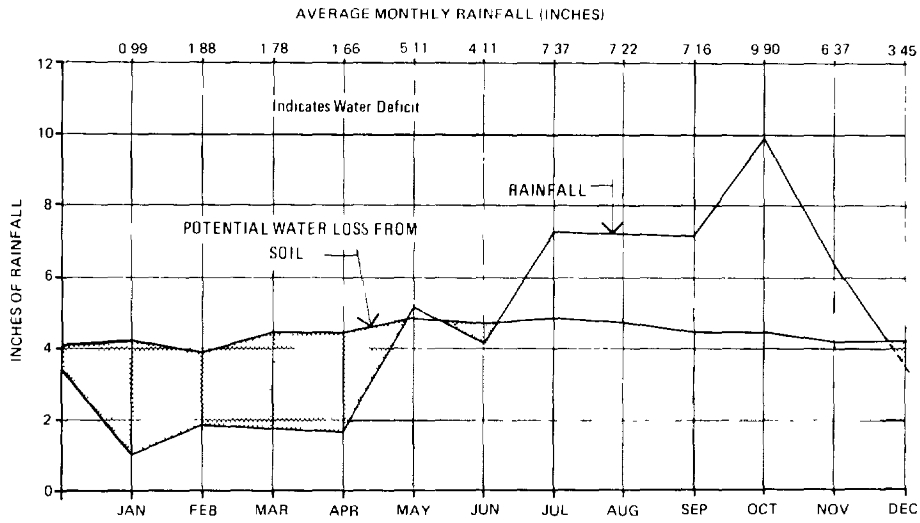


FIGURE 1-19. MEAN MONTHLY RAINFALL OF ENEWETAK ATOLL.

FLORA AND FAUNA

The types and quantities of flora found on the atoll would depend very greatly on the period in history under consideration. For example, before their introduction by German entrepreneurs in the 19th century, there were few coconut palms growing on the atoll. When they were planted to become the source of copra, they became the most conspicuous, if not the most numerous, of the plants to be found on Enewetak. Later, the number of all trees, shrubs, and bushes would be greatly affected by invasion, nuclear weapons testing, and cleanup.

Since Enewetak is located in the northern and drier section of the Marshalls, it does not have dense, lush, damp forests, and the native flora is not large in size or in variety. According to St. John, the indigenous flora totals 42 species. Of these, four are endemic, all being of the genus pandanus. Food crops and ornamentals amount to 26 in number and adventive weeds to 27. Altogether, the living flora totals 95 species. In addition, there are seven species known only by drifted seeds on the beaches.[11]

The most numerous of the larger native plants, other than coconuts, were Scaevola and Messerschmidia (Figures 1-20 and 1-21), the first classified as a large shrub and the second as a tree. Scaevola was the most abundant shrub, especially near the shore. Its leaves had some medicinal value. Messerschmidia is a small tree with edible leaves. The reported maximum height of both plants was 20 feet. The less common Pisonia grew to heights of 35 to 40 feet. These plants were to exert considerable influence on the effort required during cleanup.[12]

The larger plants of the atoll served primarily as windbreaks and as nesting places for fish-eating birds. The latter bring to the islands much needed materials, especially phosphorus, in the form of guano. Smaller plants, such as the creeping morning glory, act as a binder to hold the sand in place.[13]

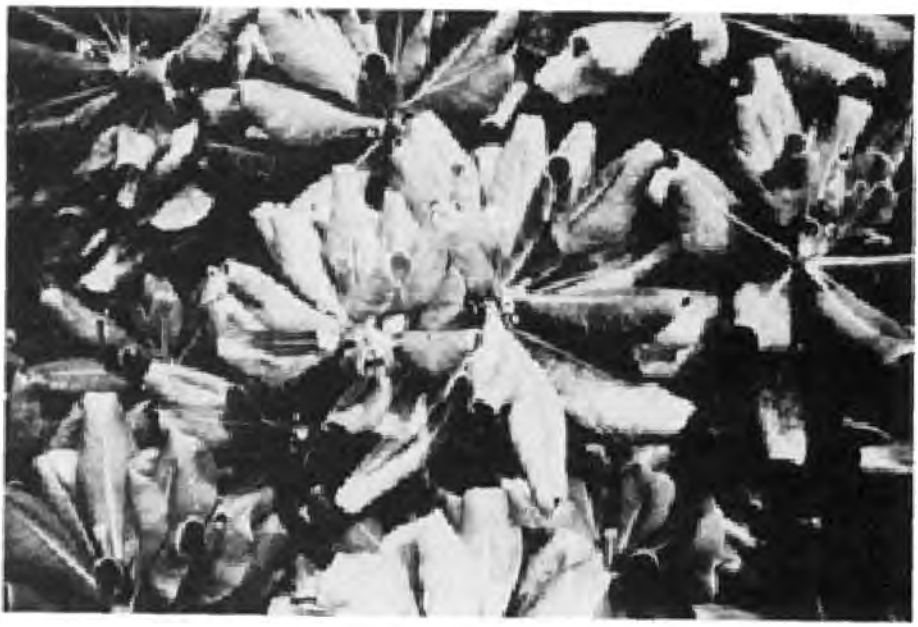


FIGURE 1-20. SCAEVOLA PLANT.

Food producing plants which have been cultivated on Enewetak in the past include coconut, breadfruit and pandanus (Figure 1-22 to 1-24). Coconut also was a cash crop in the form of copra, the dried meat of the coconut. Vegetable and crop plants which have also been grown on the atoll are tomatoes, chinese cabbage, arrowroot, sorghum, onions and radishes. Most of these were not native to the islands but had been imported by German or Japanese residents.[14]

FIGURE 1-21. MESSERSCHMIDIA PLANT.

FIGURE 1-22. COCONUT PALM GROVE.

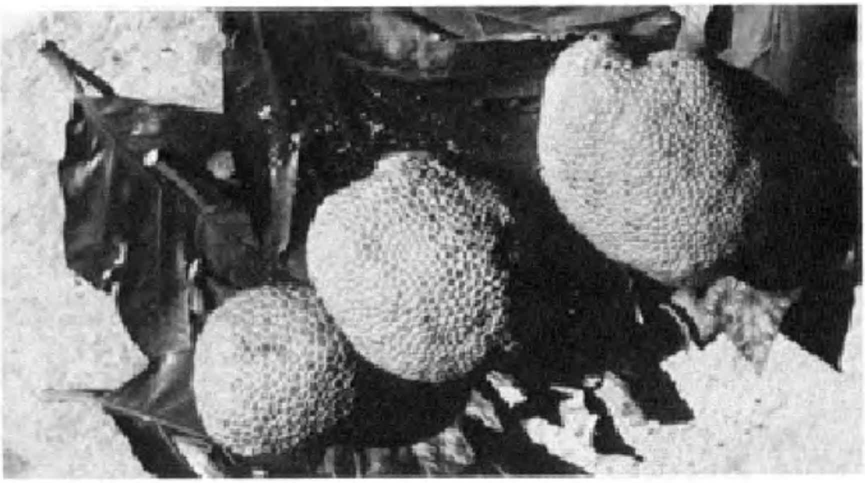


FIGURE 1-23. BREADFRUIT.

FIGURE 1-24. PANDANUS TREE.

The fauna of Enewetak may be divided, for convenience, into three groups according to their habitat: sea, land, or air. Certainly, the sea life is the most numerous in variety and number. In 1953, there were some 700 species of fish alone reported in the waters of the lagoon and surrounding ocean.[15] In addition to fish, edible sea fauna includes crabs, lobsters, sea turtles, clams, and oysters.

Besides domesticated dogs, mammals are limited to three species, two of rats and one house mouse. Reptiles include at least four species of geckoes, three skinks, a blind snake, and a monitor lizard introduced by the Japanese to control rats. The turtles are the green and the hawkbill, both inhabitants of the sea. Invertebrates include snails, nocturnal crabs, centipedes, scorpions, spiders, and other insects of considerable variety including cockroaches, scale insects, termites, fruit beetles, fruit flies, ants, and others.[16]

Thirty-two species of birds have been reported from Enewetak Atoll including seabirds, shorebirds, a heron, a cuckoo, and domestic fowl. Of these, nine are definitely known to breed on the islands, and six others are suspected to do so but have not been observed with nests or young birds.[17] Some of these birds serve as food sources in the form of meat or eggs. It will be recounted later in this documentary how concern over the nesting of one species of bird delayed progress in cleaning up contaminated soil. Figure 1-25 illustrates the density of bird population on one island of the atoll.

FIGURE 1-25. SEA BIRDS ON BOKEN (IRENE) ISLAND.

PEOPLE

Most anthropologists are of the opinion that the Marshalls and other islands of Micronesia were settled by people who migrated from the area of Indonesia into the insular Pacific centuries ago. Reflecting the ancient migration patterns in Oceania, the Marshallese language belongs to the large Malayo-Polynesian language family which spreads from Madagascar, through the Indonesian area, and across Micronesia, Polynesia, and most regions of Melanesia. Physically, the Marshallese are relatively short in stature and of stocky build. They have brown skin, brown eyes, broad flat noses, straight to curly black hair, and sparse body hair.[18]

According to their own oral tradition, the dri-Enewetak had always lived on Enewetak Atoll before their relocation to Ujelang in 1947. Because of the atoll's isolated location in the northwestern region of the Marshallese archipelago, the people of Enewetak had relatively little contact with other people prior to the European era. As a consequence, the language and culture became differentiated from those of other Marshall Islanders, and the people no longer identified themselves with the others. Rather, they think of themselves as a people who were separate and unique from the islanders to the east and south.[19]

The past and current accomplishments of the dri-Enewetak indicate intelligence and qualities of ingenuity, self-reliance, and hardiness which have allowed them to meet the challenge of the atoll environment, one that is quite restrictive when compared to the high volcanic islands of Oceania. Long before the advent of Europeans, the Marshallese had developed a culture which represented a sophisticated adaptation to their ecological setting. They were skilled navigators, an art which has largely been lost with the availability of travel on the vessels of foreigners, but they remain expert builders of sailing canoes and are among the world's best fishermen. To traders, missionaries, and the successive colonial governments which have dominated the islands over the past century, they have been quick to respond by learning and adjusting to each of these outsiders. Today, they have achieved a good understanding of the behavior and values of Americans, and several have distinguished themselves in government and mission schools operated by Americans.[20] Figure 1-26 portrays a typical family grouping of the Marshall Islands.

ECONOMY AND POLITICS

Throughout the Marshall Islands the traditional forms of settlement patterns and exploitation of the natural resources are characterized by several general features. The first is that the people on an atoll reside on

FIGURE I-26. A FAMILY GROUP IN THE MARSHALL ISLANDS.

one or a few of its largest islands. The second is a mobility that is demonstrated by various extended fishing and collecting activities that embrace every niche of the environment. For example, they have a nonintensive form of agriculture in which regular expeditions are made to all islands of an atoll to make copra and collect coconuts, breadfruit, pandanus, arrowroot, and other vegetable foods in season. Clearing of brush and planting are done during these visits. Marine resources are also exploited, with a wide variety of marine animals being utilized. Special expeditions are made to collect shellfish, capture turtles, and gather their eggs, in addition to catching fish. Several species of birds are also captured as a food source. The Enewetak people may be expected to continue this way of life to some degree when they return to their home atoll, although they may remain strongly influenced in many ways by their contacts with western culture.[21] The typical outrigger canoe of the Marshallese is shown in Figure I-27.

Historically, the people of Enewetak have been divided into two separate and distinct communities which were located on the two largest islands of the atoll. Here "community" is defined as the maximum group of persons who normally reside together in face-to-face association. One community was situated primarily on Enjebi (Janet) Island on the northern rim, and the other was located primarily on Enewetak Island across the lagoon in the southeast quadrant of the atoll. The traditional

FIGURE 1-27. TYPICAL OUTRIGGER CANOE OF THE MARSHALL ISLANDS.

settlement pattern of both communities was dispersed; residences were located on separate land parcels and were scattered along the length of the lagoon beach.[22]

The sociopolitical structure of the two communities was identical. Each was headed by a hereditary iroij or chief, and succession to the office was patrilineal. The chiefs directed the affairs of their respective communities, arbitrated disputes, and consulted one another with regard to concerns of the entire atoll and the total population's relations with outsiders. The atoll was divided into two geographical areas, and each of the chiefs had authority over one of the two domains. The domain of the Enewetak chief began with the Islands of Kidrenen (Keith), Ribewon (James), Boken (Irwin), Mut (Henry), and Ikuren (Glenn) in the atoll's southwest quadrant, extended counterclockwise around the atoll up to and including Runit (Yvonne) Island, as well as Aomon (Sally) on the northeast rim. With the exception of Aomon, the Enjebi chief's domain extended north of Runit beginning with Billae (Wilma) Island and extended counterclockwise around the atoll's northern and western rim up to and including Biken (Leroy) Island.[23]

Relations between the two communities and the traditional dispersed pattern of residence were altered with the military invasion of Enewetak Atoll in 1944. Because Enewetak and Enjebi Islands had been devastated by the battle for the atoll, the U.S. Navy resettled all of the people in a compact village on small Aomon Island which, as indicated earlier, fell within the domain of the Enewetak Island chief. After several months, the people of Enjebi moved to the adjacent Bijire (Tilda) Island which was within the domain of their own iroij. With these relocations, the dri-Enjebi and dri-Enewetak were no longer separated by the atoll's large lagoon; and, while retaining their dual political structure, they had, in fact, become a single community.[24,25]

The consolidation of the population into one community and the new compact settlement pattern were continued with the transfer of the islanders to Ujelang Atoll in 1947. This atoll has only one sizeable island, Ujelang Island, and the entire population was settled there. Navy officials established a dividing line at the midpoint of the island and allotted the western half to the people of Enjebi and the eastern half to the people of Enewetak Island. A compact village was constructed in the middle of the island with the Enjebi and Enewetak people occupying houses on their respective sides of the dividing line. Later, each group divided the land on its portion of the island. At a still later date, other islands in the Ujelang Atoll were divided among members of the two groups.[26,27]

During the first few years on Ujelang, the traditional political structure remained intact. The chiefs functioned in their accustomed roles and resisted American efforts to introduce democratic institutions It had been intended by American planners that each atoll population be governed by an elected governmental council of elders headed by an elected magistrate, but this was not acceptable to the iroijs. By the early 1960's, however, some change was observable. Both chiefs were, by then, quite aged men, who had matured in an earlier era. Some of the contemporary problems required that the decision-making process be opened to include younger men who had attended schools and/or had some other experiences with the American administration. Meetings of all males were held occasionally, and some decisions about community affairs were decided by a majority vote. The authority and status of the chiefs declined further in the later 1960's when the old Enjebi chief died and was succeeded in office by his younger brother, who was also elderly and suffered the additional disadvantage of frequent poor health.[28]

These events precipitated a major transformation of the political structure. The chiefs yielded to younger men who desired, and had been gaining, a greater voice in community affairs. In 1968, a magistrate and a council of 12 men were elected. Reflecting the traditional division of the population, the people of Enjebi elected six councilmen from among their ranks, and the people of Enewetak elected six from theirs. The magistrate became the head of the entire community, and the council became the legislative body governing the people's affairs. In a later election, the 12 councilmen were elected from the population at large, not equally from the two groups. Thus, the current council reflects the demise of the traditional system and indicates that the old division between Enjebi and Enewetak peoples has lost much of its meaning. The council is now a representative body drawn from the entire population and reflects a unified community with acknowledged common goals. The iroijs, however, remain important figures as advisors and men of influence.[29]

RELIGION

The church is the focal point for many community social activities of the Enewetak people. The prevailing religious system is a conservative type of Protestantism in which church services, bible classes, church group meetings, and hymn singing have replaced traditional intertribal wars, sports, games, and dancing.

The minister is the spiritual leader of the community and is supported and assisted by the two chiefs. The church functions are time-consuming and require a considerable effort from the membership. Sundays, in particular, are devoted almost entirely to church services and related activities. From this, it is apparent that the church influences the life of the dri-Enewetak to a great degree.[30]

LAND USE

The atoll soil is basically coral rock and coralline sands with only minimal organic contents, so that the practice of agriculture is limited. For centuries, subsistence has been marginal and precarious for the island inhabitants, requiring hard work on their part. Despite this, the dri-Enewetak have always maintained a deep emotional attachment to their home islands and ancestral holdings. The land parcels, or "watos," on Enewetak Atoll were like those found elsewhere in the Marshalls. Most commonly, each was a strip of land stretching across an island from lagoon beach to ocean reef and varying in size from about 1 to 5 acres. The resources of all ecological zones were thus available to the individuals who held rights to the land. Less commonly, a parcel was divided into two or more portions with transverse boundaries. This usually occurred when an island, Enjebi for example, was very wide. Boundaries were usually marked by slashes on the trunks of coconut trees or, less commonly, ornamental plants. Also, other features of the natural topography, for example, large boulders on the ocean reef or the very configuration of an island, were used to fix the position of landholdings. The latter type of markers have been employed by the Marshallese after all other markings had been obliterated.[31] The map of one of the islands of Enewetak Atoll (Medren) showing wato division lines appears on Figure 1-28.

One facet of Enewetak Atoll culture that differed from that of other Marshall Islands was the system of land tenure and inheritance. In the rest of the Marshalls, matrilineal is the rule. The land tenure system at Enewetak was, in ideal and in practice, a bilateral one. In most cases, a married couple divided the land which each had inherited among their children, and a child usually received some land from both his father and mother. As the younger islanders matured, they worked the land with their parents. As the parental generation died and as members of the next generation married and produced children, the process was repeated with parents allocating land among their offspring.[32] Every individual possessed rights to some land on islands away from the settlements of Enewetak and Enjebi. All land in the atoll was held by someone, with the exception of one parcel on Enewetak Island which was donated for the location of a church.

The people resided on their landholdings on Enjebi and Enewetak Islands. In most cases, households were headed by males and were situated upon land held by them. Ideally, residence was patrilocal, i.e., upon marriage, females moved to their husband's households, although exceptions to the rule did occur [33]

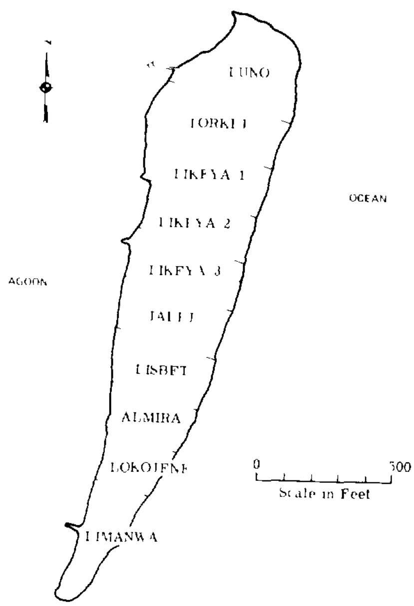


FIGURE 1-28. MEDREN ISLAND SHOWING NAMES AND BOUNDARIES OF WATOS.

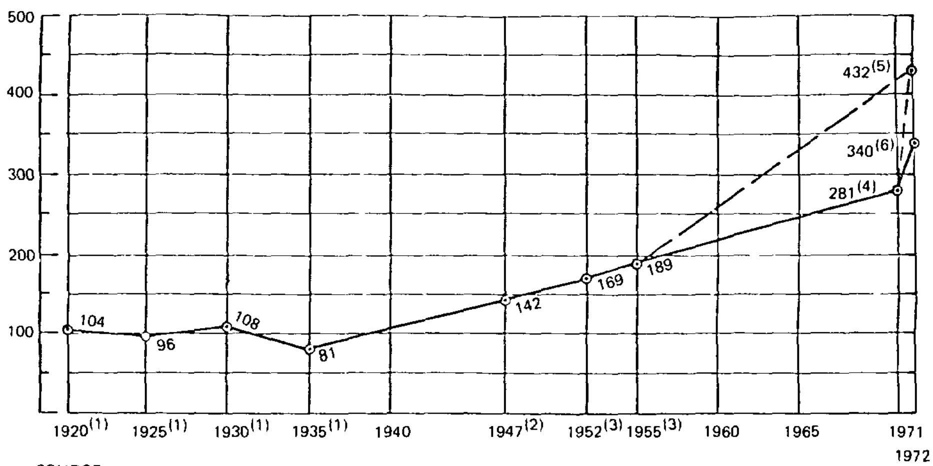
DIET

The diet of the dri-Enewetak was primarily vegetarian, based on coconuts, pandanus, and arrowroot. Breadfruit, taro, and bananas were rare, but the people learned to cultivate some of these plants on Ujelang and will probably bring them back and attempt to continue their use. There may be associated problems caused by the more northern location of Enewetak and the absence of a swamp or bog for growing taro.

The vegetable diet is supplemented by seafood, pork, and chicken, the last two locally raised. Almost all forms of sea life are favored including fish, clams, and turtles, as well as sea birds and their eggs. However, canned fish has largely replaced the fresh fish formerly taken from lagoon and ocean, and foods previously unknown, such as rice, have become staples. This will certainly affect the menu after their return to the atoll.[34]

POPULATION

The growth trend of the Enewetak people from 1920 to 1972 is shown in Figure 1-29. The reduction in population from 1930 to 1935 can be explained partially by the fact that members of the community left the atoll



SOURCE

(1) Japanese Consul General, Honolulu (1966)
(2) U S NAVY (at the time of relocation to Ujelang)
(3) J A Tobin (on Ujelang)
(4) TTPI Official Census (on Ujelang only)
(5) J A Tobin (Total–Ujelang & elsewhere)
(6) J A Tobin (on Ujelang only)
Data from J A Tobin -1973

FIGURE 1-29. POPULATION TRENDS OF THE PEOPLE OF ENEWETAK, 1920-1972.

for extended periods at different times to work on the copra plantations on Ujelang and to visit the administrative headquarters on Ponape. Likewise, subsequent increases in population can be attributed to the return of the Ujelang workers accompanied by Ujelang spouses It should be noted that the 1971 Trust Territory of the Pacific Islands (TTPI) official census of 281 and the 1972 census of 340 taken by J. A. Tobin include only those people of Enewetak in residence on Ujelang at the time. The 1972 figure of 432 includes these people as well as those residing elsewhere.[35,36]

Estimates based on available census data indicate a growth rate of the Enewetak people from 1948 to 1973 of approximately 6 percent per year. Figure 1-30 depicts projected population growth curves based on rates of growth of 3 percent, 5 percent, and 7 percent. If actual population growth lies within this range, these curves show that, in 1983, the population may be between 600 and 900 persons. Limitations on food supply or other resources might reduce population growth below the minimal curve of the chart, and, at some further time, the growth curve might tend to stabilize. At this time, however, there is insufficient data for an accurate projection.[37]

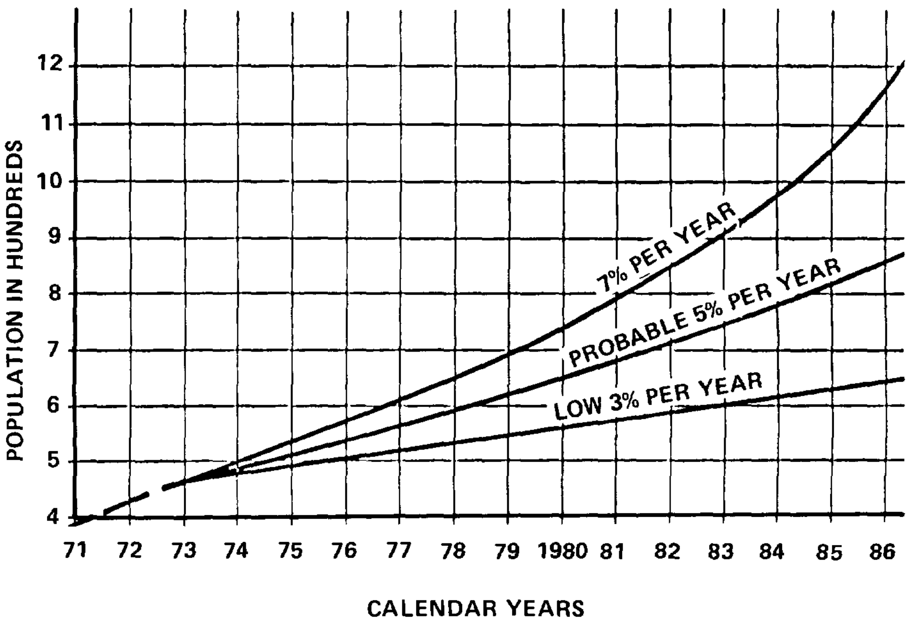


FIGURE 1-30. PROJECTED POPULATION CURVES, 1972-1986.

DISCOVERY ERA: 1526 - 1886

The recorded history of Enewetak begins in the 16th century and may be divided into four distinct eras. The first of these was the era of discovery dating from 1526 to 1886. This was followed by the German Protectorate from 1886 to 1914, the Japanese Mandate from 1914 to 1944, and the United States Trusteeship from 1944 to its expected expiration in 1981. The atoll was first reported as sighted by Spanish explorers in 1526. Three years later, a landing was made on Enewetak by Alvaro de Saavedra in October 1529. It was rediscovered on 13 December 1794 by Captain Thomas Butler who was engaged in the China trade. The atoll was given the name "Browne's Range" for a Mr. Browne, one of the associates in the firm employing Captain Butler. The name persisted, being used by the Japanese and even appearing on recent U.S. Hydrographic charts, although the "e" had been dropped and the islands had become "Brown Atoll." According to one source, the name Enewetak means "Land between West and East," but this is uncertain.[38]

GERMAN PROTECTORATE: 1886 - 1914

In 1886, Germany established a formal protectorate over the Marshall Islands. The people of Enewetak, as well as other Marshallese, were given coconut seedlings by German traders and instructed in the growing, gathering, and converting of the meat of the coconut into copra. The Germans were also interested in whaling and established the Jaluit Company, a trading organization. Political and commercial administration was merged with the imperial administrator acting as the company's chief official in residence. However, the atoll, being isolated, did not have much direct contact with the central government, and visits by foreigners were discouraged.[39,40] German control was, on the whole, benign, and it did not arouse much antagonism in the Marshallese. Roads were built, health and sanitation were improved, and the islands were searched for potential sources of economic wealth. The Germans provided the islanders with protection from unscrupulous traders and helped them to enter the culture of the Western world.[41]

JAPANESE MANDATE: 1914 - 1944

At the beginning of the First World War, Japan seized Enewetak, the other Marshall Islands, and all other German possessions in Micronesia.

When that war was concluded, Japan, having been on the side of the victorious Allies, was awarded the islands lying north of the equator by the Treaty of Versailles. This was in the form of a mandate to control and develop these islands, but not to fortify them.

The Japanese established the South Seas Bureau with headquarters at Kolonia in Ponape, and divided the mandated territory into six districts, one of which was the Marshall Islands. Visits to Enewetak were made by the Japanese Navy and by Japanese traders. Both Enewetak and Ujelang were administered from Ponape, and the only foreign residents on Enewetak were a Japanese trader and his two assistants. A weather station was established there in the 1930's, but other Japanese associations with the atoll languished.

Early in World War II, the Japanese set out, contrary to the terms of the mandate, to make Enewetak Atoll a strategic base in their planned conquest of the Pacific. Japan maintained a guard unit of about 20 men on Enjebi until December 1942, when construction workers arrived to construct an airstrip. This was completed in July 1943, and, in October, the detachment at Kwajalein was moved to Enjebi to act as a maintenance force. In January 1944, 110 aviation officers and men were billeted on Enjebi, and 2,686 soldiers were landed on Enewetak to prepare the defense on the atoll. These were placed on Enjebi, Medren, and Enewetak. About 1,000 laborers and other noncombatant personnel were also present. The aviation personnel were to be evacuated to Truk by flying boat but, for most of them, this operation was begun too late.[42] Noting the preparations for battle, the 30 dri-Enewetak inhabitants of Enjebi moved to islands on the eastern reef.

BATTLE OF ENEWETAK: FEBRUARY 1944

The original U.S plan for invading the Marshalls included amphibious assaults on strongly defended atolls of the Ratak or eastern chain in order to secure airstrips there. Air reconnaissance in December 1943 showed the construction of a Japanese airstrip on Kwajalein Island, so plans were altered to bypass Wotje, Maloelap, and Mili on the Ratak Atolls, and to attack the north and south ends of Kwajalein Atoll simultaneously. Planning included the capture of Majuro Atoll which was very lightly defended. After securing Kwajalein, Enewetak was to be attacked.

The Marshall Islands operation was code-named "Flintlock" and was under the overall command of Vice Admiral Raymond A. Spruance. The capture of Enewetak was considered to be a preliminary step to landing on Truk farther west and was code-named "Catchpole." Many of the lessons learned in the previously completed campaign to capture the Gilbert

Islands were employed in the assault on Kwajalein. This included heavy naval bombardment by battleships, use of infantry landing craft to saturate the landing beaches with high explosive fire, use of tracked landing vehicles to transport assault infantry across the coral reefs to dry beaches, and establishment of field artillery on lightly held islands adjacent to the objective islands to provide close-in artillery support for the main assault groups. The result at Kwajalein Atoll was the capture of Roi-Namur in the north and Kwajalein Island in the south, with the loss of 372 killed and 1,582 wounded. The enemy strength was estimated to be 8,675, of which only 265 remained alive to be taken prisoner and, of these, 165 were Korean laborers. The seizure of Enewetak Atoll was to follow immediately after.[43]

The Enewetak Expeditionary Group was commanded by Rear Admiral Harry W. Hill. The assault troops were under Brigadier General Thomas E. Watson. The plan was to complete the occupation in four phases. Phase One was the seizure of two islets south of Enjebi—Aej (Olive), and Lujor (Pearl)—where field artillery would be emplaced. Phase Two was the landing on Enjebi by Marines, supported by the emplaced field artillery. Phase Three was to be the seizure of Enewetak Island and Medren. Phase Four was a mopping-up operation of the remaining islands to rid them of any remaining Japanese.[44] The map in Figure 1-31 shows the location of these events.

At 0700 hours on 17 February 1944, minesweeping began and was followed by the entry of troop transports into the lagoon. Phase One was completed by 1632 hours with the positioning of Marine and Army artillery on Aej and Lujor. Marine scout company landings on Enjebi took place at 0315 hours on 18 February, and the island was secured by 1600 hours. The third phase, the capture of Enewetak and Medren Islands, began on the morning of 19 February with the 106th Infantry landing on Enewetak Island. The island was not pronounced secure until 1630 hours on the 21st. In the meantime, Marine artillery had landed on Japtan, and guns emplaced there and on Enewetak were registered on Medren by 1200 hours on 20 February. Marines landed on Medren at 1900 hours on the 22nd, and Phase Three was completed by 1930 hours of the same day.[45] Figures 1-32 and 1-33 show some of the action during the battle.

In conducting Phase Four, no opposition was met in landing and occupying the other islands of the atoll. All action had ceased by the evening of 23 February 1944. The toll of the battle is shown in Figure 1-34. Only 64 Japanese were taken prisoner, some of whom were wounded. Most had died fighting.[46] Fifty dri-Enewetak were found on D+1 by American troops and were sheltered in a huge bomb crater. Other people found later in the battle were brought there also, including 17 from Medren. On 24 February 1944, all of the surviving people were moved to

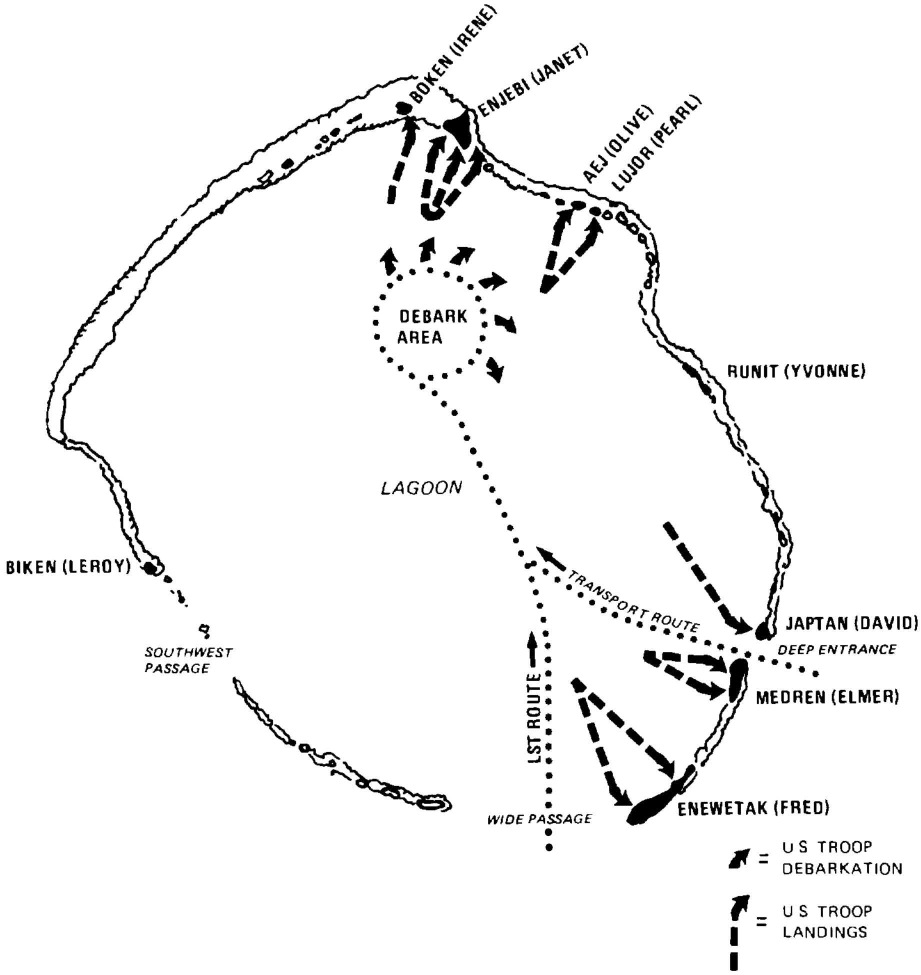


FIGURE 1-31. OPERATION CATCHPOLE—THE SEIZURE OF ENEWETAK ATOLL, 17-23 FEBRUARY 1944.

FIGURE 1-32. U.S. MARINES SEARCHING FOR SNIPERS, ENEWETAK ATOLL.

FIGURE 1-33. MOPPING UP AFTER THE BATTLE, ENEWETAK ATOLL.

	AMERICAN		JAPANESE		
	Killed & Missing	Wounded	Killed & Burial Count	Prisoners	Total
Enjebi Is.	85	166	934	16	1201
Enewetak Is	37	94	704	23	858
Medren Is	73	261	1027	25	1386
Other			12		12
	195	521	2677	64	3457

FIGURE 1-34. CASUALTIES IN THE CONQUEST OF ENEWETAK ATOLL.

Aomon, where a few houses and some coconut trees were still standing. The total number of people gathered on Aomon was 117; 18 had been killed during the battle.

After its capture, Enewetak was used primarily as a support or staging area. A 7,000-foot bomber strip was laid down on Enewetak Island. Little or no attempt was made to clean up the debris resulting from the invasion. The beaches contained many rusting hulks of landing craft, tanks, and other vehicles. Ammunition, mortars, and other implements of war littered the land and the reefs. The coconut trees of the islands, which had been bombarded and assaulted, were largely destroyed.[47]

Years later, Iroij Johannes Peter spoke of the battle—the airplanes, the bombs, the fears, the wounded, and the dead. He recalled that these had been very sad times.

After the surrender of Japan, all small naval vessels moving through the Marshalls picked up and carried repatriates back to their home islands. Those who returned to Enewetak Atoll found that the U.S. military forces had placed all people from Enjebi and Enewetak Islands on Aomon in the northeastern part of the atoll chain. The U.S. Navy provided building construction materials, food, and water.[48]

The dri-Enjebi were not content with dwelling on Aomon because, in spite of its northern location, it was under the authority of the iroij of the dri-Enewetak. Consequently, the dri-Enjebi were moved to the neighboring island of Bijire.[49,50] Their stay there was also brief due to major events in other parts of the world.

THE NUCLEAR AGE BEGINS: JULY 1945

The nuclear age arrived with the detonation of an atomic bomb on 16 July 1945 near Alamogordo, New Mexico. That test, known as the Trinity Event, was part of the Manhattan Project organized to develop the military application of atomic energy. In August of the same year, two nuclear bombs were dropped on the Japanese cities of Hiroshima and Nagasaki, thereby accelerating the end of World War II.

While the use of nuclear weapons already had modified military concepts of war, they still needed further study and development if their full capabilities were to be realized. Interest in their development was shared by the scientific community and the general public as well as the military establishment.

On 10 November 1945, a subcommittee of the Joint Chiefs of Staff (JCS) began developing detailed plans for a series of tests of existing and newly developed nuclear weapons. The tests were to be conducted under very carefully controlled conditions and as a matter of primary concern, were to explore the effects of atomic explosions on naval vessels. The subcommittee proposed a program to be headed by Vice Admiral William H. P. Blandy, Deputy Chief of Naval Operations for Special Weapons. The program was accepted by the JCS, generally as proposed, on 28 December 1945 and approved by President Truman on 10 January 1946. The organization for conducting the program was identified as Joint Task Force One (JTF-1).[51]

An important objective of the program was to obtain and prepare an appropriate test site. Locations in the Atlantic, Pacific, and Caribbean had been considered even before the Task Force came into existence. The basic site requirements were that:

a. It be under the control of the United States.
b. The area be uninbabited or subject to evacuation without imposition of unnecessary hardship on a large number of inhabitants.
c. It be within 1,000 miles of the nearest B-29 aircraft base, as it was expected that one test nuclear device was to be delivered by air.
d. It be free from storms and extreme cold.
e. It have a protected harbor at least 6 miles in diameter thereby being large enough to accommodate both target and support vessels.
f. It be away from cities or other population concentrations.
g. The local winds be predictably uniform from sea level to 60,000 feet.
h. The water currents also be predictable and not adjacent to inhabited shorelines, shipping lanes, and fishing areas so as to avoid contaminating populaces and their food supplies.[52,53]

Several atolls in the Marshall Islands met all of these requirements to a satisfactory extent. The Marshalls had been captured from the Japanese and, by Presidential authority, were under the control of the U.S. Navy military government.

OPERATION CROSSROADS: JUNE-JULY 1946

Bikini Atoll was the one chosen as the site of Operation Crossroads, which was to be the occasion of the first peacetime detonations of nuclear weapons. The climatic, wind, current, and harbor size requirements could be met. The selection was influenced by the fact that the population of the atoll was small and could be relocated easily and that Bikini was close to Kwajalein and Enewetak Atolls, both of which held military support facilities. Under the Presidential authority, the Navy also relocated the people of Enewetak to Meik Island in Kwajalein Atoll while the Bikini tests were being conducted.[54,55]

Three tests were planned for Operation Crossroads, two of which—Able and Baker—were eventually carried out. The first of these was an aerial drop, and the second an underwater shot. The bombs were similar to those which had been used against the Japanese cities and which had produced yields of 13 KT at Hiroshima and 23 KT at Nagasaki.

The yield, stated in KT (thousands of tons), expresses the explosive equivalent of a weight of TNT. For example, a nuclear bomb having a yield of 25 KT would have the same explosive force as a single explosion of 25,000 tons of TNT A "nominal" yield was one approximately equivalent to that of the bombs used against the Japanese cities.

Test Able occurred on 30 June 1946. The bomb was dropped from a B-29 aircraft and exploded about 500 feet above the lagoon surface. The bomb detonated 1,500 feet west of the center target vessel. The vessel did not sink, but five other vessels were sunk and others were burned or damaged. The sunken ships were two attack transports, two destroyers, and a Japanese light cruiser.[56] The yield of the nuclear device of Test Able was 23 KT.

Test Baker was performed with a nuclear device suspended 90 feet below a landing ship in the center of another array of ships in the lagoon. At detonation, a hollow column of water rose to a height of a mile above the surface of the lagoon. The U.S. battleship ARKANSAS, the aircraft carrier Saratoga, and the Japanese battleship Nagato were sunk, as well as other surface vessels and submarines. Some sank immediately and others took from 7-1/2 hours to 5 days to sink.[57] Test Baker also yielded the equivalent of 23 KT of TNT.[58]

Although these tests were successful, Bikini ifself demonstrated a number of deficiencies as a test site. One was the lack of land area, which necessitated the use of surface vessels for planning, administration, scientific laboratory work, and for life support. A second was the combination of island orientation and wind direction, which prevented the installation of an adequate airstrip.

ESTABLISHMENT OF AEC AND AFSWP

The passage of the Atomic Energy Act of 1946 resulted in the restructuring of the Manhattan Project organization. Responsibility for future atomic development was assigned to the AEC, a new civilian agency. Most of the Manhattan Project scientific personnel and laboratories went to the AEC. The Manhattan Project itself was renamed the Armed Forces Special Weapons Project (AFSWP) and remained a military organization. The AFSWP has been renamed twice, as the Defense Atomic Support Agency in 1959 and as the Defense Nuclear Agency in 1971. The first head of this organization was Major General Leslie R. Groves, USA, who had directed the Manhattan Project. He was named Chief, AFSWP on 28 February 1947 and Rear Admiral William R. Parsons, USN, became his deputy. RADM Parsons also had participated in the Manbattan Project and was bomb commander aboard the plane, the "Enola Gay," that dropped the first atomic weapon on Hiroshima. He had also served as Commander, JTF-1, at Bikini Atoll.[59]

The U.S. Army Element of the Manhattan Project at Los Alamos Scientific Laboratory was Company C, Santa Fe Detachment, 38th Engineer Battalion, U.S. Army Corps of Engineers. In the spring of 1947, it was relocated to Sandia Base, near Albuquerque, New Mexico, and established as Field Command, AFSWP, the principal operating element of the project. Later in the year, U.S. Air Force and Navy personnel were assigned, making AFSWP a joint service command. As the central coordinating agency between civilian and military interests in atomic development, AFSWP provided staff and technical assistance to the Secretary of Defense; overall surveillance, storage, and maintenance of the nuclear weapons stockpile; technical, logistics, training and stockpile management support to the Military Services; and, direction of the Department of Defense (DOD) weapons effects test programs. During overseas test operations, JTFs were formed af Sandia Base under the direction of the Chief, AFSWP. Military Service elements were assigned to the JTF to provide support at the proving grounds.[60] The first AFSWP JTF was formed under the command of Captain T. A. Hederman, USN, to conduct a resurvey of Bikini Atoll following Operation Crossroads.[61]

ESTABLISHMENT OF ENEWETAK PROVING GROUND: JULY-DECEMBER 1947

Meanwhile, action was being taken in the United Nations (U.N.) to place the Pacific islands, which Japan had administered under a League of Nations mandate, under the trusteeship of the United States. In

November 1946, President Truman announced that the U.S. was prepared to place the islands under trust. The agreement establishing the TTPI as a strategic area trusteeship was approved by the U.N. Security Council on 2 April 1947 and by President Truman on 18 July 1947. Under the agreement, most of Micronesia was placed under the administration, legislation, and jurisdiction of the United States.[62] The Department of the Interior became the executive agency of the United States, relieving the Navy of its interim control. The United States was to take all appropriate measures to advance the interests of the people of the TTPI and, additionally, the U.S. was authorized to establish military bases in the TTPI.

Concurrently with the establishment of the TTPI, action was being taken by the AEC to establish a nuclear test site at Enewetak Atoll. The AEC had studied several possible locations including island sites in the Indian Ocean, Alaska, and Kwajalein Atoll, as well as in the continental U.S. Bikini Atoll islands were neither large enough nor properly oriented for construction of a major airfield and support base. The AEC selected Enewetak Atoll and, upon approval of the proposal by President Truman, requested that the Military Services prepare the Enewetak Proving Ground and provide logistical support.

On 18 October 1947, JTF-7 was activated under the command of Lieutenant General John E. Hull, USA, to prepare the proving ground and to conduct the next series of nuclear tests, Operation Sandstone. The selection of Enewetak as a proving ground necessitated the removal of the people once again, this time to Ujelang Atoll to the southwest of Enewetak.[63] On 21 December 1947, 136 dri-Enewetak were transported to Ujelang to begin their long residence on that Atoll.

Ujelang lies 124 miles southwest of Enewetak. It had been inhabited by Marshallese, but a typhoon in the late 1800's swept over the atoll and killed all but a few of the inhabitants. The survivors moved to the southern Marshalls, leaving the atoll deserted.

During the German and Japanese colonial eras, the atoll was developed as a commercial copra plantation, with a small group of islanders from the Eastern Carolines serving as paid laborers. In World War II, it was again abandoned. When the U.S. obtained the TTPI, Ujelang became available for the relocation of the populations of other atolls.[64,65]

Ujelang is much smaller than Enewetak, containing less land and less lagoon areas. The lagoon is only 25.47 square miles in extent, compared with Enewetak's 387.99 square miles. The land area is 0.67 square miles or 428 acres, of which only 274 acres are usable. Enewetak has 2.75 total square miles, or about 1,761 acres of land. From these figures, it is possible to see that the potential for the production of food at Ujelang from the reefs, lagoon, and land was considerably less than that at Enewetak. The limited food potential on Ujelang has made it necessary to import more commodities than might normally be required on Enewetak.[66,67]

"Inem jen jab inebata bwe ankilan Anij."

(But we do not worry for it is the will of the Lord.)

In this way was the attitude of the people of Enewetak expressed.[68]

LIVING ON UJELANG

A village for the people of Enewetak was constructed by the U.S. Navy on the main island of the atoll. Figure 1-35 is a map of the atoll giving the village location. A brush clearing program also had been in progress at the time they arrived on the atoll. The coconut trees planted by the Germans and Japanese still were bearing, and breadfruit and pandanus seedlings had been brought in and planted

Ujelang was provided a water system, including numerous rain catchments, a church, a council hall, a school, and a dispensary. Supply ships brought in tools, clothing, and food to supplement the meager natural resources. There was, however, no U.S. official remaining on the atoll, and there was no means of communication with the outside world.[69,70]

The people continued to practice nonintensive agricultural operations while utilizing the environment extensively. Coconut was converted into copra for cash sale, and consumer goods were purchased with the proceeds. Interest payments were received from a trust fund provided by the TTPI. Rice, flour, sugar, canned meats, and other canned goods originally were additions to the traditional Enewetak diet, but they had all become staple items over the years. Marine resources were extremely important in the diet of these people, with fish, clams, lobsters, turtles, and sea birds, as well as land animals (domesticated chickens and pigs), continuing to provide the required protein. Coconuts, pandanus, breadfruit, and arrowroot were still the principal vegetables used. Bananas, papayas, and squash were not prominent in the diet because they did not grow well in Ujelang (although better than on Enewetak).[71,72] Figures 1-36 and 1-37 show scenes of the village on Ujelang.

Perhaps the most profound effects of the experience of residing on Ujelang have been in two directions, each related to the style of living of the people of Enewetak. One was in the location of houses and the relationship with other people. On Enewetak, family groups lived scattered along the lagoon shore on watos running, in most cases, from lagoon to ocean. On Ujelang, dwellings were close together and, aside from the area immediately surrounding the house, the land appears to have been held in common.[73,74]

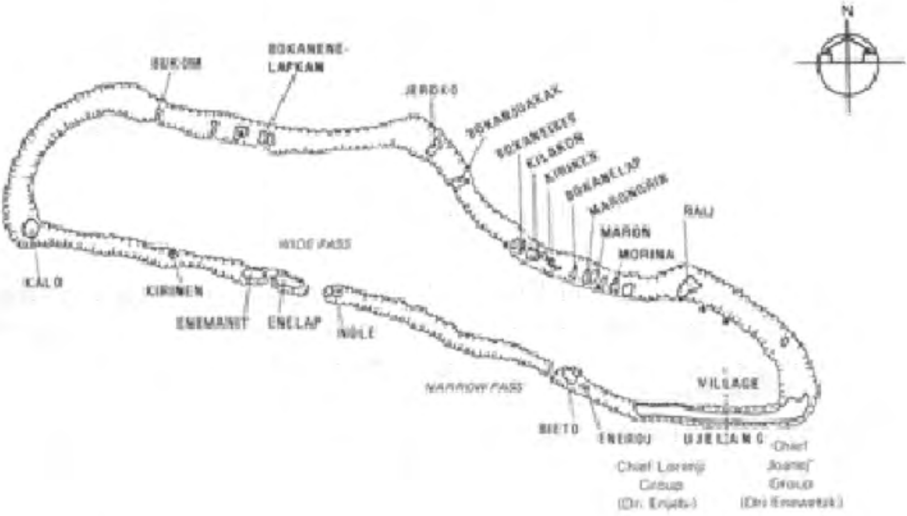


FIGURE 1-35. UJELANG ATOLL SHOWING RESIDENCE ISLANDS.

FIGURE 1-36. DWELLINGS ON UJELANG ISLAND.

FIGURE 1-37. FOOD PREPARATION ON UJELANG ISLAND.

The other drastic change in the lives of the people was the close proximity in which the dri-Enewetak and dri-Enjebi were compelled to live. Traditionally, a distance of more than 20 miles separated the two communities except for a brief period on Aomon. On Ujelang, they occupied two sides of an arbitrary line which had no real significance. One effect of this was more intermarriages and a corresponding increase in crossed land rights, so that the dri-Enjebi acquired more rights in the south than ever before, and vice versa. However, this did not affect the strong desire of the dri-Enjebi to possess a residence on their traditional island.

OPERATION SANDSTONE: APRIL-MAY 1948

Operation Sandstone was conducted by JTF-7, under the command of LTG Hull. The Task Force included Army, Navy, Air Force, and an AEC scientific group. Captain James Russel, USN, AEC's Division of Military Applications (DMA), was Test Director and Dr. Darol Froman, also from AEC-DMA, was Scientific Director. Military Service elements of the JTF were commanded by Brigadier General B. T. Ogden, USA, Rear Admiral Francis Denebrink, USN, and Major General Roger Ramey, USAF.[75] Construction of temporary facilities at Enewetak Proving Ground began in late December 1948 following the relocation of the dri-Enewetak to Ujelang Atoll. The construction work was performed by U.S. Army elements of the JTF.[76] Because of the lack of ground facilities on the atoll, the Task Force was quartered on and operated from U.S. Navy vessels. Three nuclear devices were detonated in this operation. Each was placed on a 200-foot-high tower on one of three separate islands. The first shot, code named X-ray, was conducted on Enjebi on 14 April 1948, with a yield of 37 KT. The next test, Yoke, took place on Aomon on 30 April, with a yield of 49 KT. The last, Zebra, was carried out on Runit on 14 May, with a yield of 18 KT. Details of devices tested and of test results remain classified at this writing.[77]

CONSTRUCTION ACTIVITIES

Operation Sandstone established a pattern that was to be followed in other test series. That pattern was: a rehabilitation phase in which existing facilities were readied to support the upcoming operation; a construction phase devoted to providing support and scientific requirements; an execution phase for actual testing; and a roll-up phase during which the atoll was made secure and preserved for further use. Figures 1-38 through 1-41 show construction activities on various test and test support installations. The activities shown occurred at various times in the test program.

The construction and development work on Enewetak Atoll in support of Operation Sandstone was carried out by U.S. Army construction units with civilian contractor assistance. The construction phase consisted of:

a. Developing Enewetak Island as the administrative and logistic base for all atoll operations.
b. Developing Medren as the scientific and technical control and coordinating center for all atoll operations.
c. Developing construction camps on islands either on or near the islands on which tests were to be conducted.
d. Constructing the scientific and technical facilities on the test islands.

As time went on, Army construction units had smaller and smaller roles, while those of civilian contractors continued to grow. The AEC decided in mid-1949 to carry out major construction projects on the atoll with the view of providing an adequate support base ashore, with more adequate housing and technical facilities. A survey had previously been made by Holmes & Narver, Inc. to determine the existing conditions and the additional facilities required. The results were submitted on 7 January 1949, and a design and construction contract was signed in June of that year.

FIGURE 1-38. UNLOADING MATERIAL AND EQUIPMENT AT MEDREN PIER.

FIGURE 1-39. TRANSPORTING CONSTRUCTION MATERIALS ON ENEWETAK.

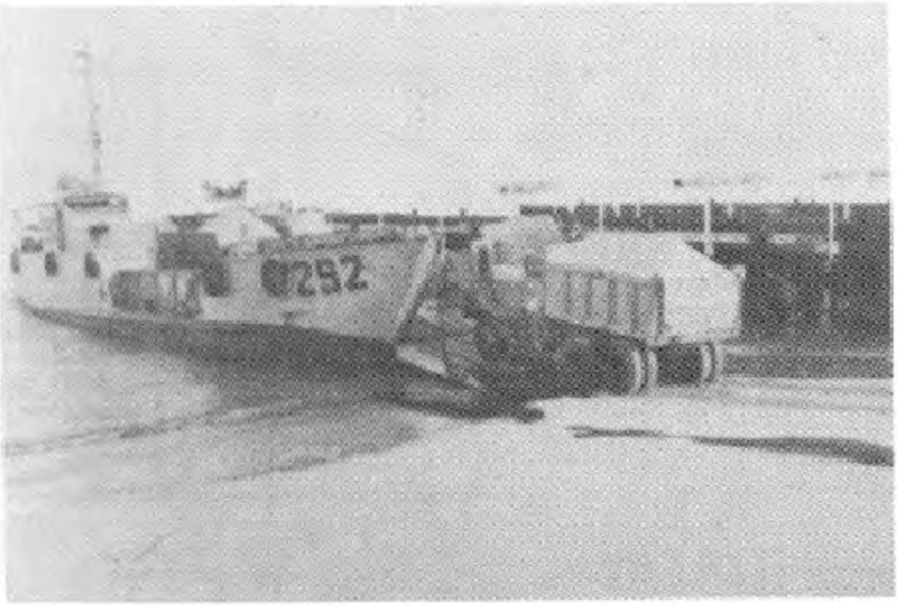


FIGURE 1-40. MOVING AGGREGATE FROM MEDREN TO ENEWETAK ISLAND.

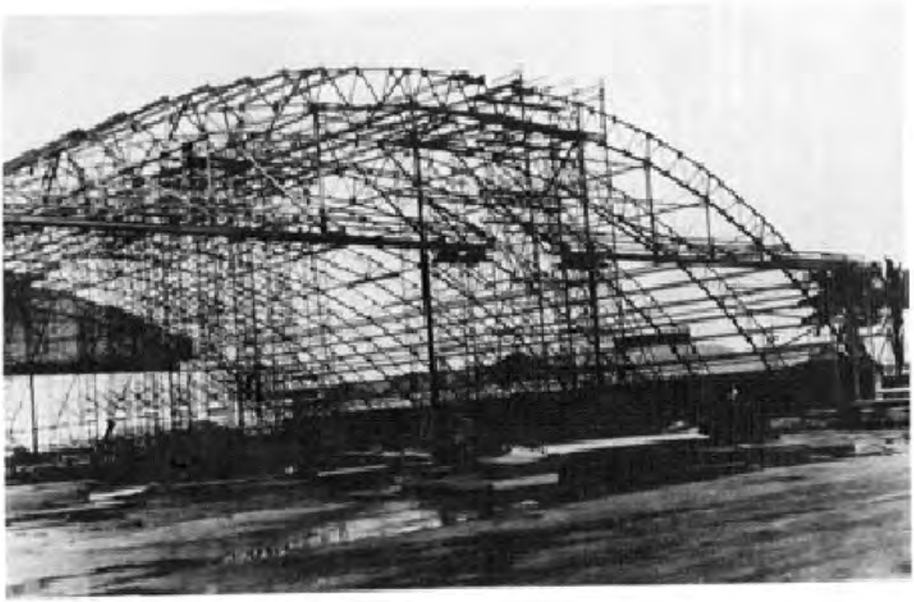


FIGURE 1-41. ERECTION OF AIRCRAFT HANGAR.

The general plan proposed was, as stated earlier, the development of Medren (also called Parry) as the base for laboratory, scientific, and administrative operations, and for the quarters of construction personnel, with the military being housed on Enewetak Island. An important part of the plan was that all possible support functions, including engineering design, prefabrication, procurement, and accounting, would be performed in the United States. The purpose in doing this was to increase productivity, reduce the cost of maintaining personnel living away from their homes, and speed up the procurement of necessary equipment and materials. Construction camps were to be developed on the test or neighboring islands, and the scientific and technical facilities were to be built on the test islands and on islands appropriate for measurement and observation.[78] A section of Enewetak Island as it appeared in full operation is shown in Figure 1-42. This was the military headquarters and residence island. Medren, at a similar phase, appears in Figure 1-43. This island served as the headquarters and residence for civilian scientists and contractors. Construction camps on Lidilbut (Gene) and Enjebi are shown in Figures 1-44 and 1-45.

OPERATION GREENHOUSE: APRIL-MAY 1951

On 31 January 1950, President Truman announced that the decision had been made to develop the hydrogen or thermonuclear bomb, and that the AEC had been directed to continue to work on all forms of nuclear weapons, including the H-bomb. In June of the same year, the Korean conflict began. Both events, though unrelated, created the need for more and faster-paced tests. Enewetak was the obvious place for testing the H-bomb, once developed, but Enewetak could not be expected to accommodate all of the test operations that now loomed in the immediate future. In order to ease this situation, the AEC decided to establish a proving ground in the continental United States which could be used for tests of weapons of nominal yield. The site selected was part of the Las Vegas Bombing and Gunnery Range in southeastern Nevada. This became the Nevada Proving Ground, later the Nevada Test Site.

In 1951, at the time that the next series of tests in the Pacific was to be conducted, the H-bomb was still under development. However, some devices related to thermonuclear bombs were tested in Operation Greenhouse. This operation consisted of four tests (Dog, Easy, George, and Item) conducted during April and May 1951. The only yield published was that of Easy—47 KT. All were tower shots.[79]

One of the important "nuclear weapons effects" tests carried out during this series measured the effect of blast on military and industrial facilities.

FIGURE 1-42. THE CENTER OF ENEWETAK (FRED) ISLAND.

FIGURE 1-43. MEDREN (ELMER) ISLAND.

FIGURE 1-44. CONSTRUCTION CAMP ON LIDILBUT (GENE) ISLAND.

FIGURE 1-45. ENJEBI (JANET) ISLAND CAMP AREA.

Twenty-seven structures of various designs were erected, and blast force and other measurements were made on them.[80] Two of the structures constructed for this purpose are shown in Figures 1-46 and 1-47.

OPERATION IVY: OCTOBER-NOVEMBER 1952

There were only two detonations in Operation Ivy, but the first of these, Event Mike, was especially significant as it was the first test of an experimental thermonuclear device. The test occurred on 31 October 1952, and the device (it was not a bomb in the true sense) was located on the surface of Elugelab, one of the most northern islands of the atoll. The yield was 10.4 megatons (MT), equivalent to 10.4 million tons of high explosives. The general appearance of the device is shown in Figure 1-48.

The island of Elugelab was practically vaporized by the detonation and in its place was a crater more than a mile in diameter and 200 feet deep. A large fireball, 3-1/2 miles in diameter and followed by a wave of water, swept across neighboring islands. Trees and shrubs facing the test site on the island of Biken were scorched and wilted, although they were located 14 miles southwest of the Mike shot site.[81] Figure 1-49 shows the island chain before the shot. The visible causeways were constructed to carry

FIGURE 1-46. HANGARS CONSTRUCTED TO STUDY BLAST EFFECTS, ENJEBI.

FIGURE 1-47. STRUCTURE-TEST BRICK HOUSE, ENJEBI.

instrumentation lines, as well as to provide access to the shot island. Figure I-50 shows the island chain after Event Mike.

The second test of Operation Ivy, Event King, was an air drop 2,000 feet north of Runit. The detonation took place at an altitude of 1,500 feet and the yield was 500 KT.[82] This was the largest fission weapon ever detonated. Weapons with greater energy releases were of the fusion type.

OPERATION CASTLE: FEBRUARY-MAY 1954

In September 1952, the AEC removed Bikini Atoll from the provisional status in which it had been held since Operation Crossroads and made it a part of the Pacific Proving Ground. In the next test series, Operation Castle, five of six shots were carried out at Bikini. Only Event Nectar, a barge shot, was conducted at Enewetak. The shot location was Mike Crater, and the yield was 1.69 MT.[83]

One of the Bikini shots, Bravo, became well known because the fallout from this 15 MT detonation was carried to the east, rather than to the north as had been predicted, and fell on the atolls of Rongelap, Ailinginae, and Rongerik. Fallout was heavy enough to cause serious illness and at least one death among the crew of the Japanese fishing boat Fikuryu Maru, which had not received warning of the test and had sailed into the danger zone. These events produced renewed interest in radiological health

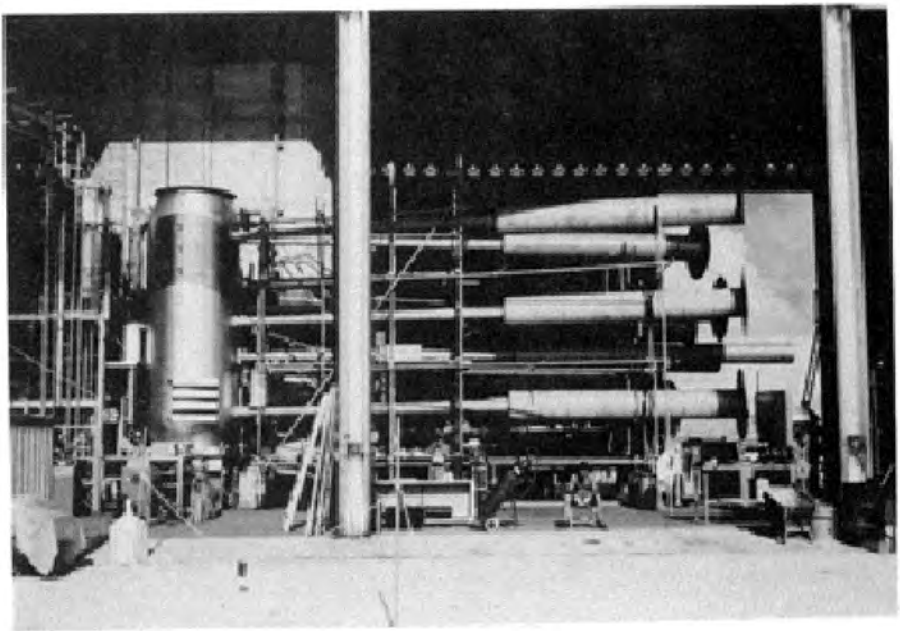


FIGURE 1-48. THE MIKE DEVICE OF OPERATION IVY ON ELUGELAB.

FIGURE 1-49. EVENT MIKE FACILITIES ON ELUGELAB, LIDILBUT, BOKAIDRIKDRIK, AND BOKEN.

FIGURE 1-50. THE ISLAND CHAIN AND CRATER AFTER EVENT MIKE.

effects and caused the United States to enlarge the oceanic area in which fishing and shipping would be excluded.[84]

OPERATION REDWING: MAY-JULY 1956

In 1953, the United States had established the pattern of testing in the Pacific and in Nevada on alternate years. This was continued in 1956, when 11 of the 17 shots of Operation Redwing were fired at Enewetak and the other six were conducted at Bikini. Most of the yields from this series were classified and only the Seminole Event at 13.7 KT and the Lacrosse Event at 40 KT were announced. Of the Enewetak events, two were carried out on island surfaces, six were tower shots, and two were barge shots. Additionally, the first air drop of a thermonuclear bomb was executed, with a yield of several megatons. The Redwing series at Enewetak extended from 4 May to 21 July 1956.

Seminole, one of the surface shots, removed a good part of Boken (Irene) Island in much the same manner as Mike removed Elugelab. The other surface shot was Lacrosse, which formed a large crater on the northern reef of Runit. The shot tower on Aomon for Event Kickapoo of the Redwing series is shown at Figure 1-51.

FIGURE 1-51. EVENT KICKAPOO SHOT TOWER, AOMON.

OPERATION HARDTACK I: APRIL-AUGUST 1958

Though international discussions had been opened on the cessation of atmospheric nuclear testing, the AEC and DOD announced on 15 September 1957 that, in the absence of a disarmament agreement, the U.S. would continue testing in the Pacific with the conduct of the Hardtack I series, beginning in April 1958. Hardtack I consisted of 34 events, 22 of which were at Enewetak, two in the Johnston Atoll area, and ten at Bikini. The first event of the Hardtack I series was carried by balloon to a height of 86,000 feet and detonated over the ocean about 80 miles northeast of the atoll. This event, Yucca, is not classified as an Enewetak shot since it occurred between Enewetak and Bikini. Three surface events took place on Runit, and these were to produce significant effects. Cactus Event formed a crater on the Runit reef, while the Quince and Fig Events caused widespread surface and subsurface contamination of northern Runit. A fourth surface event, Koa, 1.37 MT, was carried out on Lidilbut, vaporizing it in the same manner that Mike had removed Elugelab. Two events, Wahoo and Umbrella, were conducted underwater, the first at a depth of 500 feet in the ocean, the second at a depth of 150 feet in the lagoon. All other events were barge events in the lagoon, with the exception of the Oak Event which, although a barge shot, was carried out on the western reef. Construction of one of the scientific stations on Runit for the Hardtack series is shown in Figure 1-52. The events conducted during Hardtack I represented slightly more than 50 percent of all nuclear tests conducted at Enewetak. They also were the last nuclear explosions to occur on either Enewetak or Bikini. Figure 1-53 shows the locations of all test events that were detonated during nuclear testing at Enewetak Atoll.[85]

MORATORIUM AND TEST BAN

A conference to explore methods of detection of possible violations during a potential suspension of nuclear weapons testing was held in Geneva, Switzerland, from 1 July through 21 August 1958. The attendees included the United States, the United Kingdom, Canada, France, the Soviet Union, Poland, Romania, and Czechoslovakia. The final report stated that it would be "technically feasible to set up, with certain

FIGURE 1-52. EVENT HARDTACK SCIENTIFIC STATION 1310, RUNIT.

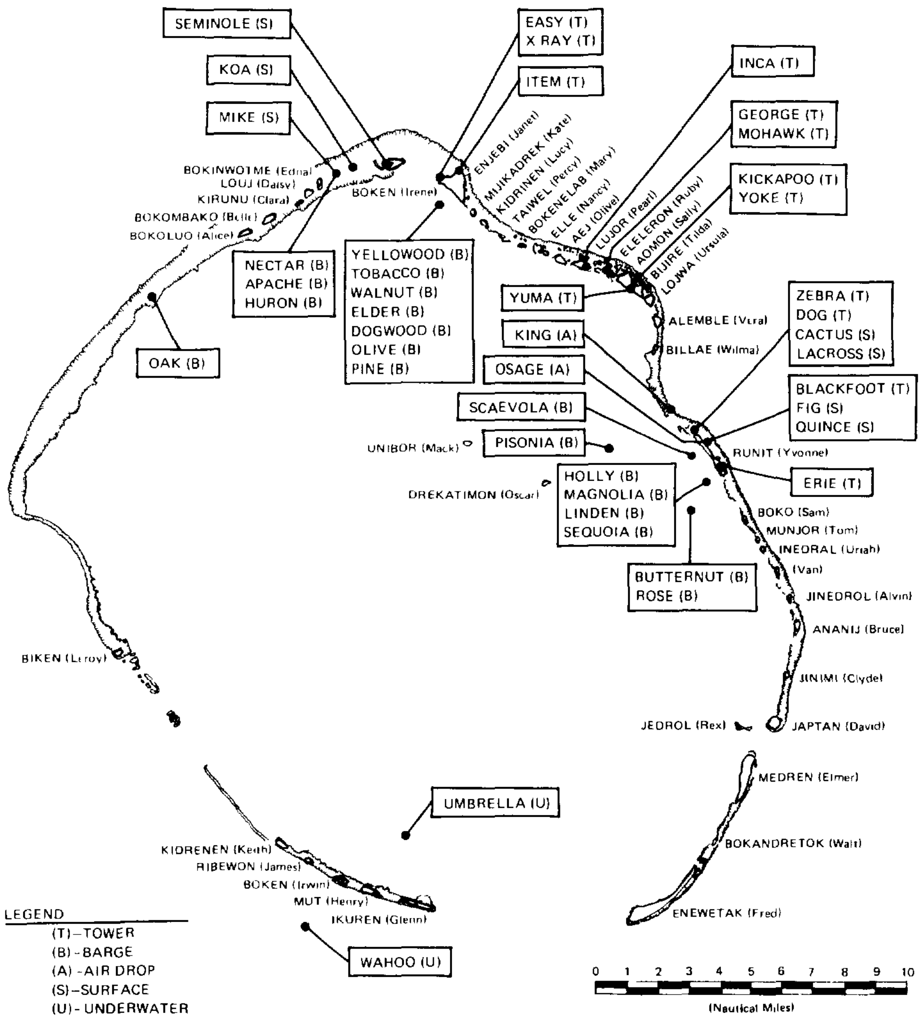


FIGURE 1-53. NUCLEAR DETONATION SITES ON ENEWETAK ATOLL.

capabilities and limitations, a workable and effective control system for the detection of violations."[86] On 22 August, the day after the closing of the conference, President Eisenhower declared the intention of this country to negotiate with any other country on nuclear weapon test suspension. This offer was accepted by the Soviet Union on 29 August 1958. The end of the atmospheric testing of nuclear weapons was set at 30 October 1958.

Hardtack II, a series of 11 events, was conducted at the Nevada Test Site between 12 September and 30 October, with the objective of completing as much of the U.S. atmospheric testing program as possible. Although the joint moratorium on testing by the United States and the Soviet Union started on 31 October 1958,[87] the Soviet test program was concluded later, with one test on 1 November and another on 3 November. Discussions to formalize a ban on atmospheric nuclear testing were then underway in Geneva.

Three years later, on 1 September 1961, the Soviet Union announced its intention to resume nuclear testing, and the Soviets began testing within a few days of the announcement. The United States was not prepared to resume testing immediately, and it was not until April 1962 that the first U.S. test was held. The U.S. program was code named Operation Dominic, and it was conducted in the vicinity of Johnston Atoll and Christmas Island in the central Pacific.[88,89] In all, 34 events were conducted in the eastern Pacific, commencing on 25 April and concluding on 4 November 1962.

The Limited Test Ban Treaty with the Soviet Union was signed in September 1963, prohibiting nuclear weapons tests in the atmosphere, underwater, and in space, and permitting only underground testing. Since then, the only atmospheric tests that have been reported have been held by countries other than the United States, United Kingdom, and the Soviet Union.

SUMMARY OF TEST EFFECTS

Figure 1-54 lists the 43 events which were detonated during nuclear weapons testing at Enewetak Atoll from 1948 to 1958.[90] Each of these tests produced some measurable effects on some part of the atoll, while a number of them caused major changes in the topography of some islands. In addition, noticeable changes were produced by the construction operations required for test preparation and for the measurement and recording of results. The following listing represents most of the visible effects which nuclear weapons tests produced on Enewetak Atoll:

a. The islands of Elugelab and Lidilbut were removed, together with most of Bokaidrikdrik (Helen) and Eleleron (Ruby).

Operation	Event Name	Date (GCT)	Type and Height of Burst	Location	Yield
Sandstone	X-ray Yoke Zebra	14 Apr 48 30 Apr 48 14 May 48	Tower 200′ Tower 200′ Tower 200′	Enjebi (Janet) Aomon (Sally) Runit (Yvonne)	37 KT 49 KT 18 KT
Greenhouse	Dog Easy George Item	7 Apr 51 20 Apr 51 8 May 51 24 May 51	Tower 300′ Tower 300′ Tower 200′ Tower 200′	Runit (Yvonne) Enjebi (Janet) Eleleron (Ruby) Enjebi (Janet)	Class. 47 KT Class Class
Ivy	Mike King	31 Oct 51 15 Nov 52	Surface Airdrop 1500′	Elugelab (Flora) 2000′ North of Runit (Yvonne)	10 4 MT 500 KT
Castle	Nectar	13 May 54	Barge	Mike Crater	1 69 MT
Redwing	Lacrosse Yuma Erie Seminole Blackfoot Kickapoo Osage Inca Mohawk Apache Huron	4 May 56 27 May 56 30 May 56 6 Jun 56 11 Jun 56 13 Jun 56 16 Jun 56 21 Jun 56 2 Jul 56 8 Jul 56 21 Jul 56	Surface Tower 200′ Tower 300′ Surface Tower 200′ Tower 300′ Airdrop Tower 200′ Tower 300′ Barge Barge	Runit (Yvonne) Aomon (Sally) Runit (Yvonne) Boken (Irene) Runit (Yvonne) Aomon (Sally) Runit (Yvonne) Lujor (Pearl) Eleleron (Ruby) Mike Crater Mike Crater	40 KT Class Class 13 7 KT Class Class Class Class Class Class Class
Hardtack I	Cactus Butternut Koa Wahoo Holly Yellowwood Magnolia Tobacco Rose Umbrella Walnut Linden Elder Oak Sequoia Dogwood Scaevola Pisonia Olive Pine Quince Fig	5 May 58 11 May 58 12 May 58 16 May 58 20 May 58 26 May 58 26 May 58 30 May 58 2 Jun 58 8 Jun 58 14 Jun 58 18 Jun 58 27 Jun 58 28 Jun 58 1 Jul 58 5 Jul 58 14 Jul 58 17 Jul 58 22 Jul 58 26 Jul 58 6 Aug 58 18 Aug 58	Surface Barge Surface Underwater 500′ Barge Barge Barge Barge Barge Underwater 150′ Barge Barge Barge Barge Barge Barge Barge Barge Barge Barge Surface Surface	Runit (Yvonne) Lagoon Lidilbut (Gene) Ocean Lagoon Lagoon Lagoon Lagoon Lagoon Lagoon Lagoon Lagoon Lagoon Reef Lagoon Lagoon Lagoon Lagoon Lagoon Lagoon Runit (Yvonne) Runit (Yvonne)	18 KT Low Yield 1 37 MT Class Class Class Class Class Class Class Class Class Class 8.9 MT Class Class Class Class Class Class Class Class

Notes Dates are determined from the Greenwich Civil Time (GCT) of the detonation
Tests are given as kilotons (KT), megatons (MT), or as "Classified" (Class)
Height or depth of burst are from other sources

FIGURE 1-54. NUCLEAR EVENTS AT ENEWETAK ATOLL

b. Large craters were formed on the reefs on the north end of Runit, to the Northeast of Bokinwotme (Edna) where Elugelab and Lidilbut had been, and on Boken (Figures 1-55, 1-56 and 1-57).

c. Surface profiles in the vicinity of ground zeroes were changed by blasts as well as by efforts to restore the area for continued use.

d. Coconut palms and other vegetation were destroyed in many areas.

e. The construction of causeways, landfills, and the excavation of borrow areas in the course of test preparation had modified the atoll topography.

f. Large structures and bunkers for test measurement or observation remained after testing was completed.

g. Semipermanent buildings were left standing, especially on the islands of the southeast.

h. Tons of concrete and metal debris remained.

Conditions that were not readily visible included contaminated soil on many islands of the atoll and contaminated sediments on the bottom of the lagoon. The lagoon also contained many miles of cable that had been laid between islands for instrumentation, communication, and the activation of the nuclear devices.

The principal radioisotopes that made up the residual radioactivity on Enewetak Atoll following the test period were:

a. Cobalt-60, an emitter of gamma rays and beta particles, with a half-

FIGURE 1-55. CRATERS ON RUNIT.

FIGURE 1-56. CRATERS RESULTING FROM MIKE AND KOA EVENTS (SEMINOLE CRATER IN THE BACKGROUND).

FIGURE 1-57. SEMINOLE CRATER ON BOKEN.

life of 5.3 years.

b. Strontium-90, an emitter of beta rays, with a half-life of 29 years.

c. Cesium-137, an emitter of gamma rays and beta particles, with a half-life of 30 years.

d. Plutonium-239, an emitter of alpha particles, with a half-life of 24,000 years.

e. Plutonium-240, an emitter of alpha particles with a half-life of 6,600 years.

f. Americium-241, an emitter of gamma rays with a half-life of 433 years.

In addition to the radionuclides present in the soil and lagoon sediments of Enewetak Atoll, other radioactive materials were present on some of the islands in the form of contaminated debris. Some of this debris was on the surface and some was in burial sites on certain islands. All of these evidences of the nuclear test program were to have some influence on the cleanup operation. In chapters to follow, the condition of each individual island is described. These descriptions are based on the conditions of the island in 1977, almost 20 years after the last test shot was fired and before any cleaning operations had begun.

WESTERN TEST RANGE: 1958 - 1972

The years between the termination of the nuclear weapons test program and the commencement of cleanup planning were not without activity. For a short time, the atoll lagoon was used as a target area for missiles fired from Vandenberg Air Force Base in California. Later, that function was transferred to the much larger lagoon of Kwajalein Atoll. In the 1960's, explorations and experiments on the upwelling of deep-ocean water were conducted by the University of California at San Diego. Neither of these operations had much effect upon the effort that would be required in the cleanup project, although some structures were erected to provide operations and maintenance support.

PROJECT HIGH ENERGY UPPER STAGE (HEUS)

During the time that the atoll was under the control of the U.S. Air Force, two test firings of a developmental HEUS rocket motor were conducted. One was conducted in 1968 and the other in 1970, both on Enjebi. The rocket motors tested each contained 2,500 pounds of propellant of which 300 pounds was beryllium. The first firing, in April

1968, resulted in a high-order detonation which scattered propellant over the western tip of Enjebi.[91] The location of the HEUS operation is shown in Figure I-58.

The engine started operating normally but, after a short time, it exhibited uncontrolled burning which resulted in destruction of the

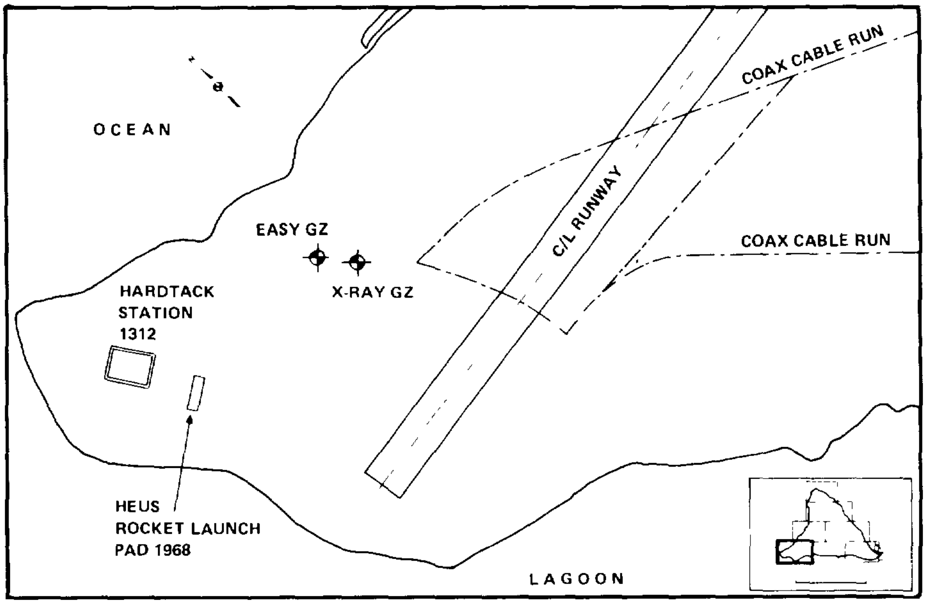


FIGURE 1-58. PROJECT HEUS, ENJEBI.

engine, spalling of the concrete blockhouse to which it was attached, and the spreading of beryllium metal and oxides over a wide area in a nonuniform manner. After wetting the area thoroughly, a decontamination crew scraped dirt from the surface inside a circle of 100 feet radius. The dirt was buried in the crater resulting from the explosion. In addition to soil contamination, some beryllium was plated on the surface of a concrete blockhouse. No attempt was made at that time to determine the exact location or extent of contamination. An investigation was made in May 1969 and, although the area was indicated to be safe without protective clothing or breathing apparatus, the results also were considered to be equivocal because of the random nature of the contamination pattern.

A second firing conducted in January 1970 was successful and did not result in an explosion. The U.S. Air Force Environmental Health Laboratory took soil samples before, during, and after firing. The results were published in the Laboratory's Report Number 71M-2.[92] Sampling after decontamination showed the cleaning operation to be "quite successful" or "reasonably successful," the beryllium content of the soil being, in many cases, less than the contamination that was present before the second test.[93]

Beryllium is toxic to man when inhaled and lodged in the lungs. The threshold level for such toxicity was defined in 1971 as 0.01 microgram per cubic meter of atmospheric air.[94] The area was rechecked in 1971 by AEC contractor personnel. Soil sample analysis showed no surface contamination greater than 0.05 microgram of beryllium per gram of dry soil. It was believed that decontamination and erosion of the western tip of Enjebi had reduced contamination such that there would be no problem with beryllium on the surface.

CHAPTER 2

PLANNING AND PROGRAMMING 1972 - 1977

DECISIONS FOR THE FUTURE: APRIL 1972

The agreement under which Enewetak was used by the United States for nuclear testing required a review on 30 June 1961 and every 5 years thereafter to determine the need for its continued use.[1] During the June 1971 review, it became apparent that the need had dramatically declined and that the atoll could be returned to the Trust Territory of the Pacific Islands (TTPI). Nuclear testing at Enewetak had ended in 1958 when it was realized that atmospheric testing, even at that remote atoll, was affecting much of man's environment. Enewetak's remoteness then became a liability for most other test programs, in that it was less economical and less practical than other available sites. For example, Johnston Atoll and Christmas Island replaced Enewetak as the main bases for a series of nuclear tests the United States conducted in 1962 after Russia had resumed nuclear testing in the atmosphere in violation of the 1958 moratorium.

By 1971, only two military test programs were still scheduled at Enewetak: (1) a U.S. Air Force space research program; and (2) the Defense Nuclear Agency's (DNA's) proposed Pacific Cratering Experiment (PACE). Both were to be completed in 1973. There also were two long-term biological studies being conducted by civilian agencies; however, they did not conflict with the return of the atoll to the TTPI. Based on the June 1971 review, the decision was made to terminate use of Enewetak as a test range and return the atoll to the TTPI.[2] Under the original agreement, the United States had 30 days to remove any improvements and structures it desired to retain, after which everything remaining reverted with the land to the TTPI. Since immediate departure would have left much debris, many dilapidated buildings, and numerous radiologically contaminated islands, the United States recognized a moral, if not legal, obligation to restore the atoll to a more habitable condition.

An interagency conference on the return of Enewetak Atoll was held in February 1972 in Washington, D.C., and attended by representatives from the Office of Micronesian Status Negotiations (MSN), the Department of Defense (DOD), the Department of the Interior (DOI), and the Atomic Energy Commission (AEC). DNA also was represented, since it had managed the cleanup of Bikini Atoll and was preparing to use Enewetak for one last weapons-related experiment, the PACE program, before return of the atoll by the United States This conference marked the beginning of DNA's involvement in the Enewetak Cleanup Project.[3] Shortly after the conference, DOI formally notified President Nixon's personal representative for the MSN, Ambassador Franklin Haydn Williams, of the following decisions:

a. The United States was phasing down research programs to permit an early return of the atoll to the TTPI.
b. Cleanup and rehabilitation of three islands—Medren (Elmer), Japtan (David), and Ananij (Bruce)—could begin in 1973.
c. Subject to TTPI permission to continue the four test programs then scheduled, the United States was prepared to release the atoll at the end of 1973.[4]

These decisions were made public on 18 April 1972 in a joint statement by Ambassador Williams and the High Commissioner of the TTPI, the Honorable Edward E. Johnston. The announcement stated that, prior to actual resettlement of the atoll, it would be necessary to carry out the same type of survey, cleanup, and rehabilitation that had been carried out at Bikini. It also stated that the United States planned to commence the survey later that summer.[5] The survey did begin in 1972; however, due to unforeseen events which are described in subsequent sections, the atoll was not released until 16 September 1976, and formal cleanup operations did not begin until 1977.

DETERMINING THE SCOPE OF WORK: MAY 1972

On 10-24 May 1972, a preliminary radiological survey and initial reconnaissance of the atoll was made by representatives from AEC, DNA, the Environmental Protection Agency's (EPA) Western Environmental Research Laboratory, and the University of Washington. They were joined on 18-20 May 1972 by representatives of the U.S. Air Force, TTPI, and the dri-Enewetak and their attorneys, Micronesian Legal Services Corporation (MLSC), for conferences and tours of some major islands. Dri-Enewetak representatives included Iroij (Chief) Johannes Peter of the dri-Enewetak, Iroij Lorenzi Jitiam of the dri-Enjebi, and the Ujelang Community Council. This was their first visit to their homeland since they were removed in 1947. The tour party included several key participants in the subsequent planning and cleanup efforts, such as Mr. Peter T. Coleman, the Deputy High Commissioner of the TTPI, Mr. Oscar DeBrum, the TTPI District Administrator of the Marshall Islands, Mr. Roger Ray of the Nevada Operations Office of the AEC (AEC-NV), and Mr. Theodore R. Mitchell, Executive Director of the MLSC. What they found were badly deteriorated test and support facilities, which had been evacuated in 1958 almost as if for a fire drill rather than the end of an era. On Medren, unfinished memos lay on the desks in some buildings, while landing craft sat rusting where they had been pulled from the water. Everywhere, nature—in the form of impenetrable brush, termite burrows, rot, and rust—was reclaiming the atoll from the ruins of an advanced technology.[6,7,8] What many had not believed when the nuclear test moratorium began in 1958 was an obvious fact in 1972—nuclear weapons testing had ended at Enewetak Atoll.

Nuclear testing had left its unmistakable mark. The preliminary radiological survey found potentially significant radiation hazards on the islands of Bokombako (Belle), Enjebi (Janet), Aomon (Sally), and Runit (Yvonne). More detailed surveys would be required to identify locations and to determine degrees of contamination. More study and planning would be necessary to develop removal and disposal procedures for the contaminated soil and debris.[9]

PACIFIC CRATERING EXPERIMENT: 1971 - 1972

Preparation for PACE had been underway at Enewetak for almost a year prior to AEC's preliminary radiological survey in May 1972. PACE was a DNA-funded program conducted by the U.S. Air Force Weapons Laboratory (AFWL) at Enewetak Atoll from June 1971 to October 1972. The program had two basic objectives: (1) PACE I, to define the geology, geophysics, and material properties of the near subsurface (0-100m depth) of the atoll rim; and (2) PACE II, to conduct a series of high explosive cratering experiments, ranging from 1,000 pounds to 500 tons, to establish nuclear explosive/high explosive equivalence for cratering and ground motions.[10] The PACE operations were preceded by two separate radiological surveys, neither of which indicated any serious hazards, and they were supported by a radiological safety program.[11] Measurements during the PACE program indicated no significant radiation hazard, no need to decontaminate equipment, and no requirement for radiological protective clothing or equipment. Nevertheless, bioassay samples were taken as an added precaution, and none showed any indication of plutonium uptake.[12,13]

AFWL personnel drilled the first test hole in the rim of the Cactus Crater on Runit on 30 September 1971. They continued drilling holes and digging trenches on Runit for the next 8 months before the preliminary AEC radiological survey began in May 1972. During the same period, researchers from the Enewetak Marine Biological Laboratory (EMBL), an AEC contractor, were camped on the Cactus Crater rim and conducting biological surveys around Runit using no special protective clothing.

QUARANTINE OF RUNIT: MAY 1972

During the May 1972 AEC survey, several bits of metal with centimeter-range dimensions were found on Runit. Three fragments were hand-carried to the University of Washington for analysis, where they were identified as plutonium-contaminated beryllium. They appeared to be residue from the nonnuclear detonation of the Quince shot or the very-low-order Fig shot and similar to residue found on Johnston Atoll after two low-order detonations there. The presence on Runit of discrete pieces of metal contaminated with plutonium presented a new and serious concern.[14] The senior AEC representative, Mr. Roger Ray, recommended immediate quarantine of Runit; i.e., to cease all operations thereon and to not remove any vehicles, equipment, or materials until adequate decontamination procedures could be established The AEC's recommendation was intended primarily to prevent further aggravation, through dispersion, of an already difficult contamination problem and did not imply that activities to date had caused any significant personnel exposures.[15] In response to the AEC's recommendation, the U.S. Air Force Space and Missile Test Center (SAMTEC), which then managed the atoll, put the quarantine into effect on 22 May 1972.[16]

Considering previous results, the quarantine seemed somewhat severe to DNA Since the quarantine stopped PACE operations on Runit, DNA asked the AEC Nevada Operations Office (AEC-NV) for additional data on the nature of the hazard which might then allow completion of PACE.[17] On 30 June 1972, DNA and AEC representatives met and agreed that an additional survey should be made to determine if PACE might safely resume on Runit. That survey was carried out from 26 July to 2 August 1972 by AEC and DOD personnel. Safe zones were identified in and around the Fig/Quince area. The quarantine was lifted to permit work in those zones, and PACE operations on Runit continued until September 1972 when the program was again halted, this time by a restraining order issued by the U.S District Court in Honolulu at the request of Mr. Mitchell, the dri-Enewetak's legal counsel. The principal bases of the complaint were that the PACE Project had been started before DOD had filed a final environmental impact statement; that DOD had refused to hold hearings on Ujelang Atoll; and that the decision to conduct PACE on Enewetak was a violation of both the National Environmental Policy Act (NEPA) and the Trusteeship Agreement.[18,19]

On 5 October 1972, the District Court ruled that the plaintiffs were entitled to an injunction because of the violation of NEPA and, therefore, PACE activities, including core drilling and seismic surveys at Enewetak, were prohibited. The injunction included a prohibition on excavation of land, reef, or beach areas; core drilling; detonation of explosives of any kind; clearing of vegetation; and construction of roads in connection with PACE. From October 1972 until a court hearing in June 1973, AFWL prepared a draft Environmental Impact Statement (DEIS), held public hearings at Ujelang Atoll in an attempt to obtain dri-Enewetak support, and reorganized the PACE test plan. The court hearing resulted in cancellation of the cratering experiments; however, the geological portions of PACE were permitted to continue as the Exploratory Program on Eniwetok (EXPOE) which is described in a subsequent section.[20]

Before the restraining order and injunction halted PACE activities on the atoll, a 19-acre area covering approximately one-fifth of Aomon had been excavated to form a large depression for use as a bed for a 1000-pound high explosive parametric test shot. The court ordered that the area be restored to its original profile. DNA obtained Mr. Mitchell's approval of a modified stipulation to accomplish the restoration in conjunction with the forthcoming radiological cleanup project or, if the project were cancelled, as a separate action.[21] When the cleanup project was approved and funded, restoration of the PACE test bed was included in the cleanup project operation plan.

During preparations for PACE, large quantities of high explosives were stockpiled on Medren. These became excess when PACE was cancelled, and they were transferred to the TTPI for use in channel clearance in the Marshall Islands District. Unfortunately, the ship chartered by the TTPI to remove the explosives was overloaded, foundered, and sank a few hundred miles from Enewetak Atoll; however, the crew was rescued.

ASSIGNMENT OF RESPONSIBILITIES: JULY-NOVEMBER 1972

On 17 July 1972, the Assistant Secretary of Defense for International Security Affairs, ASD(ISA), advised DNA that DOD planned to conduct the cleanup of Enewetak Atoll with the technical support of AEC. He requested that DNA initiate planning actions with AEC to identify the scope of work and the resources necessary for this mission.[22] During the next month, DNA presented a series of introductory briefings on the project for officials of the Office of the Secretary of Defense and Joint Chiefs of Staff (JCS) and met with AEC representatives to develop a preliminary planning strategy.[23] The Director, DNA, Lieutenant General Carroll H. Dunn, USA, went to Enewetak on 2 September 1972 for a personal survey of the situation.[24] The following week, on 7 September 1972, there was a major conference in Washington, D.C., attended by representatives from over a dozen departments and agencies. The primary results were agreements on planning actions and basic responsibilities for the cleanup and rehabilitation efforts as follows:

- DOD would fund the precleanup engineering survey; the monitoring and surveys required to support cleanup operations and to insure the safety of personnel involved in the cleanup; and the actual radiological and nonradiological cleanup efforts.
- AEC would fund the precleanup radiological survey of Enewetak; any other survey activities required to understand radiological exposure of the people and development of standards; and periodic radiological surveys after cleanup. DOD would reimburse for any subsequent AEC field and/or laboratory work done in support of cleanup.
- DOI would fund the rehabilitation work.[25]

DNA and AEC did not wait for the completion of supporting paperwork. Both organizations began their precleanup surveys in October 1972 while formal agreements and tasking documents were being developed.

On 14 November 1972, the Secretary of Defense formally advised the Chairman of the JCS of DOD's responsibilities for cleanup and requested that the Director, DNA be designated as Project Manager.[26] The formal designation was made by the JCS on 30 November 1972. It contained specific guidance and authorizations from the Secretary of Defense, including: (1) authorization to act for the Secretary of Defense in planning and—if approval was granted—in accomplishing the project, including direct liaison with other agencies and development of agreements with them; (2) direction to keep the Secretary and the Chairman, JCS informed throughout the planning and execution of the project, specifically including any requirements for military service support; (3) tasking for preparation of an Environmental Impact Statement (EIS); and (4) guidance to not commit the DOD to financing or executing the cleanup project until further funding guidance was received.[27] Formal funding guidance was not received from the Office of Management and Budget (OMB) until October 1973, almost a year later.[28]

DNA and AEC formalized the agreement on the conduct and support of the radiological and engineering surveys on 8 December 1972, about 2 months after the surveys began.

ENEWETAK ENGINEERING SURVEY: OCTOBER 1972-APRIL 1973

DNA contracted with Holmes & Narver, Inc. (H&N) to conduct the engineering survey of Enewetak Atoll and provide the results in an engineering study, to include recommendations and cost estimates for cleanup of the atoll. H&N was selected because of their long experience in providing technical and logistics support at Enewetak during the nuclear test period and because the firm had a large repository of data and maps pertinent to the locations and effects of the tests.[29]

The Enewetak Engineering Survey began on 12 October 1972. Field work was accomplished by three two-man teams working in conjunction with the AEC radiological survey team. They used motor launches for transportation across the lagoon and rubber rafts to travel from the launches across the shallow reefs to most of the islands. The H&N teams' first effort on each island was to locate the buildings and other facilities shown on maps from the nuclear testing era. Then they recorded each object's present condition and their recommendations for its disposition. When all previously recorded objects had been accounted for, each island was resurveyed to assure that any other hazardous objects had been located and recorded for the survey report. Vegetation was so dense on some islands that it prevented a thorough search for hazardous objects. On islands where radiological contamination was suspected, the AEC radiological survey personnel checked each object for contamination. Readings were marked on the Engineering Survey maps. Material which showed radiation measurements greater than measurements of local background was shown as contaminated.[30]

The surveys were severely hampered by adverse weather. Heavy sea conditions prevented actual survey of Boken (Irwin) and Ribewon (James) Islands; however, they had been adequately covered by the May 1972 survey. Typhoon Olga struck the atoll on 23 October 1972, and the Commanding General, SAMTEC, ordered an air evacuation of all personnel to Kwajalein Missile Range. Little time was given to protect the base camp from the effects of the typhoon, and several facilities were severely damaged. After the return to the atoll, AEC-NV had two turbine generators from the Nevada Test Site flown in to restore power for essential life-support facilities. Engineering Survey field work resumed on 8 November and was completed on 21 December 1972. Results of the survey, together with some data from the AEC Radiological Survey, were published in April 1973 as the Engineering Study for a Cleanup Plan.[31]

The Engineering Study contained the results of the field survey and conceptual plans for accomplishing the cleanup project using a commercial contractor or, as an alternative, using military forces. It was published in three volumes.

Volume I showed the results of the island-by-island site survey, with aerial photographs of each island and a listing of all structures, other construction, and major debris on each. The condition of each item was indicated, along with a recommended disposition; e.g., remove, leave as is, make safe, or rehabilitate. Each recommendation was based on potential use of the item by the dri-Enewetak and took into account criteria established by the TTPI and DNA. This volume also contained proposals for mobilization, base camp construction, cleanup, and demobilization, using contractor forces. Cost estimates and cleanup work estimates were based on preliminary standards furnished by DNA for both radiological and nonradiological cleanup. The nonradiological criteria served as a basis for future plans and much of the actual cleanup. The radiological criteria were changed many times before that part of the cleanup could begin.[32]

The Engineering Study described several options for disposition of contamination, none of which were adopted, but which continued to be proposed as alternatives in subsequent planning conferences. These included:

a. Covering contaminated soil with a blanket of clean soil.
b Dumping contaminated debris in the craters on Runit.
c. Dumping contaminated debris and soil in the lagoon.
d. Dumping contaminated debris and soil in the ocean.
e Shipping contaminated debris and soil to the continental United States (CONUS) for storage.[33]

Volume II was an assembly of large maps of each of the islands. Each map showed the location of each structure, item of construction, junk pile, concrete strip, and test station, as well as stands of vegetation and other natural features. Also shown were such items of radiological interest as contaminated burial areas, contaminated scrap piles, and other radioactive debris.

Volume III contained detailed and summary cost estimates. The total estimated cost (in 1972 dollars) for cleanup, including dumping contaminated debris in the Runit craters and spreading 62,000 cubic yards of clean soil on Enjebi, was $28.8 million using foreign contractor personnel and $18.4 million using military troops. Options added $1.4 million for ocean dumping of contaminated material or $4.3 million for its return to the United States.[34]

Before the Engineering Study data could be incorporated in an EIS, more information was required on DOI's rebabilitation plans and AEC's radiological cleanup criteria.

ENEWETAK RADIOLOGICAL SURVEY: OCTOBER 1972-OCTOBER 1973

On 13 September 1972, AEC-NV was directed to plan, organize, and conduct a radiological field survey to develop sufficient data on the total radiological environment of Enewetak Atoll to: (1) locate and identify contaminated and radiologically activated test debris; (2) locate and evaluate any significant radiological hazards which could complicate cleanup activities; and (3) identify sources of direct radiation and food-chain-to-man paths having radiological implications.[35]

The Enewetak Radiological Survey began at Enewetak on 16 October 1972, and final samples were taken on 14 February 1973.[36] The scope and plan of the survey were influenced by measurements which had been made during the preliminary cursory surveys in 1971 and 1972, by review of historical records pertaining to nuclear testing at Enewetak Atoll, and by comparisons with the 1969 cleanup of Bikini Atoll

The survey goals were to provide all the data needed for ranking the relative importance of radionuclides and pathways leading to dose and to provide data for guiding the cleanup.[37] The major dose pathways considered were: (1) external radiation; and (2) internal radiation from ingestion of terrestrial foods and water, ingestion of marine foods, and inhalation of air.

The survey required a radiological safety plan only for the sampling program on the northern portion of Runit.[38] A radiation exclusion area was established there, and complete radiation safety controls (protective clothing, bioassays, etc.) were in effect continuously. Radiation safety requirements for other areas of the atoll were limited to personnel dosimeters and checks for external gamma radiation during sampling efforts on northern islands[39] All samples packaged for transport to Enewetak Island and then off the atoll were monitored and determined to be free from external contamination.

Data for assessing external radiation doses were obtained from dosimeters placed at fixed locations throughout the atoll for extended periods and from portable radiation survey meters used in radiation detectors suspended from a helicopter. Measurements were for gamma radiation only. The aerial in situ measurements were considered valuable for reducing the possibility of missing any contaminated areas and for increasing efficiency of the survey. Areas identified as "clean" from the air did not require survey from the ground.[40] The aerial and ground measurements were in excellent agreement.[41] Key products of the aerial survey, in addition to gamma radiation measurements, were high-resolution photographs of each island and adjacent reef. These proved useful for orientation of ground surveyors and for displaying results in the final survey report.

There were limited terrestrial foods available for sampling. Although coconuts are the staple food of the dri-Enewetak, very few coconut trees were growing at Enewetak Atoll. Therefore, only 23 coconut (meat) samples were obtained during the initial survey An additional six samples, including coconut meat and milk, were obtained in July 1973, and their analyses were included in the survey report.[42] Secondary foods such as pandanus, breadfruit, and arrowroot were even less plentiful. Therefore, the survey sampled the wild, inedible plants which were available; e.g., Messershmidia and Scaevola. Since there were no domestic animals at Enewetak, the survey included extensive sampling of rats as an alternative. Wild birds, bird eggs, crabs, and turtles were also part of the sampling effort, to provide data for terrestrial food ingestion dose estimates. Although survey plans included the sampling of wells and rain for drinking water,[43] no such samples from these sources were taken. (A water sample was taken from the distillation plant on Enewetak (Fred) Island. No radioactivity was in the water, but two samples of sludge from the plant showed positive strontium-90 and plutonium-239. The high plutonium-239 value was 56 pico curies per gram, pCi/g.).[44]

Since most of the edible plants which would be consumed by the dri-Enewetak after resettlement were not growing at Enewetak Atoll at the time of the survey, the major terrestrial sampling effort involved soil. Expectations were that, with an understanding of the amount of radioactivity in the soil, estimates could be made of the amount of radioactivity in plants when grown in that soil. Soil samples were collected from random locations on the surface (top 15 cm) of each island at a frequency which averaged about 1.5 samples per hectare. Sampling locations were estimated relative to landmarks, as engineering surveyors were not available. Profile samples, extending to depths of 1.8 meters, were taken at a frequency averaging about 0.2 samples per hectare. The radiological exclusion area on Runit was much more intensely covered. Profile samples were taken at each location on a uniform grid.

The marine sampling program concentrated on fish which are commonly eaten by the Marshallese. This includes the reef and bottom (lagoon) feeders as well as pelagic species. Approximately 800 samples of fish and other marine life were obtained.[45] Sediment and water samples from the lagoon and from water-filled craters were also taken

Air sampling was limited.[46] Samples had been collected for 5 days when the program was interrupted by Typhoon Olga on 23 October 1972. Following the typhoon, samples were collected for 3 weeks. Samplers included low- and ultra-high-volume types, as well as a particle spectrometer. The samplers were operated at six locations on five islands.

Samples were processed initially at Enewetak (scanned, homogenized, packaged, etc.) and then returned to CONUS for analysis.[47] A gamma spectral analysis was made on each sample at the Lawrence Livermore Laboratory (LLL), and then samples were analyzed radiochemically for radionuclides which are not amenable to gamma spectral analysis. These later analyses were conducted at a number of commercial and governmental laboratories. Quality control of these laboratories consisted of interlaboratory analyses of fractions (aliquots) from common samples over the course of the analytical program.[48,49]

The survey included debris monitoring primarily for estimating cleanup requirements: the results would not be needed for dose estimates if the debris was to be removed during cleanup. Debris sampling was carried out on ten islands which were considered most likely to contain contaminated debris.[50] The debris sampled was that which was visible and accessible.[51] One gamma exposure rate was reported for each item.[52] (In the absence of specific guidance, some monitors identified debris as noncontaminated while others recorded actual readings no matter how low.)[53] Alpha radiation monitoring was not feasible, as the survey was performed during the rainy season.[54]

The Enewetak Radiological Survey is reported in a three-volume document identified as NVO-140, October 1973. The principal portion is Volume I, which describes the survey, summarizes data, and presents dose estimates based on various combinations of contamination removal (cleanup) and lifestyle. Volumes II and III display terrestrial surface sample analyses at their respective sampling locations on aerial photographs and profile analyses on semilogarithmic plots (concentration as a function of sample depth). Volume III also contains an attached envelope of microfiche cards which show concentrations (or upper limits) and relative errors for analysis results of all samples processed during the survey.

The dose estimates in NVO-140 were of fundamental importance, as they established the framework for subsequent cleanup and rehabilitation planning. The estimates were designed around six "living patterns," each of which included a specific location in the atoll, where "living" allowed for residence, agriculture, fishing, or visiting. The locations considered for residence were limited to the two largest southern islands (Enewetak and Medren), the largest northern island (Enjebi), and Bokombako (Belle). The latter island was included to provide an example which would lead to highest dose estimates, not necessarily to represent an island where people desired to reside. Agricultural locations considered were limited to a group of southeast islands, a group of northeast islands, Enjebi, and Bokombako. The entire lagoon was available for fishing; and visits were allowed to various groups of islands. Runit was not considered in NVO-140 as available for any function for any living pattern.

Dose was estimated for each function at the allowed locations, and then doses were added to give overall doses for a living pattern. In adding the doses, components were weighted according to amount of time assumed for each function.

External dose estimates for the various allowed locations were determined using exposure rates measured by the aerial survey. An average exposure rate was defined for each island. When an average rate was needed for a group of islands, it was obtained by weighting individual island rates according to the area of each island in the group. The exposure rates were converted to absorbed dose based on assumed duration of exposure.

Inhalation dose estimates were determined using the International Commission on Radiological Protection (ICRP) lung model. Intakes to this model were derived from concentrations of plutonium in soil and an assumed air-mass loading. (Average concentrations for plutonium in soil of islands/group of islands were used.) This method was considered preferable to using the survey air sample data, which were representative only of a very short period of time. Had actual air sample data been used, inhalation dose estimates would have been several orders of magnitude lower than reported.

Ingestion dose estimates were based on an assumed diet (including local marine and terrestrial food and imported food) and measured or derived concentrations of radionuclides in components of the diet. Significant radionuclides for ingestion dose were determined to be cesium-137 and strontium-90. A concentration for these nuclides was determined for the average fish of the atoll, for use in estimating doses via the marine food pathway. The concentration of the significant radionuclides in terrestrial foods was estimated primarily by correlation between concentrations of radionuclides in soil and in indicator plants or animals.

The survey report included estimates of annual dose rate and accumulated dose over extended periods of time for the various living patterns. The effect on possible dose due to cleanup modifications; e.g., covering contaminated soil with clean soil, plowing soil to mix contaminated surface layers with cleaner subsurface layers, was assessed. The report ranked dose pathways in the following order of decreasing dose: ingestion of terrestrial food; external gamma exposure; ingestion of marine food; and inhalation of contaminated air. The most significant contribution to dose via the terrestrial food chain was determined to be strontium-90 in pandanus, breadfruit, and coconut.[55]

The Enewetak Radiological Survey provided a data base and general concepts for radiological cleanup. Considerable effort was still required, however, to evaluate and adapt the data for actual cleanup operations.

AEC TASK GROUP REPORT: JULY 1973-JUNE 1974

In July 1973, an AEC Task Group was appointed by the Director, Division of Operational Safety of the AEC, to review NVO-140 and to prepare cleanup and rehabilitation recommendations. Members of the

Task Group were Mr. Tommy F. McCraw (AEC Operational Safety), Drs. W. Nervik and D. Wilson (LLL), and Mr. W. Schroebel (AEC/ Division of Biomedical and Environmental Research). The Group was assisted by seven consultants. All members and consultants worked either directly for the AEC or for an AEC laboratory, and most had been associated with AEC efforts at Bikini Atoll. Liaison representatives of DNA, EPA, and DOI attended the Task Group meetings.

The AEC Task Group's findings were compiled in a "Report by the AEC Task Group on Recommendations for Cleanup and Rehabilitation of Enewetak Atoll," which was circulated in draft form for comment in February 1974 and, after revisions, again in April 1974. There was lively debate, even among the AEC staff, over aspects of the report. Typical points at issue were: the appropriate contamination threshold for removal of soil from Runit and Boken; the scientific or technical basis for making a judgment that plutonium levels in the soil on Runit and Boken were high enough to justify removal of large amounts of soil; and the limited (3 weeks versus an annual program) air sampling data which indicated that airborne plutonium levels at Runit were quite low, comparable to some levels in the United States.[56]

Dr. William Ogle, an eminent scientist long associated with the nuclear test program, was consulted by DNA on the Task Group Report. He questioned the recommendation that the dri-Enewetak be kept off Enjebi until subsequent AEC measurements and analysis indicated that they could return to that island. His concern was based on the belief that the U.S. would not be in control indefinitely. He recommended that cleanup actions be taken which would allow the dri-Enewetak free use of the atoll in the future. Regarding Runit, he felt there was every reason to suspect that the problem was caused by small particles of plutonium. He questioned the need for the dri-Enewetak to stay off Runit.[57] He realized that the AEC recommendations assumed there was a genuine hazard, but he felt that the information available did not fully support that assumption. He felt that Runit should be cleaned as well as possible and turned over to the people.[58]

DNA believed that the recommended cleanup standards (in terms of residual radiation) were too low (that is, too conservative), that cleanup to these levels was not necessary, and that the funds likely to be made available for cleanup would not permit reducing residual radiation to these levels.

In commenting on the April 1974 draft, one AEC office expressed the belief that the plutonium cleanup could be generally characterized as "reduction of plutonium contamination accessibility" and recommended that no numerical guides be published for residual plutonium levels in soil except those essential for guidance of a group of experts in the field to advise on plutonium cleanup operations.[59] Others in AEC expressed concern that numerical standards provided for Enewetak would be misconstrued or misapplied to other locations such as the Nevada Test Site or Bikini Atoll.

After consideration of comments on the drafts, the AEC Task Group recommendations (discussed below) were published in final form on 19 June 1974. At a meeting of the Commissioners of the AEC on 12 August 1974, the recommendations were approved and subsequently forwarded to DNA on 16 August 1974.[60] The Director, DNA responded on 20 August 1974, advising the AEC that the recommendations had been adopted and would be reflected in the DEIS.[61]

The Task Group Report pointed out that the tasks required for Enewetak were similar to those carried out for the Bikini cleanup and rehabilitation,[62] and it stated that its recommendations for Enewetak were therefore similar to those that guided cleanup and rehabilitation of Bikini Atoll.[63]

The Task Group Report adopted radiation protection criteria for evaluation of the significance of dose estimates, and it recommended that the same criteria be used for planning the cleanup and rehabilitation. The criteria for dose limit to individuals were set at 50 percent of the Federal Radiation Council (FRC) annual rate limit, and 80 percent of the FRC 30-year genetic limit. These more stringent criteria were deemed appropriate so that individuals would not receive doses at the maximum level of current U.S. standards from weapon-test residue alone and to account for uncertainty in predicting doses.[64] Although the Task Group Report discussed the FRC annual rate limits for population as a whole, it did not use or recommend these FRC criteria. Instead, the Task Group Report recommended that the population dose "should be kept to the minimum practicable level."[65]

The Task Group Report noted that no criteria existed for radiological contamination of soil and food and that there were definite pathways whereby such contamination could lead to dose to individuals. The Enewetak Radiological Survey had obtained environmental data especially for evaluating dose via these pathways, and for all significant radionuclides at Enewetak. The Task Group Report singled out the soil-resuspension-inhalation pathway for plutonium as a key one on which experts could not agree how to estimate dose properly. Guidance on plutonium in soil was therefore considered needed, and the Task Group Report was careful to point out that any guidance it offered would not apply to the AEC at other locations. Thus, the Task Group Report recommended guidance on plutonium in soil that was unique to Enewetak Atoll. This guidance was that soil should be removed if the plutonium concentration exceeded 400 pCi/g of soil, and that it could be left in place if the concentration was less than 40 pCi/g. For concentrations in the range of 40-400 pCi/g, decisions should be made on a case-by-case basis, considering the potential island use, the plutonium concentration near the ground surface, the potential for erosion, and the amount of effort involved in removing soil.

The NVO-140 Report had presented integrated dose estimates for periods of time ranging from 5 to 70 years. Since the Task Group adopted annual rate criteria to evaluate estimates, additional calculations were made, and the results of these calculations were included in the Task Group Report. Additionally, doses were estimated for bone marrow, rather than entire bone as had been done for the NVO-140 Report.

The Task Group Report added the dose estimates in numerous ways to obtain total estimates for various living patterns. The living patterns were structured to include preferences expressed by the dri-Enewetak. In combining estimates to produce total dose, the Task Group Report tested the improvements gained by adding clean soil to contaminated soil, by plowing contaminated soil, and by restricting the growing of certain crops. The Task Group Report was not enthusiastic about these alternatives or about soil removal as a dependable and feasible method for reducing dose via the dietary pathway.[66]

After comparing dose estimates against adopted criteria, and considering the desires of the dri-Enewetak, the Task Group Report recommended a living pattern which would not actually require any cleanup. Key features of this living pattern were that:

a. Residence and agriculture (except coconuts) would be restricted to southern islands.
b. Coconuts could be grown on northeast islands for subsistence and commercial purposes.
c. Fishing could be conducted anywhere.
d. Any island except Runit could be visited.

Minimum cleanup recommendations were offered to provide better assurance that the dose for the recommended living pattern would be minimized. These recommendations were that:

a. All radioactive scrap metal be removed.
b. Contaminated debris in "burial sites" be removed.
c. Runit be quarantined until plutonium contamination thereon was removed.
d. Plutonium contamination on Runit and Boken be removed.

The AEC Task Group Report also recommended that additional studies be conducted prior to rehabilitation to determine radioactivity in coconut and other food crops, in lens water, and in air under conditions approximating human habitation; and that after rehabilitation, continuing checks be made of the people and environment to assure that exposure criteria were not being approached or exceeded.

ENEWETAK ATOLL MASTER PLAN: MAY-NOVEMBER 1973

The Government agencies realized the importance of having the dri-Enewetak involved in every step of cleanup and rehabilitation of their homeland. On 20-23 February 1973 (the week after field work on the NVO-140 was completed), representatives from DNA, DOI, and AEC met in Honolulu with dri-Enewetak community council members, their attorney, and the Marshall Islands District Administrator to brief them on results of the recent surveys and to discuss their desires. The parties met again at Majuro, the Marshall Islands District Center, on 2-4 May 1973, this time with representatives of the TTPI. At this meeting, the idea of a Master Plan for rehabilitation and resettlement was proposed to provide information for the DEIS and for funding estimates. The Master Plan was to be developed by the TTPI, based on the expected results of the cleanup project and the desires of the dri-Enewetak Conferees proposed that the people elect a Planning Council to work with TTPI in developing the Master Plan and with DNA in planning the cleanup project.[67]

The TTPI contracted with H&N to develop the Enewetak Master Plan. A survey team consisting of Mr. Carleton Hawpe, TTPI architectural consultant under contract to H&N, Mr. John Stewart, of AEC, and Mr. Ken Marsh, of LLL, visited Ujelang Atoll in July 1973 to coordinate with the Enewetak Planning Council. Mr. Hawpe was engaged by H&N at the request of the dri-Enewetak. He was a Peace Corps volunteer in the Marshall Islands, who had made his home in Majuro, and was well liked and fluent in Marshallese. Together, they covered all aspects of rehabilitation, resettlement, and development of the atoll. This survey, together with results of the Enewetak Engineering Survey, provided a basis for the first draft of the Master Plan, which was issued in November 1973.[68]

Since the AEC's Radiological Survey Report had not yet been completed, the draft Master Plan was based on certain assumptions derived from preliminary results of that survey. Upon issuance of the final Enewetak Radiological Survey Report, some of the assumptions proved not to be valid. Key among these was the draft Master Plan's assumption that Enewetak Atoll could be sufficiently cleaned of all radiological hazards so that Enjebi would be safe for habitation.[69] These changes in the radiological dose estimates and predictions required that the Master Plan be revised and republished in January 1975. Thus, the final Master Plan called for all residence to be on the southern islands, whereas the draft

Master Plan had been based on the dri-Enjebi returning to their home-island. Further details of the final Master Plan are contained in Chapter 10.

Information obtained from the meetings with the dri-Enewetak, plus data from the Engineering Study and from preliminary results of the Radiological Survey, was enough to begin preparing a DEIS for the project and to develop initial funding estimates. H&N was engaged by DNA to compile the DEIS, and they started work on 19 June 1973. On 21 June 1973, LTG Dunn testified before the House Subcommittee on Appropriations, seeking Fiscal Year (FY) 1974 funds to complete the planning studies and surveys.[70] A total of $270,000 was provided in FY 1974 for the EIS and other planning studies.

THE EXPLORATORY PROGRAM ON ENIWETOK: JUNE 1973

In June 1973, DNA decided to abandon the PACE II high explosive cratering program at Enewetak and so stipulated in the U.S. District Court in Hawaii. The court order preventing PACE II authorized the continuation of the PACE I geological studies, which were renamed the Exploratory Program on Eniwetok (EXPOE).[71]

Field studies for EXPOE began in October 1973 and included the core drilling of 46 bore holes (50-100m depth) on ten islands. The purpose was to define the near-subsurface geology of the atoll in order that preevent geologic models could be made at each of the six nuclear crater sites. In addition, seismic refraction profiles were conducted on the same islands to define seismic velocities. Also in the program approved by the District Court was a 40-foot, cylindrical, high explosive, in situ test, which was conducted at the PACE test bed on Aomon to provide dynamic material properties of the PACE media. Several miles of over-water seismic reflection profiles also were conducted during EXPOE. These over-water seismic studies centered on the three high-yield nuclear craters (Oak, 9 megatons; Mike, 10.4 megatons; and Koa, 1.37 megatons) and provided significant information concerning the subsurface morphology of the craters. In addition to the EXPOE field studies, a comprehensive search was conducted of old photos, films, drawings, etc., to define the exact crater dimensions, device emplacement details, device yield and performance details, and ejecta and debris distribution for the cratering events.[72]

Several significant studies were conducted in support of the PACE and EXPOE programs. These additional studies included: soil and water surveys in the northern part of the atoll for radioactive debris location and characterization; analysis of previous studies on cratering and testing in general; flora and fauna ecological studies; and identification of water-well sampling sites for DOE. These studies proved useful in planning the cleanup and rehabilitation of Enewetak. The most valuable by-products of PACE and EXPOE for the cleanup project were geological data for the selection of quarry sites and design of crater containment for radiological contamination; and soil chemistry analyses applicable to contaminated soil surveys.[73]

A NEW DIRECTOR'S NEW MISSION: SEPTEMBER 1973

In September 1973, LTG Dunn completed his 3-year assignment as Director, DNA and was replaced by Lieutenant General Warren D. Johnson, USAF, who had been at the Agency since July 1973 as Deputy Director for Operations and Administration. The new Director was confronted by a new mission. The Air Force proposed that DNA assume responsibility for operation and maintenance of the austere base camp at Enewetak Atoll.[74,75] LTG Johnson did not concur and presented DNA's case to the ASD(ISA). The Agency had transferred the last of its installations to the Military Services in July 1971, based on a Secretary of Defense policy decision that DNA would not operate installations.[76] The Air Force was proposing that an exception be made in this case, and DNA did not have the resources to manage a base. In July 1973, the Air Force had transferred management of Johnston Atoll to DNA, and now, before DNA had time to assimilate that new mission, the Air Force was proposing to transfer another installation. Nevertheless, ASD(ISA) decided to transfer Enewetak Atoll to DNA,[77] and the change of responsibility occurred on 1 January 1974. In accepting the mission, DNA and the Air Force agreed to the transfer of three Air Force manpower positions to help manage the new mission in the Pacific.[78]

FY 1975 MILITARY CONSTRUCTION PROGRAM: 1973 - 1974

Formal guidance on funding responsibility was received from OMB on 18 October 1973, in a memorandum which confirmed the decisions made during the previous year (see "Assignment of Responsibilities," above). It recognized the incomplete state of planning for cleanup and rehabilitation but advised the agencies to request sufficient funds to initiate some cleanup effort in FY 1975 to show continuing Administration commitment to the cleanup and rehabilitation of the atoll. The FY 1975 President's Budget was to reflect the following agency responsibilities: DOD for maintaining ongoing facilities and operations in Enewetak and for cleanup operations; DOI for rehabilitation; and AEC for radiological monitoring and survey.[79]

The first problem for DNA was to decide which appropriation should fund the cleanup project. Operations at Enewetak Atoll during the various tests had been financed primarily with Research, Development, Test and Evaluation (RDT&E) funds. RDT&E funds could be requested for the cleanup project, since their purpose was to close out an RDT&E facility and since the radiological cleanup certainly would require research and development of new technology. However, the use of such funds for cleanup might conflict with, and dilute, DNA's normal RDT&E program funding. For this and other reasons, it was decided to treat the cleanup project as a site-restoration and site-preparation project; i.e., preparing the site for DOI's construction work in the Rehabilitation Program. On this basis, the cleanup project was treated as a Military Construction (MILCON) Program.[80] Since MILCON channels within DOD and the Congress are accustomed to traditional construction projects, there were many difficulties in explaining and justifying the more unorthodox Enewetak Cleanup Project request through these channels.

DNA's initial FY 1975 request was for a $35.5 million authorization for a MILCON program for radiological and other cleanup efforts.[81] A revised estimate was submitted on 21 November 1973 to include an additional $1.5 million to reimburse AEC for radiological support of cleanup, as agreed at the 7 September 1972 conference. The revised request of $37 million was to be appropriated as follows: $12.5 million in FY 1975, $21.7 million in FY 1976, and $2.8 million in FY 1977.[82]

OMB/DOD Program Budget Decision Number 166 reduced the FY 1975 request to $4 million and recommended $21.2 million for FY 1976 and $10.3 million for FY 1977. The additional funding to reimburse AEC was not addressed in the decision.[83] DNA requested that funding for this support be included, giving new totals of $21.7 million in FY 1976 and $11.3 million FY 1977.[84] The President's Budget for FY 1975 requested an initial MILCON appropriation of $4 million to provide for initial mobilization and base camp rehabilitation. The authorization request was approved by the Senate Armed Services Committee; however, the House Committee on Armed Services denied authorization of FY 1975 funds for the initial phase of cleanup on the grounds that "insufficient planning had been completed to permit a firm estimate of overall costs."[85] The Joint Conference Committee upheld the House Committee's position, thus ending action on the matter in the first session of the 93d Congress.[86] Meanwhile, other preparations for the cleanup project were progressing.

FY 1975 CONCEPT PLANNING: 1974

DNA's original concept for accomplishing the cleanup was to contract it out to a private construction company. Defense Agencies such as DNA normally cannot directly let construction contracts financed by MILCON funds but must go through the military construction agencies; e.g., the Naval Facilities Engineering Command or the Army Corps of Engineers. Therefore, DNA planned to have the Pacific Ocean Division (POD) of the Corps of Engineers accomplish the actual contracting, including design, preparation, award of the contract, and monitoring of the contractor's performance. As the using agency, or client, for whom the work would be done, DNA was to furnish basic concepts for accomplishing and supporting the cleanup project. Responsibility for developing these concepts was assigned to DMA's operational element, Field Command, DNA.

Field Command, DNA, a joint service organization located in Albuquerque, New Mexico, was commanded in 1974 by Rear Admiral L. V. Swanson, USN. In addition to being responsible for developing cleanup concepts, Field Command was tasked to assume the responsibility for operation and maintenance of the base camp at Enewetak Atoll, effective 1 January 1974. Field Command's Logistics Directorate, under Colonel Alan C. Esser, USA, was assigned primary staff responsibility for both efforts. On 23-25 January 1974, representatives from DNA's Headquarters and Field Command traveled to Enewetak Atoll to inspect base camp operations and maintenance and to confer with POD officials on cleanup project concepts. Major General John McEnery, USA, Deputy Director for Operations and Administration, DNA, headed the conference, which included Mr. Earl Eagles, of DNA; COL Esser, Lieutenant Colonel Donald B. Hente, USAF, and Mr. David Wilson, of Field Command; Commander Fritz Wolff, of AEC Headquarters; Mr Roger Ray, of AEC-NV; Mr. Harry Brown, of DOI; Colonel John Hughes, USA, of POD; and Mr. Earl Gilmore, of H&N. While radiological planning awaited several key decisions, the conference established several basic concepts for base camp rehabilitation and noncontaminated cleanup including:[87]

a. A Joint Task Group (JTG) would be formed to coordinate and control the cleanup operation.
b. A temporary base camp would be established in the northern islands to support cleanup in that area and reduce transportation time and requirements.
c. Costs would be reduced by using existing military equipment.
d. There would be only one contractor at Enewetak who would operate the base camp as well as accomplish the actual cleanup described in the Engineering Study.
e. POD would serve as contracting office for the cleanup contract.
f. DOI would have POD contract for their rehabilitation program, possibly using the same contractor as DOD used for cleanup.

Subsequent Congressional actions precluded use of a contractor for the cleanup itself; however, the first three concepts remained valid throughout subsequent cleanup planning.

On 30 January 1974, Field Command formed the Field Command Planning Group of civil engineering, finance, and supply and services experts to develop concept plans, cost estimates, and MILCON program documents for the cleanup project.[88] Major Earl Kinsley, USAF, of AFWL, who had been the radiological safety officer for the PACE program and who had participated in the radiological cleanup at Palomares, Spain, served as radiological advisor to the Field Command Planning Group until his retirement when he was replaced by Dr. E. T. Bramlitt of Field Command.

The group's first planning effort was to develop plans and recommendations based on the January 1974 conference at Enewetak. They included the proposed manning for a JTG staff, some of whom would be assigned on a 3- to 4-year permanent change of station (PCS) basis to Hawaii and work at Enewetak on a rotational temporary duty (TDY) basis to provide engineering and management continuity. Had other planning and funding efforts remained on schedule, this PCS group would have initiated and completed the entire cleanup project. The concept later was dropped when funding problems made it difficult to implement. The group also recommended that Field Command be delegated responsibility and authority at the earliest moment to manage the cleanup project and to coordinate with POD on project definition and base camp rehabilitation.[89] Headquarters, DNA did not accept that recommendation in its entirety;[90] however, Field Command was subsequently assigned responsibility for operational management of the cleanup project.[91]

During the 2d session of the 93d Congress, Headquarters, DNA continued its efforts to obtain authorization and appropriation, with hearings before committees of both Houses.[92,93,94,95,96] At the same time, work was progressing on development of the EIS.

THE DRAFT ENVIRONMENTAL IMPACT STATEMENT: APRIL-SEPTEMBER 1974

The NEPA requires that an EIS be prepared for any major action which significantly affects the quality of the human environment.[97] The act covers not only actions which might have adverse effects but also those intended to have beneficial effects, such as the cleanup, rehabilitation, and resettlement of Enewetak Atoll. DNA assumed the responsibility for preparation of an EIS which covered not only the cleanup project but also the rehabilitation and resettlement efforts. In January 1973, DNA engaged H&N to develop a DEIS.[98]

The NEPA requires utilization of a systematic interdisciplinary approach which insures integrated use of the natural and social sciences in planning and decision-making. To satisfy this requirement, extensive information was needed on the condition of the atoll, social and economic background of the people, plans for future use of the atoll and, above all, guidelines on the cleanup and disposition of radiological contamination. Some of this information was available in the Enewetak Engineering Study; however, much of the material was just then being developed in the Master Plan, the Enewetak Radiological Survey, and the AEC Task Group Report and would not be available for more than 18 months. Meanwhile, there was pressure to provide plans and cost estimates for MILCON program authorization and appropriation requests. In response to these pressures, a preliminary DEIS was prepared, based on the best available, albeit incomplete, information. Thus, when this preliminary DEIS was circulated to the participating federal agencies for review in April 1974,[99] it did not reflect an approved position on radiation exposures and cleanup guidelines (since the AEC position had not yet been defined). Rather, it contained alternative solutions developed to show minimum and maximum required resources. Some of the information in the preliminary DEIS concerning potential impacts was quite controversial. The Director, DNA had planned to publish the formal DEIS for comment by 15 May 1974 and the final EIS on 15 September 1974.[100] As a result of the critical nature of some comments on the preliminary DEIS and the concern over public acceptance of the concepts, publication of the formal DEIS was delayed until approved radiological guidelines were available on 16 August 1974. Instead of 15 May 1974, it was 7 September 1974 before the formal DEIS was issued for public review and comment.[101]

The DEIS consisted of three volumes. Volume I included a review of the radiological and physical condition of the atoll and described several cleanup and habitation alternatives, an evaluation of their effects, a selection of a preferred cleanup operation, and a proposed rehabilitation and resettlement plan. Volume II contained extracts from related reference documents, including the 1972 Enewetak Radiological Survey and the 1973 Master Plan for Rehabilitation and Resettlement, plus calculations and other supporting data. Volume III was a résume of the DEIS in the Marshallese language and a direct retranslation of that resume into English.[102]

The approach taken in the DEIS was to identify all reasonable courses of action, evaluate the advantages and disadvantages of each, and arrive at the safest and most effective solution. The AEC had established recommended guidelines for use in the radiological cleanup (Figure 2-1).

Critical Organs	Individual in Population (AEC Task Group Report)
Whole Body	0.25
Bone	0.75
Bone Marrow	0.25
Gonads	4 rems in 30 years
Thyroid	0.75

These guides are Atomic Energy Commission Task Group Report recommendations applicable to the Enewetak Atoll Situation. They are derived from the Federal Radiation Council (FRC) Radiation Protection Guides (RPG) by using 50 percent of the FRC RPG for individual exposure and 80 percent of the FRC RPG guide for gonadal exposure. These reduced values are recommended as a necessary precaution to allow for uncertainty in prediction of annual exposures to individuals in the alternative programs.

FIGURE 2-1. DOSE GUIDELINES FOR ENEWETAK ATOLL (REM/YR).

The cleanup would remove as much radioactivity as possible from the islands, after which other remedial measures would be relied upon to reduce the predicted dose to lower levels, if necessary. If the cleanup did not result in a predicted dose less than the AEC guidelines for Enewetak Atoll, the return of the dri-Enewetak to the atoll would not be recommended.[103]

In accordance with the recommendations of the AEC Task Group Report, options for cleanup of radiological hazards were limited to removal of contaminated scrap and removal of plutonium-contaminated soil. A third possibility, that of removing soil contaminated with fission products; i.e., cesium-137 and strontium-90, was determined to be counterproductive at best and possibly irrevocably destructive. It required removal of such vast amounts of soil that it would result in severe ecological damage and would not positively assure the radiological safety of the people.[104] It was decided to leave the fission products to decay naturally. (The fission products have half-lives of about 30 years in contrast to the plutonium half-life of about 24,000 years.)

Following the alternatives and recommendations of the Enewetak Radiological Survey, the Master Plan, and the AEC Task Group Report, the DEIS outlined several options for habitation as a means of minimizing predicted doses. These were based on restricting the use of various islands; i.e., using only the cleanest for residence; the next cleanest for agriculture, and the next for visiting and food gathering (Figure 2-2).[105]

The cleanup and rehabilitation alternatives considered in the DEIS were based on three possible cleanup actions and four habitation plans. The cleanup actions were identified as:

I. No cleanup.

II. Removal of all hazardous, obstructive, and radioactive scrap; plutonium concentrations greater than 400 pCi/g from four islands, Lujor (Pearl), Aomon, Boken, and Runit; and other soil with plutonium concentrations between 40 and 400 pCi/g on a case-by-case basis.

III. Extensive cleanup of residential and agricultural islands. The four habitation plans were identified as:

A. No restrictions on island or food usage.

B. Live on southern islands and Enjebi; visit northern islands; use food from southern islands or Enjebi, plus coconuts from 12 northeast islands, and pandanus and breadfruit from Enjebi farm plots or imported.

C. Live on southern islands; visit northern islands; use food from southern islands plus coconuts from 12 northeast islands.

D. Live on southern islands; visit southern islands only; use food grown on southern islands only.

Habitation Plan	Residence Islands	Food Sources	
		Agriculture Islands	Foods[a]
A	All[b]	All[b]	All[b]
B	Southern islands and Enjebi	Southern islands	All
		Enjebi	Pandanus and Breadfruit[c]
C	Southern islands	Southern islands	All
		Northern islands	Coconut only
D	Southern islands	Southern islands	All

[a]Foods grown in existing soil, except where noted.

[b]People should not be permitted to return to Enewetak Atoll if cleanup does not result in dose reductions equivalent to or less than the AEC criteria, Figure 2-1.

[c]Foods grown in farming plots produced by removing radioactive soil and replacing it with nonradioactive soil in sufficient volume to contain mature root systems of these plants.

FIGURE 2-2. EXPLANATION OF HABITATION PLANS.

There were 12 possible combinations of cleanup actions and rehabilitation plans. Some were found to be incompatible, and others were rejected for basic deficiencies. Of those remaining, a matrix was constructed (Figure 2-3) to show a reasonable range of alternatives. Five representative combinations were chosen for detailed analysis of dose reduction, health effects, cost, and general acceptability. The five cases (shown in Figure 2-3) are described briefly as follows:

Case 1: No cleanup; use of all islands without restriction as indicated in the 1973 Master Plan. This case was rejected as it would expose the people to all of the radiological and physical hazards existing in the atoll.

Case 2: No radiological cleanup; removal of physical hazards and obstructions to use on the southern islands, Jinedrol (Alvin) through Kidrenen (Keith); residence on the southern islands only; use of food grown on only southern islands. This case was rejected as it did not permit eventual use of the northern islands.

Case 3: Removal of hazardous and obstructive scrap from all islands and removal of an estimated 79,000 cubic yards of plutonium concentrations from Boken, Lujor, Aomon, and Runit (Figure 2-4); disposal of contaminated debris and soil by one of several options including crater containment; residence on southern islands only; use only coconuts from northern islands. (Enjebi was regarded as a special case by the AEC Task Group, and Case 3 did not include removal of plutonium concentrations in

Habitation Plans / Cleanup Actions	A All islands used in accordance with Enewetak Master Plan	B Live on Enjebi and southern islands, use food grown on Enjebi use pandanus and breadfruit grown only in farming plots on Enjebi or imported to Enjebi	C Live on southern islands use only coconut from nothern islands	D Live on southern islands use food grown on only southern islands
I No cleanup	Case 1 AEC Option 1[a]			Case 2[b] AEC Option II
II Removal of hazardous and obstructive nonradioactive scrap, and radioactive scrap from all islands Removal of Pu concentrations from four islands [c]		Case 4 AEC Option IV	Case 3 AEC Option III	
III Extensive cleanup of residence and agriculture islands [d]	Case 5 Approximately AEC Option V			

[a] "Report by the AEC Task Group on Recommendations for Cleanup and Rehabilitation of Enewetak," June 19 1974

[b] Case 2 differs from other programs in Row 1 by removal of physical hazard and obstructive debris categories of radioactive and nonradioactive scrap on southern islands

[c] Plutonium concentrations refer to burial grounds and soil dispersions of concentration in excess of 40 pCi/g Areas of soil concentration in excess of 400 pCi/g should be removed without question areas of soil concentration between 40 and 400 pCi/g should be considered on an individual basis

[d] Removal of all scrap from all residence islands specified in each column and removal of specific amounts of soil in specific areas to achieve external and internal doses no greater than would be absorbed from naturally occurring sources

FIGURE 2-3. ALTERNATIVE CLEANUP AND HABITATION PROGRAMS.

Island		Remarks	Level of Pu Concentration*
Local Name	Code Name		
Boken	IRENE	Isopleth J**	1, 2
Runit	YVONNE	Northern half, Pu burial grounds	1, 2
Lujor	PEARL	Hot spot	1, 2
Aomon	SALLY	Pu burial grounds	1
Bokuluo	ALICE		2
Bokombako	BELLE		2
Kirunu	CLARA		2
Louj	DAISY		2
Mijikadrek	KATE		2
Kidrinen	LUCY		2
Aej	OLIVE		2
Eleleron	RUBY		2

*Actions assumed for specific ranges of Pu concentration are tabulated as follows:

Level	Plutonium Concentration (pCi/g Soil)	Action
1	> 400	Soil removal by repetitive scraping
2	$40 \leqslant C \leqslant 400$	Individual case consideration

All other islands have Pu concentrations < 40 pCi/g and do not require cleanup action.

**TAB A, Volume II, NVO 140, Enewetak Radiological Survey.

FIGURE 2-4. ISLANDS REQUIRING PLUTONIUM CLEANUP PROCEDURES.

soil on this island.) Case 3 was preferred based on the premise that safeguarding the Enewetak people from harmful radioactivity was of prime importance, and it was uncertain that Case 4 or Case 5 actions would be effective in reducing exposure potentials so that more of the northern islands could be used.

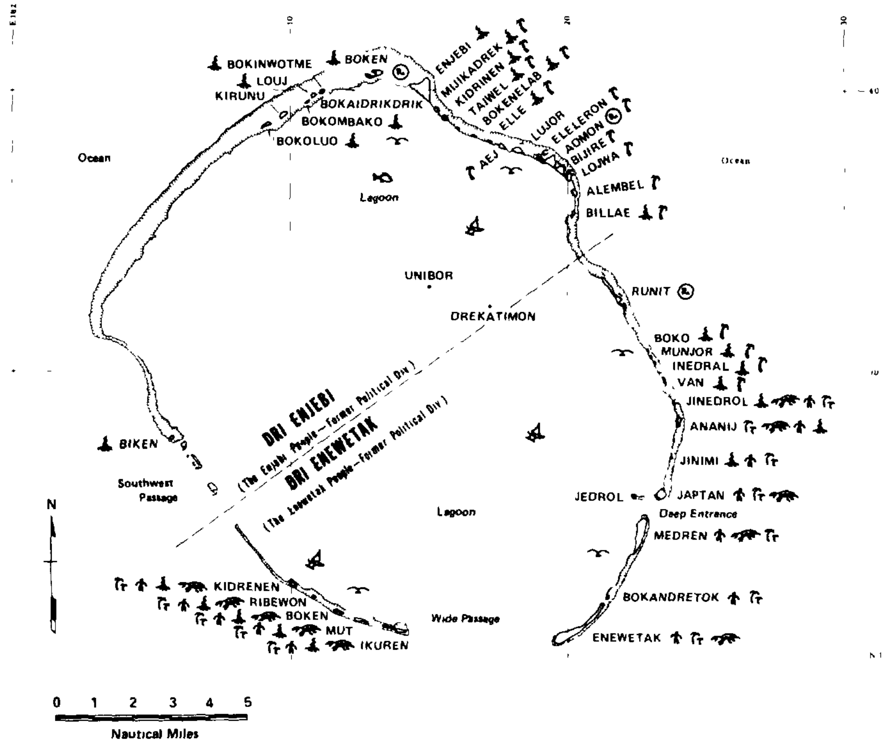
Case 4: Same cleanup and disposal as Case 3 plus removal of 239,000 cubic yards of soil from Enjebi and replacement with imported soil; same island use as Case 3 plus use of Enjebi for residence and some controlled agriculture. This case was rejected because predicted doses from the proposed use of Enjebi exceeded AEC criteria and because of the great uncertainty of maintaining the controls necessary to reach those reduced doses.

Case 5: Same cleanup as Case 3 plus removal of over 700,000 cubic yards of soil from other islands; disposal of contaminated debris and soil by ocean dumping; replacement of soil from scraped areas with imported soil; and use of all islands with no restrictions as indicated in the 1973 Master Plan. This case was rejected because of the uncertainty that it would actually reduce exposures and because it was inordinately expensive.[106]

The preferred Case 3 combined Cleanup Action II and Habitation Plan C and permitted reasonable use of the entire atoll (Figure 2-5). Not all reviewers agreed with the selection of Case 3 as the optimum case or even that it was an acceptable case. Some AEC officials argued strongly for the cleanup of Enjebi and further study of the Runit cleanup problem. Most of those involved, however, believed that Case 3 provided a practical basis for cleanup, rehabilitation, and resettlement.

LTG Johnson personally presented copies of the DEIS to the Enewetak people and their attorney, Mr. T. R. Mitchell, at a high-level meeting on Enewetak on 7 September 1974. Other attendees included: Mr. Stanley S. Carpenter, Director, Office of Territorial Affairs, DOI; Mr. William Rowe, Deputy Assistant Administrator, EPA; Mr. Peter T. Coleman, Deputy High Commissioner, TTPI; Messrs. Martin Biles, William W. Burr, Jr., and Mahlon E. Gates, of AEC; RADM Swanson, Brigadier General Wesley E. Peel, USA, POD Engineer; Mr. Earl Gilmore, H&N; and Mr. Amata Kabua, then Senator in the Congress of Micronesia and subsequently President of the Marshall Islands. Representatives from the Marshalls District Legislature and the Bikini Atoll Council also participated. Motion pictures and illustrated briefings covering nuclear testing, the Radiological Survey, the Engineering Survey, the Master Plan, and the DEIS were presented in both English and Marshallese to the over 100 dri-Enewetak who attended.[107] The Government's plans were generally well received by the people; however, they had misgivings about some aspects, particularly not being able to live on Enjebi, the plan for on-atoll disposal of radiological contamination, and the possibility that Runit might not be cleaned enough to preclude the need for quarantine.[108] Upon his return to Washington, LTG Johnson was forced to send the people more discouraging news: Congress had again denied funds to begin cleanup in FY 1975 on the grounds that insufficient planning had been completed to permit a firm estimate of overall cost.[109,110]

During the conference, it had been agreed that some 50 dri-Enewetak, including the Planning Council, should return to the atoll early and live on Japtan during the cleanup project to consult and advise on cleanup and rehabilitation problems. The early return was contingent on Congress



LEGEND

- Interisland Travel
- Picnic Island
- Unlimited Fishing
- Unlimited Use of Wild Birds & Eggs
- Coconut Crab Island
- Living Island
- Subsistence Agriculture Except for Pandanus & Breadfruit
- Unlimited Agriculture
- Pu 239 Cleanup To Less Than 40pCi/g

Case Summary

1. Pu Cleanup To Less Than 40pCi/g On Boken, Lujor & Runit Crypts On Aomon Removed
2. No Restrictions On Fishing
3. All Radioactive Scrap To Be Cleaned Up From All Islands
4. Physical Hazard & Obstructive Debris Cleanup On All Islands
5. Live on Southern Islands, Jinedrol Through Kidrenen
6. Subsistence Agriculture Limited To Southern Islands Plus Enjebi Except That Pandanus & Breadfruit are Limited To The Southern Islands
7. No Restrictions On Travel

FIGURE 2-5. ENEWETAK ATOLL, CASE 3.

approving and funding the project; and this, in turn, was contingent on the action agencies resolving the radiological cleanup problems and developing more complete cleanup plans and funding programs.

RADIOLOGICAL PROBLEMS AND ISSUES: 1974

The cleanup and disposal of radiological hazards at Enewetak Atoll posed problems which still have worldwide interest. Cleanup of radioactive contamination and disposal of radioactive waste are potential peacetime problems for the nuclear nations, as well as attendant problems during nuclear war. Enewetak Atoll was not the first peacetime radiological cleanup project. It was preceded by more limited efforts at Palomares, Spain; Thule, Greenland; Bikini Atoll; and Los Alamos, New Mexico. They all posed the same basic questions:

- How much radioactivity is there?
- How much radioactivity is too much?
- How can one remove any excess radioactivity?
- How can one dispose of any excess radioactivity?

The data on locations and amounts of radioactivity provided by the Enewetak Radiological Survey were adequate for development of general plans and gross cost estimates for removal of all or part of it. However, as the DEIS indicated, detailed field surveys would be required to provide the precise data needed before radiological cleanup could begin. Identifying contaminated debris is relatively simple compared to the problem of detecting and measuring contamination in soil. The Enewetak Radiological Survey and DEIS referred to soil contamination in terms of activity level per unit weight of soil; i.e., measurements of pCi/g. Sampling every gram on every island was clearly impractical, even if it had been possible. The technology for conducting radiological field surveys of contaminated soil was still in the developmental stage and it remained so until well into the actual cleanup operations. This problem did not delay development of the EIS or MILCON program, however.

Probably the most complex radiological question was (and still is): What amounts of radioactivity constitute a hazard? Answering that question requires data on the potential sources of exposure (air, water, soil, food, etc.); access to exposure (lifestyle, diet, etc.); organs affected (lungs, bone, etc.); and potential adverse effects. All of these factors must be known before a dose assessment can be made and the hazard can be evaluated. Many of the comments on the DEIS recommended actions to quantify these factors, such as including the contribution from ground water in the dose estimates,[111,112,113] conducting an air sampling program,[114] and establishing long-term monitoring programs.[115,116,117] These recommendations were adopted by DNA and the AEC.

DEIS criteria for contaminated soil were strongly challenged by the MLSC, the Natural Resources Defense Council and others. They suggested that criteria for cleanup should not be set until either the ICRP, the EPA, or the United Nations Scientific Committee on the Effects of Atomic Radiation set standards.[118] Some suggested that the "hot particle" theory must be used in determining contaminated soil criteria. These suggestions would have delayed the soil cleanup indefinitely. DNA believed the delay was unnecessary, since the AEC and DOD had set decontamination standards in 1968 for plutonium-in-soil in the event of a nuclear accident. These standards directed that plutonium concentration should be reduced, if possible, when levels are greater than 1000 micrograms per square meter. This value equates to about 265 pCi/g when averaged over a 15-cm depth of soil whose density is 1.5 gram per cubic centimeter. The Enewetak Cleanup DEIS specified removal of plutonium-contaminated soil when the "proximate" surface concentration (top 15 cm) is greater than 40 pCi/g and when the concentration at any depth is greater than 400 pCi/g. Thus, the DEIS criteria were much more conservative than existing DOD guides for cleanup of areas anywhere in the world.[119]

MLSC comments contended that the criterion of 40 pCi/g averaged over the top 15 cm of soil was too great and recommended that the State of Colorado standard of 0.91 pCi/g averaged over the top 1 cm should be adopted for the cleanup.[120] However, DEIS cleanup criteria were based on adherence to reasonable constraints on living patterns and diet by the people after they returned to Enewetak. Colorado criteria assumed no constraints, and they were not based on known or estimated radiation effects to man but on the arbitrary basis of approximately 25 times the level of plutonium in Colorado soils as a result of worldwide fallout.[121]

DEIS soil cleanup criteria also were challenged on the basis that they did not consider the "hot particle" theory which, according to Tamplin, Cochran, Geesaman, and Martell, indicated that existing plutonium exposure standards were too low.[122,123] DNA responded that the theory had not yet been accepted in the national or international standards for radiological protection and that only the existing guidance could be considered.[124] Soil cleanup criteria remained a highly controversial matter throughout the planning phases of the project, and even into the actual cleanup, as is described in subsequent sections.

Disposition of radioactive debris and structures can be accomplished by standard construction techniques such as cutting, sandblasting, encasing, or sealing. Removal of plutonium contamination in soil has two solutions: (1) remove the plutonium from the soil (extraction); or (2) remove the plutonium with the soil (excision). Extraction of plutonium from waste or soil is theoretically possible, and the technology has been explored by other countries. It was suggested by the AEC Task Group,[125] but a practicable technique was not available for field use since national policy precluded development or use of such technology. Thus, the only practicable process was excision—the stripping of successive layers of soil using earth-moving equipment until acceptable radiation levels were reached.[126]

Disposal of radioactive waste is one of the most controversial problems this nation faces. This was especially true as it applied to the Enewetak Cleanup Project. The Enewetak people's position was made clear in their earliest meetings with DNA[127] and was restated in their counsel's comments on the DEIS: Disposal on the atoll was rejected, and off-atoll disposal was the only acceptable solution. Several other solutions had been suggested during the radiological surveys, including use of a small island as a disposal dump,[128] packaging and shipping to the Nevada Test Site,[129] burial in place, and dumping in the lagoon.[130] The DEIS considered four alternatives for disposal:

- Level 1 - Crater Dumping, by which radioactive materials would be dumped in Cactus Crater (and in Lacrosse Crater, if required) with no further action to fix the materials in place. (The craters were named for the nuclear test shots which had created them.) The estimated cost for disposal of materials from a Case 3 cleanup using this method was $320,000.
- Level 2 - Ocean Dumping, by which radioactive materials would be containerized and dumped in the ocean at a deep-water site. The estimated cost for disposal of materials from a Case 3 cleanup using this method was $9,989,000.
- Level 3 - CONUS Disposal, by which radioactive materials would be sealed in containers and shipped to the United States for disposal. The estimated cost for disposal of materials for a Case 3 cleanup using this method was $18,910,000.
- Level 4 - Crater Entombment, by which contaminated soil and debris would be entombed in Lacrosse Crater (and in Cactus Crater, if required) by sealing the cracks in the crater, mixing the plutonium-contaminated soil with cement to form a slurry, and pumping the slurry into the crater around the contaminated debris, thereby encasing all the radioactive materials in a solid mass. The mass would be covered by an 18-inch thick concrete cap or lid, to provide an erosion resistant crypt which would seal off the radioactive material. The estimated cost for disposal of materials from a Case 3 cleanup using this method was $6,968,000.[131]

The dri-Enewetak and their attorney were on record as being opposed to any disposal of radioactive material on the atoll. AEC-NV strongly supported their position in commenting on the preliminary DEIS.[132]

Considering the relatively short radiological half-lives of the fission products and the induced radioactivity found on much of the debris, the AEC Task Group suggested that the debris be disposed of in shallow burial crypts on the land, in underwater craters, or in the deeper portions of the lagoon. The Task Group recommended that plutonium-contaminated soil and debris be stockpiled on Runit, pending determination of a final disposal method. Several methods were suggested, including returning it to the United States, casting it into concrete blocks, dumping it into a crater with a concrete cap, or dumping it in the ocean or lagoon.[133]

The EPA objected to the lagoon-dumping or ocean-dumping options contained in the draft AEC Task Group Report, citing Title I, Sec. 101(c) of Public Law 92-532 which states: "No office, employee, agent, department, agency, or instrumentality of the United States shall transport from any location outside the United States any radiological, chemical, or biological warfare agent or any high-level radioactive waste for the purpose of dumping it into ocean waters. " EPA's response to AEC also pointed out that a United States national policy prohibiting ocean-dumping of radioactive wastes had been in effect since 1970. Any proposal to reverse such a policy would have to involve the Department of State because the United States had already ratified the International Ocean Dumping Treaty.[134]

DNA's overriding consideration on this issue was the identification of an option which could gain eventual approval so that the cleanup project could proceed. EPA and DNA officials conferred on 8 August 1974 regarding disposal options in the DEIS. EPA took the same position it had taken with AEC on the ocean-dumping option.[135] The intent of Public Law 92-532 was to prohibit ocean-dumping of materials produced for radiological warfare.[136,137] Even though materials had been used for radiological testing instead of warfare, their toxicity and effect on the environment was unchanged. Even if, by some unusual logic, the contaminated materials were considered an unprohibited waste eligible for ocean dumping, the law required extensive research and special actions before EPA would authorize ocean dumping.[138] The materials would have to be placed in a container that would remain intact until contamination radiodecayed to an environmentally innocuous material, which EPA interpreted to be five half-lives.[139] This would have required the plutonium-contaminated soil containers to last for nearly 125,000 years. Ocean dumping appeared to be legally difficult.

After the radiological cleanup at Palomares, Spain, 1,310 cubic yards of contaminated soil and vegetation in 55-gallon drums had been returned to the United States for retrievable storage at Savannah River.[140] The 79,000 to 779,000 cubic yards of contamination the radiological cleanup of Enewetak might generate clearly represented a much greater problem. The conferees agreed that CONUS disposal was uneconomical, would generate considerable political resistance, and would adversely affect the entire project.[141] This option was dropped from further consideration in planning for the disposal of contaminated material.

The conferees discussed the remaining options contained in the DEIS: use of the craters on Runit, with or without cement slurry and cap. It was decided that stabilizing the radioactive contaminants in cement would provide retrievable storage. Until a more permanent solution was found, retrievable storage continued to be the only method acceptable to the United States for disposal of such waste. It had been placed in covered trenches in Los Alamos, and in caves in Nevada; but both DNA and EPA believed that cement stabilization would be necessary at Enewetak Atoll to minimize access of the contaminants to the population and environment.[142]

The question of crater volume also was considered at the 8 August 1974 EPA-DNA conference. The April 1974 preliminary DEIS had indicated that Cactus Crater would be used, then Lacrosse Crater if required. It had been estimated that there were approximately 101,800 cubic yards of material to be placed in the crater (7,300 cubic yards of debris and scrap, 87,800 cubic yards of contaminated soil-cement mixture, and 6,700 cubic yards in the concrete cap). It was estimated that Cactus Crater would hold less than half of that amount (about 52,000 cubic yards). Lacrosse Crater had an estimated volume of 105,225 cubic yards.[143] The conferees agreed that Lacrosse Crater should be filled first, even though Cactus Crater was closer to the island. This made covering the cap with soil, as proposed in the preliminary DEIS, less practical (since Lacrosse was on the reef), and that proposal was abandoned. Entombment in Lacrosse Crater was the method prescribed in the September 1974 DEIS for disposal of radiologically contaminated soil and debris. The conferees also agreed that uncontaminated scrap and debris should be disposed of in the deepest part of the Enewetak Atoll lagoon.[144] This was omitted from the September 1974 DEIS[145] but was included in the final EIS.[146]

OCEAN DUMPING VERSUS CRATER CONTAINMENT: DECEMBER 1974

The AEC remained unconvinced that ocean dumping was not a viable option for disposal of plutonium contamination. In separate letters on 9 and 23 December 1974, they argued in favor of ocean dumping instead of crater entombment [147,148] They recommended that the crater entombment option be deleted from the EIS and that the contaminated soil be stored temporarily on Runit while other options for eventual disposal were studied by AEC.[149] However, they advised that AEC was not committed to provide any additional recommendation on the eventual disposal of contaminated soil and that disposal was a DNA responsibility.[150]

The basic argument presented by proponents of ocean dumping was one commonly heard: compared to the amount of long-lived alpha contamination already dumped in the ocean, the amount from Enewetak would be insignificant. The AEC estimated there were only a few hundred grams of actual plutonium in all of the contaminated soil of Enewetak, and that at least a hundred kilograms of plutonium had already been dumped in the ocean from 1947 through 1974.[151] In other words, the additional damage that might be done was negligible compared to the possible damage that had already been done. The counterargument was also familiar: past damage probably cannot be undone, but any additional abuse to the system should be stopped completely. DNA continued planning on crater containment of contaminated soil and debris because this seemed to be the only option that would be acceptable.

On 14 February 1975, representatives from the action agencies met with the POD in Honolulu to refine plans for cleanup and rehabilitation. Conferees included: Mr. Peter T. Coleman, Deputy High Commissioner, TTPI; Mr. Oscar DeBrum, District Administrator, Marshall Islands; BG Peel, Division Engineer, POD; Mr. Earl Eagles, HQ DNA; Mr Tommy McCraw, Energy Research and Development Administration (ERDA,.formerly AEC); Mr. Harry Brown, DOI; COL Esser, Field Command; and Mr. Earl Gilmore, H&N. Much of their discussion concerned development of POD contracts for the cleanup and rehabilitation effort. (These were never written due to subsequent Congressional actions.) More useful discussions were held on the matter of crater entombment. DNA requested that POD develop a design for the crater and cost estimates for that part of the project. Also, POD was asked to provide cost estimates for the complete (Case 5) cleanup which MLSC desired. DOD and DOI tasks in the cleanup and rehabilitation efforts were reviewed in detail. The conferees also agreed that DNA and ERDA would develop a much needed Radiological Support Plan.[152]

On 24 February 1975, DNA, ERDA, and EPA representatives conferred again on the disposal method for radiologically contaminated materials. ERDA was able to present its case directly to EPA. No allowance had been made in the AEC Task Group's dose assessment for any radioactivity that might leak from the crater-entombed matrix into the lagoon or nearby ocean. For this and other reasons, ERDA preferred ocean dumping. EPA pointed out that the amount of plutonium which had already been deposited in the lagoon and was circulating in its waters was probably much greater than any that might leak from the crater.[153,154] In fact, there was a far greater amount of fallout in the lagoon than there was left on the islands to be cleaned up. The lagoon had a far greater area than the islands, and material from the islands tended to be washed into the lagoon.

EPA described the measures necessary to obtain a permit in the unlikely event the plutonium contamination could be considered something other than "material in any form produced for radiological warfare purposes." The criteria for issuance of a permit were summarized as: (1) establishment of a need to dump; (2) lack of an alternative means of disposal; (3) definition of the potential damage that could result to the marine environment; and (4) the effect of the proposed dumping on other users of the area. Permits could be granted only for an approved dump site. Obtaining approval for a dumping site required selection of a definite site, a survey of the dumping area (including the benthic community) and the ocean currents, and definition of the monitoring process to be used while the dumping is carried out. A minimum of 4 months would be required after receipt of a properly executed application before final action could be expected from a request to EPA. Involved in the process was the requirement for a public notice of 30 days and then a public hearing 30 days after publication of the public notice, followed by allowance of another 30 days for the EPA hearing officer to reach a finding. No assurances could be provided that the finding would not be adverse, particularly if any controversy existed. If the DEIS identified another feasible disposal method, it would virtually eliminate one of the requirements for an ocean-dumping permit, namely the lack of an alternative disposal method.

The ERDA representative contended that EPA was overly conservative in applying the United States ocean-dumping law, since the International Ocean-Dumping Agreement would permit other countries to dump quite large amounts of long-lived alpha contamination. EPA countered that the United States law, which predated the international agreement, was based on the philosophy of preventing further pollution rather than facilitating cleanup and disposal of radiological contamination resulting from a past event. Public laws and EPA regulations did not envision a disposal effort of the magnitude of the Enewetak radiological cleanup and provided no solution to the problem.

ERDA representatives responded that, while ERDA had several test sites which someday must be decontaminated, ERDA had no intention of adopting ocean dumping for those wastes. However, there was considerable concern that, if crater containment was used, ERDA would inherit yet another temporary storage facility, one constructed contrary to ERDA's advice.[155] The 24 February conference ended with no change in the Agencies' positions on disposal, but it helped set the stage for a top-level policy conference.

FINALIZING THE ENVIRONMENTAL IMPACT STATEMENT: APRIL 1975

The normal period for review and comment on the DEIS, which was filed on 7 September 1974, ended on 11 November 1974.[156] However, MLSC, the legal counsel for the dri-Enewetak, was allowed almost 5 months to prepare comments out of consideration for the gravity of the commitments that would be made based on the document. Mr. Mitchell, Executive Director of MLSC, submitted the comments on 1 February 1975. These comments confirmed the basic position the people had taken at Majuro in 1973 and from which neither they nor the MLSC had wavered throughout the project. They demanded total cleanup of the atoll, disposal of the radiological contaminated material away from the atoll, and restoration of the atoll, insofar as practicable, to its original state.[157]

LTG Johnson called a conference of action agency officials on 25 February 1975 to discuss the MLSC position and to make policy decisions necessary to establish the future course of the project. Conferees included: Dr. W. A. Mills, of EPA; Major General Ernest A. Graves, USA, Dr. William Forster, Mr Joseph Maher, Mr. Joe Deal, and Mr. Tommy McCraw, of ERDA; Mr. Harry Brown, of DOI; Captain E. D. Whalen, USN, of ASD(ISA); Colonel A. M Smith, USA, of MSN; and senior DNA staff officials.[158]

LTG Johnson opened the meeting with his analysis of the situation. The plans for cleanup described in the DEIS of September 1974 appeared to be technically and economically feasible, and, although they imposed some unwanted restrictions on the dri-Enewetak, these restrictions represented a reasonable compromise between the goal of maximum freedom and the need to guard the people's health and well-being. The AEC guidelines had been adopted, although there were some who felt they were excessively restrictive. Although ocean dumping of radioactive material was preferred by some, it had to be recognized that this might be legally impossible or, at best, require several years to obtain authorization. Thus, crater entombment was adopted as a reasonable alternative. Based on these compromises, there had appeared to be a reasonable consensus among those involved at the time the DEIS was published.[159]

Now, according to the Director, it appeared that the consensus was disappearing. It seemed there was no consensus even within ERDA, and he had lost confidence that the original AEC guidelines could be cited as authoritative. They had been challenged by some at AEC-NV. Ocean dumping continued to be proposed by some in AEC. There were demands that the craters be lined with thick walls of concrete and steel liners. With the apparent lack of consensus within the Government, the engineering and fiscal feasibility were becoming more and more doubtful.[160]

The new proposals were both time-consuming and expensive. With inflation at 10 percent per year, the additional time and effort required to authorize and accomplish ocean dumping could cost an additional $11 million. The Director estimated that, if the complete cleanup demanded by MLSC were adopted, the project would cost between $200 and $300 million. The Congress had opposed a $40 million price for the project. LTG Johnson was beginning to believe that he might be compelled to recommend to the DOD that the project was economically and technically infeasible. He felt very strongly, however, that the Government had a moral obligation to do everything within reason to accomplish the cleanup. Therefore, he proposed to reject the more stringent and expensive proposals and to publish the final EIS essentially as it appeared in the draft. If opposition to that proposal were sufficiently strong, then he must find some acceptable lesser alternative, such as returning the dri-Enewetak to the southern islands only, or conclude that the project was infeasible.[161]

LTG Johnson received the support he sought. MG Graves advised that he saw no problem with crater disposal. ERDA had felt all along that, if it were not for the law, deep-ocean dumping would be preferable. However, they believed crater entombment was acceptable provided it was done carefully. MG Graves mentioned the possibility of the crater leaking and added that the effectiveness of crater containment could be a problem. All those present seemed to realize that radioactive material was leaking out of the crater even then and would continue to do so.[162] However, the discussion raised the question, "If this crater containment breaks up in time, who is responsible to right this wrong?" LTG Johnson quickly answered that it was not DNA's responsibility after the cleanup was finished; it would be the responsibility of the United States. It was assumed that by the United States he meant ERDA.[163]

LTG Johnson asked if there was still a consensus on the AEC standards. His question was evoked by remarks attributed to an ERDA-NV official that the standards adopted by the AEC Task Group might not stand up. MG Graves assured him that there was still a consensus at ERDA and that ERDA would support DNA on the standards.[164]

Dr.W. A. Mills, EPA, stated that entombment was the way to go in disposing of the radioactive debris for two reasons: (1) it would be recoverable from the crater, if the need or desire ever arose to do so; and (2) EPA was generally not in favor of ocean dumping.[165] After further discussion, LTG Johnson said that he proposed to meet with Mr. Mitchell and tell him that if he demanded that DNA go for a $190M project (Case 5), it would kill the project. He felt morally obligated to push for the project as currently agreed, even if Mr. Mitchell served notice he would fight for the maximum degree of cleanup. COL Smith, of MSN, stated that there was a necessity to retain reasonableness to the project if it was to get by Congress. LTG Johnson stated that, on the basis of the discussions at this meeting, DNA would press ahead with the final EIS, seeking all the help they could get from ERDA. Also, he would go to Honolulu and discuss DNA's position with Mr. Mitchell and seek an accommodation with him. He invited representatives of the DOI, ERDA, and EPA to accompany him on his trip during the week of 17 March 1975.[166]

The Honolulu conference was held on 19 March 1975. LTG Johnson opened with comments to the effect that insistence on ocean dumping of contaminated material and a Case 5 cleanup would delay, if not cancel, the project. He advised that he had consulted with Representative Ichord, Chairman of the House MILCON Subcommittee, who foresaw difficulty in obtaining approval of even a modest program and wanted assurance that Mr. Mitchell, of MLSC, and the dri-Enewetak Iroijs would appear before the subcommittee to support the project.[167]

Mr. Mitchell accepted the invitation to appear at the Congressional hearing on the MILCON appropriations for the Enewetak Cleanup but stressed the importance of having Mr. Oscar DeBrum, District Administrator for the Marshall Islands, also present for the hearings. Mr. Mitchell also stated that:

a. The MLSC comments on the DEIS asked for the "ideal" cleanup based upon their duty to seek the best possible solution for their clients.
b. The dri-Enewetak would make the ultimate decision, not the MLSC or himself.
c. He remained unconvinced that he should recommend acceptance of Case 3, but he did not propose to engage in a lengthy court fight to achieve Case 5. He indicated a desire to get on with the cleanup at Case 3 level, if necessary, without foreclosing other possibilities.

Mr.Mitchell stressed that he intended to strive for as much as could reasonably be done to insure the safety and health of the people. He did not want to be facing a situation similar to that of Bikini in which the lack of thorough investigation could be claimed.[168] He reiterated the point made in the people's comments on the DEIS that they did not want money in any amount. They wanted their land in safe and habitable condition, regardless of cost. The cost of cleanup would be a fraction of the total cost of the nuclear test program and should be considered and funded as an extension of that program.[169]

The 25 February 1975 meeting of agency representatives in Washington and the meeting with Mr. Mitchell on 19 March 1975 cleared the way for publication of the final EIS. It was published and filed with the Council on Environmental Quality on 15 April 1975. The final EIS was nearly identical to the September 1974 draft, with only a few technical and clerical corrections, and the addition of Volume IV which contained comments received on the September 1974 DEIS and DNA's responses to them.

DNA requested authorization and funds from Congress for complete cleanup of physical and radiological hazards in accordance with Case 3 of the EIS.[170] The EIS description of Case 3 cleanup, which the JCS subsequently approved as the DNA mission statement,[171,172] was contained in paragraph 5.5.3.2 as follows:

Cleanup Actions. The following actions would be taken to clean up the atoll:

- Physical hazards would be removed from all islands.
- Obstructions to development of habitations and agriculture would be removed.
- Radioactive scrap would be removed from all islands in the atoll.
- Boken, Lujor, and Runit plutonium concentrations greater than 400 pCi/g would be excised and all other concentrations between 400 and 40 pCi/g would be dealt with on an individual basis as described in AEC Task Group Report. Concentrations of less than 40 pCi/g would not be disturbed. Cleanup of plutonium was expected to be performed iteratively until a sufficiently low concentration level well below 40 pCi/g was attained. Some 79,000 cubic yards of soil were estimated to be in this removal.
- Plutonium would be removed from the three burial crypts on Aomon.
- Unsalvable nonradioactive and noncombustible material would be disposed of by dumping in the lagoon at selected locations for forming artificial reefs.

Radioactive materials would be disposed of as discussed in Section 5.4.3.2.3, namely by containment in Lacrosse and, if necessary, Cactus craters on Runit.[173]

FY 1976 CONCEPT PLANNING: 1974 - 1975

DNA's original concept of implementing the EIS by having the Corps of Engineers contract out the cleanup had begun encountering cost problems in September 1974. Lack of detailed plans and cost estimates had led Congress to decline authorization of DNA's original request which had been based on the 1973 Enewetak Engineering Study estimate of $35.5

million total cost. A review of the study by H&N and POD on 18 September 1974 revised the cost estimates upward to $57.3 million to cover crater containment of contaminated scrap and soil, increased cost of runway repair, replacement soil for Aomon and Enjebi, marine craft, radiological monitoring, and decontamination. They indicated that these costs could be reduced to $42.5 million by elimination of helicopter support, use of foreign labor, use of temporary camps on the outer islands, and other means.[174] The escalation was disturbing since DNA had been advised by Congressional staff members that more austere cost estimates were required. When DNA so advised the Corps of Engineers,[175] they revised the scope of work to bring the cost estimate to $43.2 million.[176] After discussions with DNA, POD submitted a further revised estimate of $39.9 million for cleanup, based upon DNA's financing runway repair and other base camp rehabilitation work with other funds.[177] However, this estimate lacked essential detail, and it was apparent that the contracting-out concept was in difficulty.

Meanwhile, suggestions had been made in the Field Command Enewetak Planning Group that the only feasible means of reducing MILCON costs drastically enough to meet Congressional guidance was through use of military labor. COL Esser proposed that Army engineer troops be used, while Mr. Thomas Flora suggested use of Navy Construction Battalion (Seabee) personnel. On 24 December 1974, Field Command recommended to DNA that troops be used to reduce MILCON costs for the cleanup project[178] and, subsequently began refining the concept. It seemed probable that engineer troops from the U.S. Army Support Command, Hawaii (USASCH) would be selected. Since the U.S. Army had not officially been assigned that responsibility, Field Command could not contact that organization directly The Pacific Support Office of Field Command's Logistics Directorate, which had been working with POD on the contracting-out concept, was tasked to work with USASCH on an informal basis to identify probable military personnel and materiel requirements, as well as those USASCH resources which might be available for the project. In late 1974 and early 1975, the Pacific Support Office was augmented by three Army officers to assist in planning and initiating the project. They were Colonel Howard B. Thompson, Lieutenant Colonel Paul F. Kavanaugh, and Major William Spicuzza.

At a general planning conference in Anaheim, California, on 13-15 January 1975, COL Esser advised the other agencies of Field Command's intention to study the use of troops to accomplish the Enewetak Atoll cleanup. TTPI and H&N representatives discussed the problems of rehabilitation and resettlement at Bikini Atoll as well as Enewetak matters. Mr. Dennis McBreen, Marshall Islands District Planner, presented the Ujelang Field Trip Report. The dri-Enewetak there had generally accepted all radiological recommendations of Case 3 of the EIS. The stockpiling of scrap was discussed, and ERDA indicated that there would have to be a firm requirement to monitor these materials for radioactivity when collected. A meeting was proposed for 14 February 1975 in Honolulu to further consider cleanup and rehabilitation interfaces.[179] At that conference, which has been described previously, POD was asked to concentrate on designing crater entombment and to defer work on engineering design of the cleanup work itself.[180] From this point on, Corps of Engineers' participation in the project was limited to providing some base camp rehabilitation, designing the crater containment, and providing necessary permits.

Field Command's Enewetak Planning Group compiled a series of Concept Plans (CONPLANs) based on input from the Hawaii group, budget guidance from HQ DNA, and results of their own staff coordination and planning. These CONPLANs provided basic concepts, policies, and procedures for review and approval by the JCS and development of an implementing operations plan.

The first CONPLAN developed was for a JTG using troops to accomplish the cleanup, with civilian contractors to rehabilitate and construct base camps, operate and maintain the base camps, provide radiological support, and accomplish the crater containment. LTG Johnson was briefed on the plan during his visit to Hawaii in March 1975. Upon his approval, it was completed by the Field Command Enewetak Planning Group and issued with a blue cover in April 1975. Total cost under this CONPLAN was estimated at $30.6 million.[181] Although this "blue" CONPLAN was to undergo numerous, major revisions, it formed the basis for the final CONPLAN which was to control the cleanup.

Anticipating that a plan using troops alone would be required to further reduce project costs, COL Esser and the Field Command Enewetak Planning Group developed a second CONPLAN using a JTG of military personnel for all cleanup and support work. It also was printed in April 1975 but with a red cover. It reflected a significant increase in man-years to accomplish the work with troops alone (122 man-years) as opposed to a mixed work force (91 man-years); however, it reduced MILCON costs to an estimated $20.4 million.[182] In the event Congress did not authorize enough funds to cover the "blue" CONPLAN, DNA would be prepared to respond with the "red" CONPLAN.

MILITARY CONSTRUCTION PROGRAM: 1974 - 1975

In March 1975 (prior to completion of the CONPLANs), DNA furnished Congress new estimates of the total costs for cleanup and rehabilitation of Enewetak Atoll. DOD cleanup costs were estimated as $39.9 million, including $1.5 million to reimburse ERDA for radiological support as agreed in the 7 September 1972 meeting. DOI rehabilitation and resettlement costs were estimated as $12 million.[183] The revised DNA request for MILCON Program authorization was to be allotted as follows: $14.1 million in FY 1976, $24.7 million in FY 1977, and $1.1 million in FY 1978.[184,185]

Meanwhile, LTG Johnson had begun marshalling efforts to obtain FY 1976 Congressional funding during a conference on 17 October 1974 with officials from DOI, ASD(ISA), and MSN. LTG Johnson felt that Representative Otis G Pike of the House Armed Services Committee was the key Congressman who had to be convinced that the United States was obligated to return the Atoll, that the people wanted to return, and that cleanup plans and cost estimates were sufficiently detailed to justify the funds requested. Ambassador Williams, MSN, and Ambassador Ellsworth, ASD (ISA), agreed to meet with Mr. Pike on the matter.[186] By December 1974, it appeared that Mr Pike was convinced of the obligation but not of the sufficiency of DNA's plans and cost estimates.[187]

LTG Johnson arranged to have the Enewetak people's representatives testify before Mr. Pike's committee as well as before Senator Symington's committee [188,189] Iroij Johannes Peter of the dri-Enewetak and Iroij Binton Abraham of the dri-Enjebi appeared before the Military Construction Subcommittee of the Senate Armed Services Committee on 25 April 1975.[190] Their statement told of how the people had been taken from Enewetak to help the United States develop its nuclear arsenal and how strongly all of them wished to return to their homeland as soon as it could be cleaned up and rehabilitated. They related how important these small islands were to a people who lived in the midst of an immense ocean and how no amount of money could replace their homeland. Mr. Tony DeBrum acted as their interpreter. Also at the hearing were the dri-Enewetak Magistrate, John Abraham, and their legal counsel, Mr. Mitchell. The same delegation appeared before the Military Installations and Facilities Subcommittee of the House Armed Services Committee on 7 May 1975 and reiterated their desire to return to Enewetak Atoll.[191]

During the Senate subcommittee hearings, DNA was asked to develop the most austere cost estimate possible based on the use of troops (Army engineers or Navy Seabees) who were trained in nuclear decontamination. Field Command developed a revised (May 1975) CONPLAN similar to the April 1975 "blue" version except that troops were to be used to accomplish the crater containment as well as the cleanup. This and other refinements lowered the cost to $25 million.[192] The remaining support functions were still to be accomplished by contractor personnel.

In the Senate Armed Services Committee hearing on 22 May 1975, the matter was discussed at length. Although the moral obligation to permit the Enewetak people to return to their atoll was a consideration, the committee's decision, as noted in their report, was based "...primarily on the premise that the United States could not walk away from a testing program which cost several billion dollars without making a responsible effort to make the atoll habitable." The committee agreed to a one-time authorization of $20 million and charged the DOD to accomplish the cleanup within that amount, using every possible economy measure. The committee insisted that the radiation standards established by ERDA be met before any resettlement was accomplished.[193]

In June 1975, the House Armed Services Committee approved authorization of $14.1 million for the cleanup program.[194] House and Senate conferees met in September 1975 and, after much discussion, authorized $20 million.[195] The conferees expected the DOD to minimize the total cost through the use of Army engineers and/or Navy Seabees and by limiting the scope of the cleanup as much as possible within the constraints of radiation exposure established by ERDA. The $20 million total limit set by the Senate was changed to a target amount for completing the project.[196] Public Law 94-107, enacted on 7 October 1975, provided authorization for DNA to perform the Enewetak Atoll Cleanup Project at a cost of $20 million.[197] However, the appropriation action, which was necessary to provide MILCON funds for the project, did not fare so well.

The House Committee on Appropriations, chaired by Representative Robert L. F. Sikes, meeting in October 1975, denied funding for the project because the committee believed the minimum cost had not yet been presented to the Congress. The committee report recalled that DNA had requested $14.1 million as the first increment of a program that was estimated to cost $40 million for cleanup and another $10 million to rehabilitate the atoll for some 450 people. The committee did not believe it prudent to spend $50 million—over $100,000 per person—to reclaim the atoll at a time when tax dollars were so scarce. The committee pointed out that the dri-Enewetak had already been given title to Ujelang Atoll, plus over $1.3 million in payments for leaving Enewetak. The committee believed that the American taxpayers had a right to expect that any additional effort on behalf of the dri-Enewetak be accomplished at the lowest cost possible.[198]

The Senate Committee on Appropriations strongly supported funding the project for the full $20 million authorized and did not feel that uncertainty as to the absolute final figure should delay starting the cleanup effort. DNA's studies had indicated that $20 million might not be sufficient to complete the project, but Congress would have had ample opportunity to adjust the funding as the project proceeded.[199] (This was in line with the thinking of the Senate-House authorization conference which had authorized $20 million as a target rather than a limit.[200]) In the Senate-House appropriations conference to resolve the Committees' differences on funding, the Senate conferees, after lengthy discussion, ". . .reluctantly agreed to defer funding. . ." and conceded that other alternatives for restoration of the atoll should be explored before vast sums were spent on what could be an ineffective program.[201] This ended chances for funding and beginning the cleanup project in FY 1976.

That autumn also saw the first of many changes in Field Command management of the Enewetak Atoll Cleanup Project. RADM Swanson, the Commander, retired and was replaced by his deputy, Brigadier General Thomas E. Lacy, USAF; COL Esser, the Director of Logistics and Chairman of the Enewetak Planning Group, retired and was replaced by Colonel J. R. Schaefer, USA. Since BG Lacy and COL Schaefer had already been involved for more than a year in planning the project, this changeover did not have major impact on the management continuity.

FY 1977 MILITARY CONSTRUCTION PROGRAM: 1976

After Congress declined to provide funding for the project in FY 1976, LTG Johnson requested a conference with ASD(ISA) to review the program and determine a course for future action.[202] The conference took place on 5 December 1975. Participants included Mr. Amos Jordan, principal Deputy of ASD(ISA), LTG Johnson, and his Deputy for Operations and Administration, Major General William E. Shedd, III, USA. After a review of the situation, it was agreed that:

- DOD would seek FY 1977 funds in the amount of $20 million for the project.
- ASD(ISA) would assist in arranging for other agencies to testify on behalf of the project.
- DNA would advise the JCS of DOD's intention to use TDY military personnel for the project.
- DNA would look into reducing MILCON costs by having a scrap buyer remove the noncontaminated scrap and debris,[203] an option suggested by Field Command.[204]

In January 1976, the DNA Logistics Director, Mr. Earl Eagles, and his staff began work with Congressional staff members to promote understanding and approval of the $20 million MILCON fund request for FY 1977.[205] He arranged for Mr. Robert C. Nicholas, III, Staff Assistant to the House Appropriations Subcommittee on Military Construction, and Mr. Vorley M. Rexroad, Staff Assistant to the Senate Military Construction Appropriations Subcommittee, to accompany LTG Johnson on a tour of Enewetak, 8-13 February 1976. The better part of 2 days were spent inspecting the islands, including Enewetak, Medren, Japtan, and Runit.[206] The Congressional staff visit proved valuable in obtaining funds for the project. In addition, Mr. Rexroad was instrumental in developing the concept of augmenting MILCON funds with available worldwide Military Service assets on a nonreimbursable basis. During this same period, the Field Command Enewetak Planning Group began developing and pricing optional concepts to conform to the Congressional authorization of $20 million. It became obvious that the goal could not be achieved without considerable assistance from the Military Services. A February 1976 CONPLAN was developed, which resulted in a total cost of $26.016 million, with two cost-reduction alternatives: (1) assigning personnel on a PCS versus TDY basis, and (2) using cut-and-cover trenches versus crater containment of contaminated material. These alternatives lowered the cost to $19.361 million.[207]

An April 1976 CONPLAN modified the February 1976 version to provide an even greater variety of cost reduction possibilities, including PCS versus TDY personnel, cut-and-cover containment of contaminated material, and having the Services provide their own spare parts. Total cost ranged from $14.469 million to $24.331 million, depending on the option selected. The cut-and-cover alternative was rejected, as it would require lengthy efforts to revise the EIS.[208]

A 2 July 1976 CONPLAN was prepared to include crater containment and provide other cost-reduction options. It had a total cost of $24.331 million, which could be reduced by $3.111 million if personnel were PCS instead of TDY, and by $1.156 million if the Services provided spare parts for their equipment on a nonreimbursable basis, leaving a reduced cost of $20.064 million. This edition of the CONPLAN was sent for review to the JCS who in turn sent it to the Services and Commander in Chief, Pacific Command (CINCPAC) for comment.[209] This 2 July 1976 version of the CONPLAN (whose genesis can be traced back to the original April 1975 "blue" CONPLAN), became—after one more major revision—the "CONPLAN 1-76" upon which the cleanup was based.

THE LANDMARK HEARING: MARCH 1976

By the spring of 1976, three of the four cognizant Congressional committees had approved the Enewetak Atoll Cleanup Project. Only the House Committee on Appropriations, chaired by Representative Robert L. F. Sikes, remained to be convinced. The crucial hearing took place on 29 March 1976. The testimony presented by LTG Johnson and others was the most definitive and thorough explanation and justification of the project yet presented. The Committee's questions were incisive and exhaustive.

LTG Johnson's opening statement provided a general description of the project and of DNA's efforts to minimize costs and obtain necessary funding. He then presented a statement from the Honorable Samuel W. Lewis, Assistant Secretary of State for International Organizations, which emphasized the awkward U.S. position caused by the Enewetak and Bikini situations. They were of continuing concern in the Trusteeship Council and Security Council of the United Nations. The use of the atolls for nuclear testing had appeared to some as an abuse of our trusteeship in the first place. Twenty years had passed and the United States still had not been able to fulfill its obligation to return the people of Enewetak to their atoll in safety. The United States, which had introduced the idea of trusteeship to protect underdeveloped nations until they became self-sufficient, was under especially keen scrutiny since the TTPI was the only one of eleven trust territories established by the United Nations which had not achieved self-sufficiency. A timely appropriation of funds to resolve the Enewetak matter was essential to successful termination of the Trust in 1981 and to the best interests of the United States.[210]

LTG Johnson also presented a letter from Deputy Secretary of Defense William D. Clements urging favorable action on the appropriation. Mr. Clements believed it to be in the national interest, in order to avoid a host of political and legal liabilities in the posttrusteeship period, to make the dri-Enewetak less reliant on financial assistance and to promote a political environment in the Marshall Islands which would support continued use of the Kwajalein Missile Range by the United States.[211]

Rear Admiral William J. Crowe, Jr., of ASD(ISA), presented a statement supporting the project as a prerequisite to ending the Trusteeship and avoiding political and legal liabilities in the posttrusteeship period.[212]

Mr.Mitchell, the people's legal counsel, then presented a lengthy statement on their behalf. It chronicled their hardships during the war, their exile to Ujelang Atoll, and the hardships they had suffered there, including crop failures, rats, and starvation. Enewetak was not United States property. It belonged to the dri-Enewetak and had, Mr. Mitchell stated, been taken from them without their consent. The use of Enewetak for nuclear testing had been of immense value to the United States, with peacetime as well as wartime applications. The United States had spent over $10.6 billion on nuclear testing at Enewetak Atoll between 1950 and 1959. The cost of restoring the atoll would be insignificant in comparison, whether it was $20 million or $100 million. The real values to be considered were the total cost of the nuclear test program, including restoration of the atoll, and what that program had produced for the

United States in the way of nuclear weapons and security for all Americans, not what restoration would cost per individual resettled.[213] The two Iroijs, Johannes Peter and Binton Abraham, confirmed the statement's accuracy and responded to committee questions through their interpreter, Donald Capelle.

The committee discussed at length both the written agreements which committed the United States to return the atoll and the authority of the signatories to make such commitments. It was decided that Congress had provided that authority in Title 48, USC, Section 1681.[214]

The committee questioned the amount of payments which had already been made to the dri-Enewetak for use of the atoll, especially the $1,020,000 ex gratia payment made in trust in 1976. Mr. Mitchell explained that this was not a payment for use of the atoll, but an outright gift in recognition of the hardships the people had suffered at Ujelang. It was not a lease payment or a payment of damages, but a gift, intended to supplement their subsistence. Since it was a trust fund, they received only the interest, about $150 per person per year, or 43¢ per person per day, an extremely small amount, even for the Marshall Islands.[215]

The problem of subsistence was discussed further, especially the possibility of radioactivity in the food. ERDA representatives presented a report on the experimental farm on Enjebi which was producing fruit (but from which no data on uptake of radioactivity was yet available). Also, an ERDA report on radiological conditions at the atoll and protection of future residents was presented.[216] The committee was advised that the current plan did not envision soil removal from Enjebi,[217] and the island was not planned to be used for residence.[218]

The cleanup of Runit also received special attention. LTG Johnson indicated that 3 or 4 feet of soil might have to be removed from the Fig/Quince area on Runit.[219] All plutonium contamination on Runit above a specified level would be removed and encapsulated. The island would be made safe to work on and to visit.[220] In the event funding limits prevented complete cleanup of Runit, the project would have to be cancelled or the U.S. would have to retain indefinite control over the atoll; i.e., continue the quarantine of Runit. In response to a Congressional inquiry on the impact of a fund limitation, LTG Johnson stated that it was his view that, once the major effort and expense of mobilizing and initiating the cleanup had been incurred, it would be ineffective and uneconomical to quit work before the most significant radiological hazard on the atoll had been removed.[221]

Means of reducing total costs were discussed in detail, including: alternatives for disposal of contaminated material; the option to leave certain buildings standing; the use of Operations and Maintenance appropriations to finance the base camps; the use of excess equipment;

and the use of troop labor. DNA furnished detailed supporting data on their planned costs and savings.[222] The committee considered obtaining a waiver of further claims by the dri-Enewetak to hold project costs down. LTG Johnson expressed his belief that it would be extremely difficult to complete the project for the $20 million.[223]

The committee subsequently approved only $15 million of the $20 million requested by DNA and required DOD and DOI to develop additional plans to reduce project costs, including a maximum amount of effort by the dri-Enewetak in the nonradiological cleanup and rehabilitation efforts. The committee also added an amendment to the appropriations bill which prohibited spending any of the $15 million being appropriated until TTPI certified to DOD that the dri-Enewetak agreed that the $15 million constituted the total commitment of the United States Government for the cleanup of the atoll. This was to assure that the project did not become "...an endless drain..." on the United States.[224]

MILITARY CONSTRUCTION APPROPRIATION ACT OF FY 1977: JULY 1976

On 22 June 1976, The Senate Committee on Appropriations recommended approval of the full $20 million appropriation. Based on the exhaustive studies and documentation submitted by DNA, the Committee was convinced costs would be minimized through use of DOD resources already funded in other programs. Other considerations for accomplishing the project without delay were potential loss of goodwill and the long-term costs of maintaining the quarantine on Runit until it could be cleaned of radiological contamination.[225]

In the conference to resolve Senate and House differences on the MILCON appropriation bill, the conferees approved the $20 million requested with two provisions: (1) that the dri-Enewetak agree that this amount was the extent of the Government's obligation for cleanup; and (2) that maximum use be made of the Military Services resources to accomplish the cleanup.[226] The bill passed the House on 1 July 1976, the Senate on 2 July 1976, and, upon signature by the President on 16 July 1976, became Public Law 94-367. The law included the following key provisions:

"None of the funds appropriated for the cleanup may be expended for the Cleanup of Enewetak Atoll until such time as the Secretary of Defense receives certification from appropriate administering authorities of the Trust Territory of the Pacific Islands that an agreement has been reached with the owners of the land of Enewetak Atoll or their duly constituted representatives that this appropriation shall constitute the total commitment of the Government of the United States for the cleanup of

Enewetak Atoll." An agreement with representatives of the TTPI certifying this stipulation was signed 16 September 1976.

"All feasible economies should be realized in the accomplishment of this project through the use of Military Services' construction and support forces, their subsistence, equipment, material, supplies and transportation, which have been funded to support ongoing operations of the Military Services and would be required for normal operations of these forces. Further, such support should be furnished without reimbursement from military construction funds."[227]

The Military Construction Program request, on which the approved version of the MILCON appropriation bill was based, provided for expenditure of the $20 million in the following manner:[228]

a. Field Construction—$1.3 million. Included in this category were the rehabilitation of existing facilities on Enewetak Island essential only for cleanup operations, construction of camp facilities on Enewetak and supporting facilities for the mobile forward camp, and the construction of boat beaching facilities.
b. Mobilization—$3.3 million. This included air and sea shipping and transportation costs needed to prepare for the start of operations at Enewetak Atoll.
c. Cleanup/Operations and Maintenance—$4.5 million. Included were costs of fuel, spare parts, supplies, mess supplies, indigenous labor wages, medical operations, communications, and equipment used for cleanup and operation of camp facilities.
d. Crater Containment—$3.7 million. This category contained those cost items specific to disposing of radioactively contaminated debris and soil by encapsulation in a crater on Runit with a soil-cement mixture and covered with a concrete cap. Cost items included a technical services contract, equipment, fuel, cement, and sea and air shipment of materials.
e. Radiological Operations—$2.6 million. This category provided for the safety monitoring and quality control evaluations for all radiological operations. Cost items included procurement and shipping of equipment and supplies and the cost of reimbursing ERDA for providing a civilian contractor-operated radiation analysis laboratory augmented with military technicians.
f. Demobilization—$2.1 million. This category included air and sea shipping and transportation costs relevant to the closing of DOD operations at Enewetak.
g. Logistics—$2.5 million. Included in this category were support necessary to the conduct of the Enewetak Atoll cleanup and air and sea transportation and shipping costs.

A summary of actual expenditures incurred during the project under the MILCON appropriation is contained in Chapter 9.

FIELD COMMAND CONCEPT PLAN 1-76: 15 SEPTEMBER 1976

The JCS and the Director, DNA had advised against having the Services furnish materiel and transportation support without reimbursement on the basis that it would detract from the Services' other missions.[229] The 2 July 1976 edition of CONPLAN 1-76 reflected this position and included funds to reimburse the Services in its estimated total cost of $24.331 million. It also included $2.9 million (ERDA's latest estimate) to reimburse ERDA for radiological support based on the 7 September 1972 conference agreement.[230] This plan was reviewed by DNA officials at Headquarters and Field Command on 2 August 1976 to identify means of reducing costs to the $20 million which had been appropriated. One obvious action was to limit the reimbursement of ERDA to the $1.5 million which had been ERDA's original estimate and which had been contained in the original DNA budget request for radiological support. Other possible reductions of MILCON costs also were discussed; however, it was agreed that no further changes to the CONPLAN would be made until JCS comments were received on the 2 July 1976 version which had been distributed by the Joint Staff to the Services and the CINCPAC.[231] The Chairman of the JCS, General George S. Brown, USAF, was briefed on the CONPLAN during a visit to Field Command that autumn.

In forwarding the 2 July 1976 CONPLAN, DNA had requested that the Military Services be assigned formal responsibility for supporting the cleanup project and that supporting Service elements be designated so that detailed planning could begin immediately, with the objective of starting cleanup operations on 1 March 1977.[232] On 10 September 1976, the Deputy Secretary of Defense requested the Chairman, JCS, to inform the Military Departments of the requirement to accomplish this project under the conditions imposed by the Congress and the need to provide support to this project, including but not limited to.

a. Full and effective troop support.
b. Maximum feasible use of PCS rather than TDY to conserve project funds in order to accomplish the project within the $20 million MILCON appropriation and to keep the total project cost down.
c. Provision of supplies, equipment, including repair parts, and transportation available Service-wide required for timely accomplishment of the project.

The Deputy Secretary of Defense also requested that the Chairman, JCS have the military departments designate, at the earliest practicable date, the military support units to be deployed for this project, in order to permit the initiation of detailed operational planning.[233] The Joint Staff decided, however, to wait until CONPLAN 1-76 had been revised to reflect all changes in the concept before formally tasking the Military Services. The Joint staff did not task the Services until 24 January 1977.[234]

After reviewing the 2 July 1976 CONPLAN, the Joint Staff recommended that it be modified to include helicopters for medical evacuation and an annex on communications support.[235] Comments also were received from CINCPAC[236] and the Air Force Surgeon General.[237] Based on these comments and on the provisions of the FY 1977 MILCON Appropriations Act, CONPLAN 1-76 was revised as of 15 September 1976.[238] Several annexes were added to conform to the JCS Operations Plan format. This CONPLAN was resubmitted to the JCS, who approved it with a few final refinements. These refinements were incorporated as Change Number 1 on 1 February 1977. The final CONPLAN 1-76 contained all the basic policy and concepts and most of the procedures required to execute the project in accordance with the will of Congress and the direction of the Secretary of Defense and the JCS.[239]

THE MISSION: SEPTEMBER 1976

The mission, as authorized by Congress[240] and approved by the JCS,[241] was to conduct a full Case 3 EIS cleanup; i.e.:

a. Physical hazards will be removed from all islands.
b. Obstructions to development of habitations and agriculture will be removed.
c. Unsalvable nonradioactive material will be disposed of in accordance with appropriate procedures.
d. Boken, Lujor, and Runit plutonium concentrations greater than 400 pCi/g will be excised, and all other concentrations between 400 and 40 pCi/g will be dealt with on an individual basis (seven islands are in this range). Concentrations of less than 40 pCi/g will not be disturbed. Cleanup of plutonium is expected to be performed iteratively until a sufficiently low concentration level is attained.
e. Plutonium will be removed from the burial crypts on Aomon.
f. Radioactive scrap will be removed from all islands in the Atoll. (Radioactive scrap has been identified on nine islands.)
g. Radioactive materials will be disposed of by crater containment on Runit.[242]

CONCEPT OF OPERATIONS: SEPTEMBER 1976

It was planned that the Enewetak Atoll Cleanup Project would be accomplished by a JTG consisting of a Commander (CJTG) who reported to Field Command, a Headquarters Element (HQ JTG), elements from the three Military Services, and ERDA (Figure 2-6).[243] Most of the changes that the Joint Staff made to the final CONPLAN were minor; however, one led to serious command and control problems during the project. DNA had recommended that the CJTG be in command of the Military Service Elements on the Atoll. At the insistence of the Navy JCS representative, the CJTG was given "supervisory authority" rather than command over the Military Service Elements of the JTG. "Supervisory authority" was uniquely defined by the Joint Staff for this one project as ". . .the detailed and local direction and control of movements or maneuvers necessary to accomplish missions or tasks assigned."[244] This ambiguous and limiting phrase caused considerable confusion and resulted in many management problems and other adverse effects on cleanup operations (described in later chapters).

D-Day was designated as the day base camp construction and radiological field surveys would begin. According to the CONPLAN schedule (Figure 2-7), construction materials and supplies for base camp construction were scheduled to be ordered at D-3 months. After D-Day, 2 months were scheduled for rehabilitation of the base camp at Enewetak Island and erection of a temporary camp at Lojwa Island (Ursula). Actual cleanup operations were to begin at D+2 months and last approximately 2 years, including cleanup of the base camps and work sites at Runit, Lojwa, and Enewetak. One month was scheduled for demobilization of personnel and materiel.[245]

The schedule was based on simultaneous efforts by a Navy Harbor Clearance Team to remove debris below the high-tide line and three Army engineer teams to remove and dispose of other debris and contaminated soil. Team A would be based at Enewetak Camp and accomplish cleanup of the noncontaminated southern islands. Team B would be based at Lojwa Camp and accomplish cleanup of the northern islands, including noncontaminated hazards and contaminated soil and hazards. Team C also would be based at Lojwa Camp and would accomplish the containment of radioactive debris and soil in the crater on Runit (Figure 2-8).[246] Before containment operations began, Team C would complete prerequisite preparations, including quarrying and crushing aggregate, constructing a dike or mole to minimize the effect of tides and seas, and setting up the batch plant and other facilities. It was anticipated that before these preparations were finished, Team B would have completed soil cleanup on all islands except Runit, thereby providing a stockpile of about 30,000 cubic yards—sufficient to begin containment operations.[247]

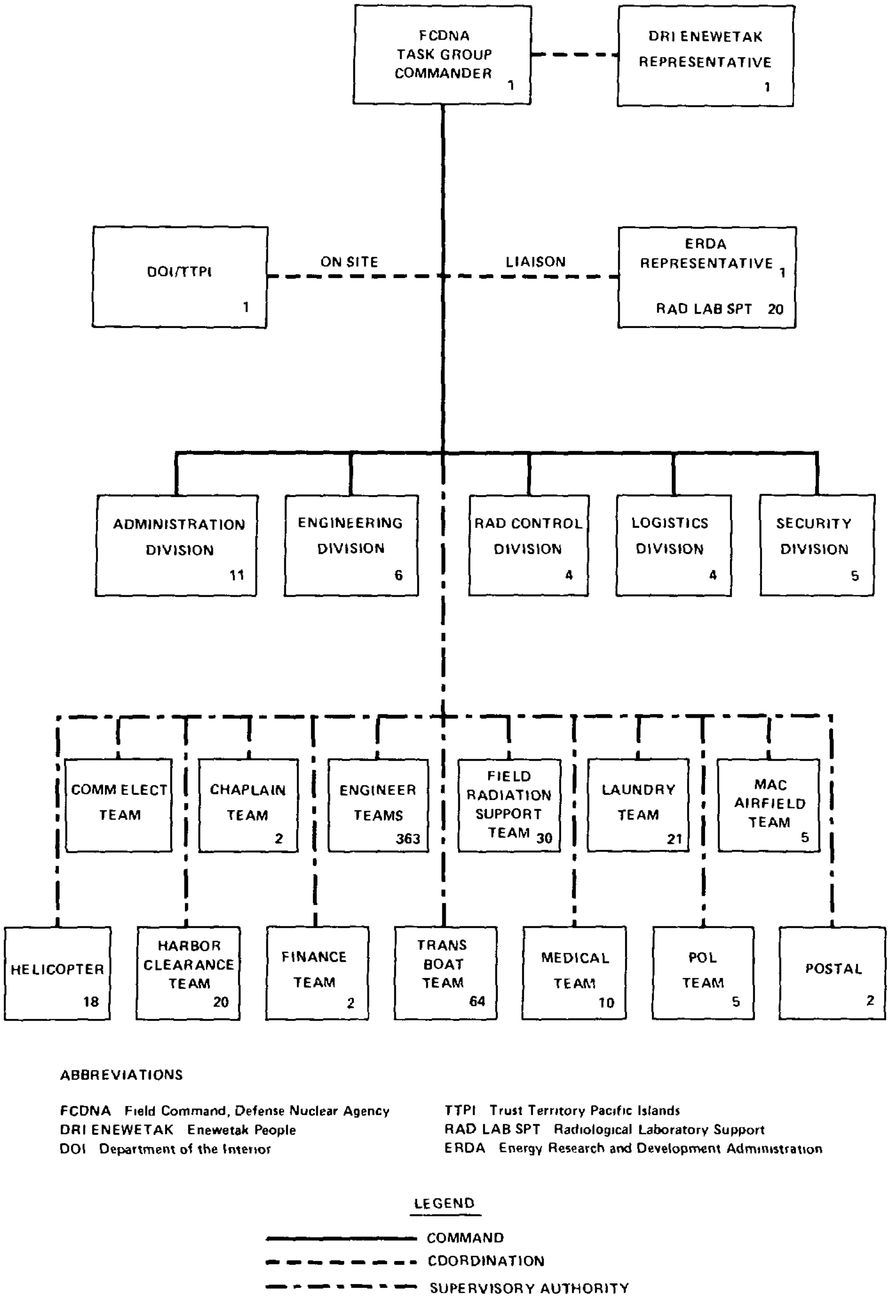


FIGURE 2-6. ENEWETAK ATOLL PROPOSED JOINT TASK GROUP

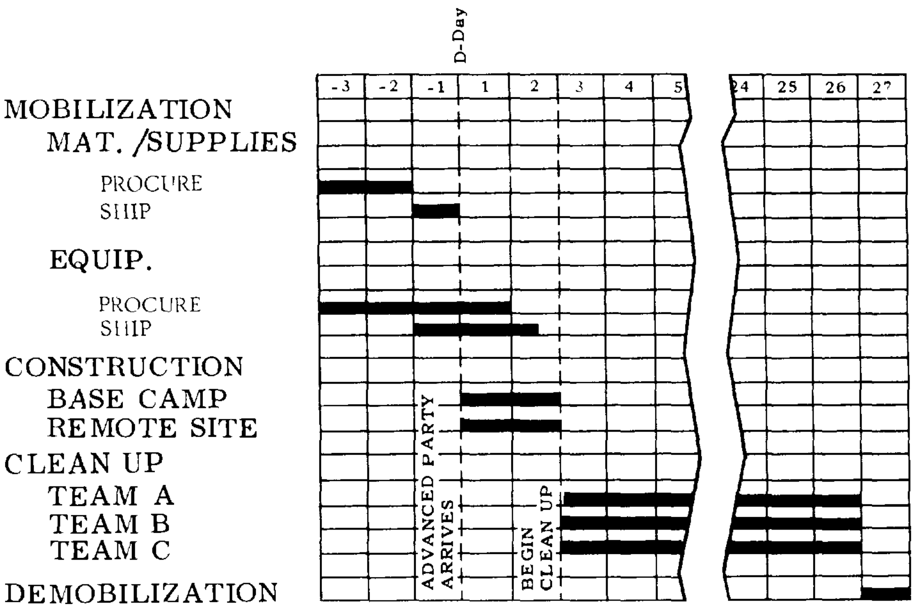


FIGURE 2-7 OPERATION SCHEDULE (MONTHS).

Containment would be accomplished by mixing contaminated soil, cement, and salt water into a slurry and pumping the mixture through pipes to a tremie barge, then to the bottom of the crater. By keeping the discharge end of the tremie pipe at least 1 foot beneath the top surface of the previously placed slurry, a monolithic mass would be accumulated, gradually displacing the water from the crater. All contaminated debris was to be removed from the islands and encapsulated in the slurry during this phase. When the water became too shallow to float the barge, the tremie operation would stop and the slurry line would be held by a crane moving slowly around to form a mound. During the inactive periods in the containment operation, Team C personnel would assist Team B in their cleanup of Runit, the last and largest soil cleanup operation. After all contaminated debris and soil had been contained, a cleanup of the containment site would be conducted to assure that all contaminated material was in the container before the concrete cap was begun. The container would be covered with an 18-inch-thick concrete cap. Once the cap was complete, the stone mole would be grouted with noncontaminated material to provide a structure more resistant to the effects of the sea.[248]

The CONPLAN cleanup schedule was based on man-hour estimates taken from the Enewetak Engineering Study and adjusted for such factors as weather, radiological safety, and emergencies.[249] The concept planners estimated that cleanup of all plutonium contamination over 40 pCi/g on 11

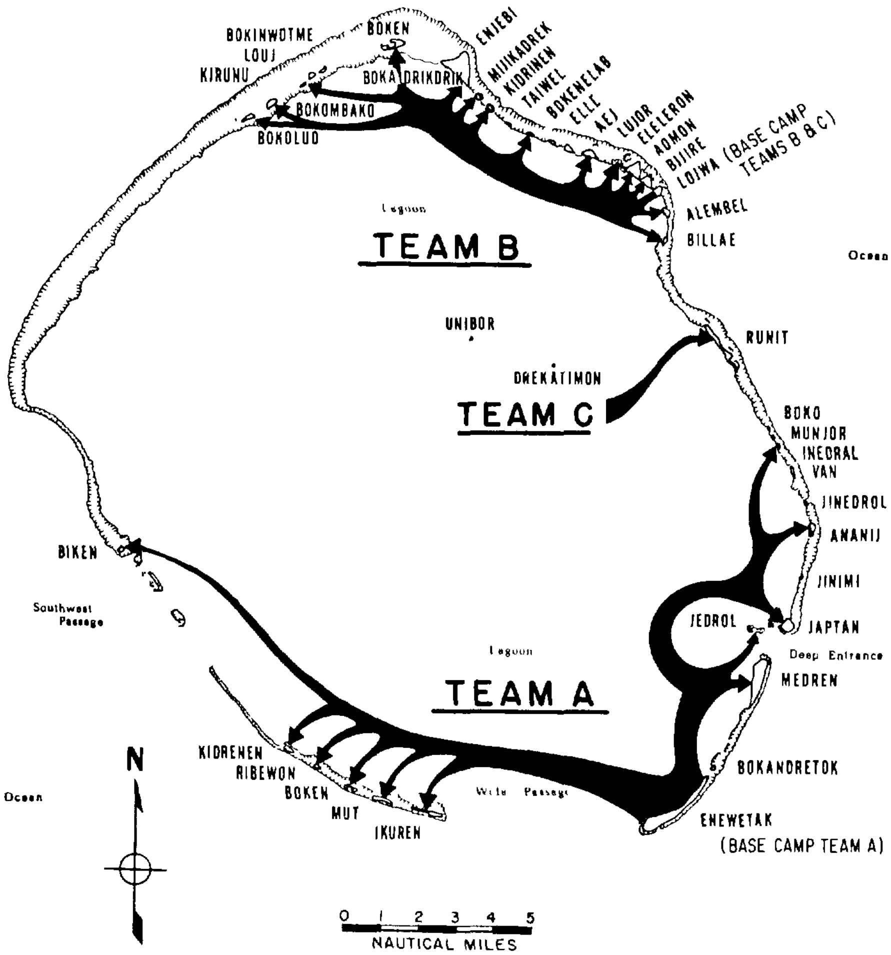


FIGURE 2-8. ARMY ENGINEER TEAM ASSIGNMENTS.

islands would require removal of 125,000 cubic yards of soil.[250] They recognized the many uncertainties in their estimates and the many unknowns in the mission, especially the radiological cleanup. Consequently, they set no fixed dates but provided only a general estimate for project completion. CONPLAN estimates ranged from 21 to 25 months for cleanup operations, including demobilization of base camps.[251,252]

SUPPORT ELEMENTS

The Joint Staff planners attempted to distribute the Enewetak project tasks among the Services as equally as possible while retaining unit mission integrity. Actual cleanup work was assigned to the Army Engineer Units and the Navy Harbor Clearance Units (later known as Water-Beach Cleanup Teams). Intra-atoll transportation was assigned to the Navy, with one exception. The Army would provide amphibious lighters (LARCs), Army amphibious vehicles with a unique capability for crossing the several hundred yards of shallow reefs which surrounded many of the islands and prevented access by the Navy landing craft. Other support teams, designated by the JCS[253,254] and identified in the CONPLAN,[255] included:

a. The Field Radiation Support Team, to be provided by the Air Force to oversee on-site radiological safety, conduct field radiological sampling of debris, and carry out explosive ordnance disposal.
b. The Medical Team, to be furnished by the Air Force to provide medical and dental care to all authorized personnel on Enewetak Atoll. The physician also would serve as staff physician to the CJTG.
c. The Chaplain Team, to be furnished by the Army to provide religious services and associated support to all personnel. The Chaplain also would serve on the staff of the CJTG.
d. The Communications-Electronics Team, to be furnished by the Air Force to provide all common-user communications support.
e. The Helicopter Team, to be furnished by the Army for intra-atoll medical evacuation, and search and rescue.
f. The Finance Team, consisting of one Army noncommissioned officer to provide military pay assistance.
g. The Laundry Team, to be furnished by the Army, since they were the only service which operated portable tactical laundry units, to operate a general laundry at Enewetak Camp and a decontamination laundry at Lojwa Camp.
h. The Petroleum-Oil-Lubricants (POL) Team, to be furnished by the Air Force to resupply forward-area POL stores and provide limited quality surveillance of POL products such as helicopter fuel.
i. The Airfield Team, to be furnished by the Air Force to operate the aerial port, including marshalling, loading, and offloading of aircraft.
j. The Postal Team, to be furnished by the Air Force to operate the military post office.

In addition to these teams, the Navy and Air Force were tasked to furnish technicians to work with the radiological support contractors, thus reducing the cost of radiological survey and laboratory operations.[256] The radiological support contractors, engaged and supervised by ERDA, were to provide soil surveys and laboratory analyses necessary to establish cleanup requirements, to evaluate the effectiveness of cleanup work, to support radiological health and safety programs, and to certify the results of radiological cleanup. The base support contractor, Holmes & Narver-

Pacific Test Division (H&N-PTD), was to operate and maintain the Enewetak base camp and furnish other contract services.[257]

Logistics support policy was based on maximum utilization of Military Services' equipment, supplies, subsistence, and transportation which had been funded by the services for normal operations. Existing Government logistics sources and systems would be used for supply, maintenance, and transportation when possible. Military Ocean Terminals at Oakland, California, and Honolulu, Hawaii, would serve as the primary surface shipping points, while Travis AFB, California, and Hickam AFB, Hawaii, would be the primary air terminals. H&N maintained logistics support offices at or near those locations to expedite acquisition, packing, and shipment of material.[258]

The Army member of the Joint Staff proposed that the CONPLAN provide for the use of MILCON funds to cover FY 1977-1978 costs fully, if necessary, to minimize impact on Service programs in the early years. The CONPLAN could then allow the Services to reprogram for the remaining costs in FY 1979. LTG Johnson pointed out that this would violate the language and intent of Congress, both by reimbursing the Services for costs which they already had programmed for troop support and by programming additional Service funds in FY 1979 solely for the Enewetak project.[259] The Joint Staff persisted in adding this provision; however, it was never implemented because the Services were able to support the project in the early years from programmed funds. The Army member of the Joint Staff also proposed that the final Operations Plan (OPLAN) be forwarded to the JCS for approval. DNA objected that this would infringe on the Director's authority as DOD Project Manager for the cleanup project and would unnecessarily involve the JCS in operational details in the execution of concepts approved by the JCS in its review of the CONPLAN. The JCS concurred with DNA and concentrated on review and approval of the CONPLAN.[260,261]

Now, all that was needed to produce a complete OPLAN were the technical and operational details which only the Military Services and the other federal agencies could provide. Until formal JCS tasking was received, Army activities could only coordinate informally with DNA officials to determine the status of planning efforts. Meanwhile, the other agencies, including the Air Force, the Navy, and the dri-Enewetak themselves, were conducting surveys and refining plans for the cleanup project.

SEPTEMBER 1976 SURVEYS AND CEREMONIES

In September 1976, the dri-Enewetak Planning Council, iroijs, and respected elders returned to the atoll to participate in field surveys and in ceremonies marking the formal, legal return of Enewetak Atoll to the people. The ceremonies took place on 16 September 1976 on the lawn in front of the Battle of Enewetak Memorial. BG Lacy represented the United States Government in the signing of agreements by the Honorable Peter T. Coleman, Acting High Commissioner of the TTPI; the dri-Enewetak Iroij, Johannes Peter, and the dri-Enjebi Iroij, Binton Abraham (Figure 2-9). The District Administrator of the Marshall Islands, Mr. Oscar DeBrum also was present, while Mr. Earl Eagles represented HQ DNA.[262]

Originally, it had been expected that this transfer could take place in 1973; however, resolution of numerous difficult issues regarding residual rights of the United States and use of the TTPI as an intermediary—as well as the higher-priority cleanup and rehabilitation planning—had required 3 years. The people's attorney did not want the TTPI involved in use agreements for the DNA cleanup forces, the Coast Guard LORAN Station, or ERDA's marine biological laboratory. However, DNA and DOI attorneys contended that the trust agreement precluded their signing agreements directly with the people.[263] The matter was resolved by preparation of agreements involving the TTPI but signed concurrently by the dri-Enewetak. Documents signed on 16 September 1976 included:

a. The agreement terminating rights, title, and interest of the United States to Enewetak Atoll under the 1944 agreement with the TTPI.[264]

FIGURE 2-9. ENEWETAK ATOLL TRANSFER CEREMONY.

b. The TTPI's release and return of use and occupancy rights at Enewetak Atoll to the dri-Enewetak.[265]
c. The TTPI's joint disclaimer of right, title, or interest in or to Enewetak Atoll.[266]
d. The TTPI's quitclaim deed to Ujelang Atoll.[267]
e. The agreement granting use and occupancy rights at Enewetak Atoll to the TTPI by the dri-Enewetak.[268]
f. The agreement granting use and occupancy rights at Enewetak Atoll (for the cleanup) to the United States by the TTPI.[269]
g. The dri-Enewetak agreement that the $20 million appropriated by the Military Construction Appropriation Act of 1977 constituted the total commitment of the United States for the cleanup of Enewetak Atoll.[270]
h. The TTPI certification to the Secretary of Defense that the dri-Enewetak had agreed that the $20 million constituted the total obligation of the United States for the cleanup of Enewetak Atoll.[271]

Following the signing ceremonies, the dri-Enewetak Planning Council, Field Command, and TTPI representatives conducted a joint survey of the islands. Results of this survey, which were confirmed in Planning Council resolutions, significantly reduced the scope of nonradiological cleanup.[272,273]

NONRADIOLOGICAL CLEANUP PLANNING: 1974 - 1976

All of the cleanup work in the southern islands, and much of the work in the northern islands, involved removal of nonradiological hazards and obstructions to use of the islands. This nonradiological cleanup included buildings and their contents, utility systems, bunkers, towers, scrap piles, derelict watercraft, and World War II armaments and debris. Some bunkers could be made safe by removing doors and protruding hazards, while others would have to be sealed with concrete. Much of the work on the southern islands involved dismantling base camp buildings and facilities to make room for the houses, gardens, and coconut plantations of the people.

The Enewetak Engineering Study described each hazard and each obstruction which had been identified for removal during the 1972 engineering survey. However, the study itself was too voluminous to be used in the field or as a ready reference. Lieutenant Colonel Charles Focht, USA, of the Field Command's Pacific Support Office, originated a Master Index to the study which satisfied those needs. The Master Index was developed jointly by Field Command and H&N to identify each task by index number, location, description of work to be accomplished, and whether the task would be accomplished by DOD as part of the cleanup project or by TTPI as part of the rehabilitation program. The Master Index was revised periodically, based on resurveys and planning changes.

The most productive resurvey effort was that conducted in September 1976 during the visit to the atoll by the Enewetak Planning Council after the signing ceremonies. It had two objectives: (1) to comply with the direction of Congress that practical measures be taken to reduce nonradiological cleanup costs; and (2) to refine nonradiological cleanup plans.

Before the main party arrived, engineers from Field Command and H&N made a detailed survey of each island. This survey revealed that some of the work identified in the first field survey in 1972 had been modified or eliminated by natural forces, such as the complete corrosion of metal. In a significant modification of previous plans, Lieutenant David Gebert, USN, of Field Command, and Mr. Charles P. Nelson, of H&N (for TTPI), arranged an exchange of TTPI work in the northern islands for DOD work in the southern islands. Before this agreement, DOD had the responsibility for cleanup of radiological debris and hazardous nonradiological debris, and TTPI had the responsibility for cleanup of nonhazardous, nonradiological debris. Since both types of nonradiological debris were present on both the northern islands and the southern islands, work crews from DOD and TTPI would be engaged in parallel efforts on virtually every island. This had an added disadvantage in the north, for it meant that TTPI crews would have to be integrated into the radiological safety program. By exchanging jobs totalling an equal number of man-hours, DOD took over all of TTPI's responsibilities for nonhazardous, nonradiological debris in the north, and TTPI took over an equal amount of DOD's responsibilities for hazardous, nonradiological debris in the south. Thus, TTPI's site restoration work was restricted to the residence islands, and all cleanup and restoration work on the contaminated northern islands would be accomplished by DOD. This exchange also eliminated such inefficiencies as having DOD remove hazardous pipe stubs from a nonhazardous concrete slab before TTPI removed the whole slab.

Upon their arrival, the Planning Council reviewed the survey and suggested additional work reductions such as leaving asphalt runways in areas designated for tree planting and cutting holes in them to permit planting, and leaving flat concrete foundation slabs for use as copra drying locations. The Planning Council passed a resolution approving the resurvey results, and the Master Index was revised accordingly. This resurvey eliminated approximately 80,000 man-hours of work from the southern islands cleanup effort.[274] The Planning Council also agreed to the following criteria for nonradiological cleanup of islands, according to use-categories defined in the March 1975 Master Plan:[275]

Major Inhabited Islands: Remove all hazards and all obstructions to reasonable use of the land, out to the Mean Low Water Line.

Intensive Agriculture Islands: Remove all hazards out to the Mean Low Water Line. Remove all obstructions to reasonable use of the land out to the periphery of the vegetation area.

Food Gathering Islands: Remove all hazards out to the Mean Low Water Line. Leave in place objects which do not significantly interfere with food gathering.

NONCONTAMINATED MATERIAL DISPOSAL: 1974 - 1976

Disposition of noncontaminated material did not have the many problems connected with the disposal of radiologically contaminated materials. The EIS provided three basic methods for disposal of noncontaminated material:

a. Combustibles would be burned in a pit, the ashes gathered and stockpiled for future use as a soil conditioner, and the pit backfilled and restored to its original contour.
b. Materials that could be used by the Enewetak people would be salvaged and stockpiled. Presumably, this included wood which the people could burn for cooking. The dri-Enewetak requested that usable material be stockpiled for them and not sent to other areas of the TTPI.
c. Unusable material would be dumped in the lagoon at selected locations.[276]

The question of lagoon-dumping of uncontaminated scrap had been settled at the meeting held at the EPA on 8 August 1974. After some discussion as to whether shallow dumping would create artificial reef habitats for marine life or cause reef damage leading to ciguatoxic contamination of marine life, deep-water lagoon-dumping had been decided upon. All present had agreed that the practice would have no substantial adverse effect, especially since depths of 200 feet were to be used as dumping sites.[277]

DISPOSAL BY SALE: 1975 - 1976

Most of the uncontaminated material to be removed during cleanup was on three islands designated for residence (Japtan, Medren, and Enewetak). Much of it had commercial value as scrap. On 5 December 1975, DOD had requested DNA to examine the possibility of reducing MILCON costs by having a Japanese scrap buyer remove the noncontaminated scrap.[278] There was some question, however, as to the ownership of the scrap and the eligibility of a foreign buyer. Under the existing agreement between the United States and the TTPI for the use of Enewetak Atoll, the scrap material would have been abandoned in place According to the Engineering Study and the EIS, it would be dismantled and stockpiled for use or sale by the people. The TTPI-Marshall Islands District Early Return Program anticipated some employment and revenue for the dri-Enewetak from the sale of scrap. The Marshall Islands District Administrator, Mr. Oscar DeBrum, expressed an interest in contracting for the sale and removal of the material Initially, this appeared to provide an excellent means of accomplishing much of the southern islands cleanup and reducing the effort and cost of the DOD project. Accordingly, in December 1975[279] and in January 1976,[280] Field Command recommended that the facilities and material required for the cleanup operations be identified and that the remaining facilities and material revert to TTPI under the use agreement so that TTPI could contract for its sale and removal by commercial contract. At the same time, LTC Hente, of Field Command's Pacific Support Office, was coordinating with Defense Property Disposal Office (DPDO) officials in Hawaii regarding another alternative—that of having DPDO contract for the sale and removal of the scrap.

On 13 January 1976, the HQ DNA Logistics Directorate advised Field Command that a recent change in Public Law 40-USC 472 and Federal Property Disposal Regulations prohibited transfer of the material to TTPI or the dri-Enewetak without prior determination by DPDO that the material was "uneconomically salvageable."[281] This guidance did not apply to buildings left standing by cleanup forces. Thus, in planning the disposition of Lojwa Camp, it was determined that cleanup forces would remove the installed equipment and facilities for which DOD had other requirements, and that the remaining buildings which had been erected for the project would revert to TTPI for use by the dri-Enewetak or disassembly by TTPI forces.

The HQ DNA Logistics Directorate also advised that it would be extremely costly to conduct a special radiological survey at that time to assure the material was noncontaminated. Therefore, the survey and sale, if any, could not take place until cleanup operations had begun.[282] Mr. Oscar DeBrum was so advised on 3 February 1976.

The advantages of accomplishing some cleanup by scrap sale continued to be explored. Since most of the facilities and material had been acquired under the Enewetak base support contract, it was suggested that the current base support contractor, H&N-PTD, remove and sell the material as a plant closure action, with net proceeds being credited to the base support contract. However, in view of the 13 January 1976 decision, this suggestion was rejected. Field Command continued to pursue the matter. LTC Hente escorted Mr. Dean Easton, Chief, DPDO, Hawaii, and Mr. R. Rupert, DPDO, to Enewetak for a physical survey of scrap materials and excess/surplus equipment on 22-30 June 1976. Both men were impressed by the quantity and quality of available material and were confident that a number of companies would be interested and submit bids. It was estimated that 80 percent (24,000 gross tons) of the material was, in effect, base support contractor inventory and that any proceeds of its sale, less DPDO's expenses, would be returned to H&N-PTD for credit against the base support contract. This was confirmed in a DNA-Defense Supply Agency conference on 2 September 1976.[283]

At Enewetak, following the 16 September 1976 signing ceremonies marking formal return of the atoll to the dri-Enewetak, their iroijs and Planning Council were informed that, due to the change in the law, the usable material could not be left for them. They were, however, given permission to dismantle buildings 190 and 544 and take the material to Ujelang. Their removal of these buildings saved an estimated 400 man-hours of cleanup work for DOD forces.[284]

In November 1976 a team from Field Command led by Lieutenant Colonel Manuel Sanches, USA, monitored all of the material for radioactive contamination and, together with a team from DPDO, Hawaii, marked it for inspection by potential buyers.[285] The scrap sale and removal operations are described in Chapter 4.

OTHER PLANNING ACTIONS: NOVEMBER-DECEMBER 1976

BG Lacy and a few key staff officials embarked on a series of coordinating conferences in November 1976. The first, at Headquarters DNA on 11 November, was to brief the Director on the current planning status and to establish a new D-Day. When the 2 July 1976 version of the CONPLAN was forwarded to the JCS, a tentative D-Day of 1 March 1977 had been set forth. However, by November, the CONPLAN still was not approved by the JCS, the Military Services still had not been tasked to support the cleanup, and a radiological support plan had not been prepared. Planning was behind to the extent that BG Lacy felt that the 1 March 1977 D-Day could not be met. He recommended that D-Day be established at least 6 months after the date that the JCS tasked the Services.[286] Instead, LTG Johnson chose to fix a new target D-Day of 15 June 1977 and challenged the planners to meet it.

The next conference was called by the District Administrator of the Marshall Islands, at Majuro, on 15-19 November 1976. Organizations represented included Field Command, TTPI, ERDA, H&N, and MLSC.

The conferees prepared a new schedule for developing an OPLAN and for mobilizing personnel and equipment based on a 15 June 1977 D-Day. They also developed plans for support of the rehabilitation program. Plans for the early return of 50 dri-Enewetak to Japtan in March 1977 were completed, as well as plans for employing some of the dri-Enewetak in the cleanup and rehabilitation work. Logistics policy and plans for support of the activities at Enewetak were also developed.[287]

BG Lacy's team next met in Saipan with the Acting High Commissioner of the TTPI, Mr. Coleman, and the dri-Enewetak legal counsel, Mr. Mitchell, on 20 November 1976 to coordinate plans for the early return and for interface of the cleanup and rehabilitation efforts. The Field Command team then conferred with Hawaiian area officials on 22-23 November 1976 on preparations for the cleanup project, including establishment of a branch exchange at Enewetak and a forthcoming survey by a Navy team.[288]

This Navy survey team, assisted by Field Command personnel, conducted a thorough investigation of Enewetak Atoll waters and beaches from 30 November through 15 December 1976. They produced a definitive report of harbor clearance requirements, beach access and trafficability, and personnel and equipment requirements.[289] The report was incorporated in the Field Command OPLAN with only minor changes. In December 1976, a team from the Pacific Air Forces Surgeon's Office also conducted a survey at Enewetak Atoll in preparation for establishing a Medical Clinic at Enewetak Camp and a Medical Aid Station at Lojwa Camp.[290]

CRATER CONTAINMENT DESIGN: 1975 - 1977

On 29 November 1976, POD completed the initial "Design Analysis for Crater Containment of Contaminated Material at Enewetak." It concluded that use of Lacrosse Crater would be unduly expensive and provided procedures for use of Cactus Crater, as the preliminary DEIS had proposed. At Field Command's request, the design analysis provided for a capacity of up to 200,000 cubic yards of soil, the worst case anticipated,[291,292] with the capability of containing even larger quantities if necessary. POD recommended that the tremie method of placing soil-cement slurry be used below the water level only and that placement above the water level be accomplished by windrowing the dry soil and cement, then spraying it with water to initiate the cement's bonding action.[293] The POD design called for containing contaminated debris in the contaminated slurry mix and using dikes to contain slurry and debris placed after soil cement operations had begun.[294] Further details on crater containment design and construction are in Chapter 8.

RADIOLOGICAL SUPPORT AND CLEANUP PLANNING: 1975 - 1977

On 16 June 1975, the Director, DNA requested ERDA assistance in developing a plan for radiological monitoring and support. This plan was considered to be one of the most important elements in planning for accomplishment of the project. A draft DNA-ERDA agreement for radiological support was forwarded with the request.[295]

While the agreement was being negotiated at the Washington level, Field Command and ERDA-NV began developing a proposed radiological support plan. It was immediately apparent that some radiological control and survey tasks could be accomplished by troops but that other radiological support would have to be provided by ERDA contractors. A target date of 31 August 1975 was established for completing the draft radiological cleanup plan.[296]

The DNA-ERDA agreement, commonly referred to as the "Shedd-Liverman" agreement, for radiological support of the cleanup project was signed on 28 August (DNA) and 10 September (ERDA) 1975. It proclaimed the intent of both agencies to ensure that radiological hazards were disposed of in such a manner that safe resettlement could be accomplished. Further, it specified compliance with the guidelines which had been recommended for the cleanup by the AEC Task Group.[297] These guidelines were more stringent than those in general use in the United States, and they had received endorsement by the Congress as a precondition for resettlement.[298] The agreement obligated ERDA to provide certification when the radiological cleanup had complied with the guidelines.

In October 1975, representatives of Field Command and ERDA-NV met to review the DNA-ERDA agreement and discuss development of the radiological cleanup plan.[299] A draft plan was completed on 13 November 1975, based on results of this conference.[300] The two parties met again in May 1976, at which time ERDA-NV proposed to develop a field survey system for measuring plutonium concentrations in the soil using a gamma detector mounted on a boom extending from a van. (The van was a small tracked vehicle with the trade name "IMP." This trade name and its derivatives and variations as used herein are or were derived from a trademark which is the property of the De Lorean Manufacturing Company. Hereafter, throughout the documentary, the process of conducting an in situ survey using this van is referred to as "IMPing," and the vehicles are referred to as "IMPs.") It was anticipated that this in situ system—in comparison with conventional soil sampling techniques—would significantly reduce the effort and increase the speed of measuring plutonium concentrations. It also was expected to expedite soil cleanup and minimize the volume of soil excised. Possible disadvantages were the limited soil depth which the system would survey and the possibility that this new approach might not be acceptable to EPA and other concerned agencies. A prototype in situ detector was undergoing tests at the site of the Hamilton event on the Nevada Test Site, and it was anticipated that ERDA would approve the system for use at Enewetak.[301]

The Radiological Cleanup Plan was revised again on 16 July 1976, but it left some basic questions relative to radiological cleanup criteria still unanswered. Field Command asked for HQ DNA assistance in obtaining definitive answers from ERDA as soon as possible.[302,303] Detailed criteria and guidance were required to complete a Radiological Cleanup Appendix to the CONPLAN[304] and to develop estimates of work requirements upon which to base resource needs. The situation was complicated by two factors: (1) ERDA Headquarters in Washington had not formally assigned ERDA-NV the responsibility for furnishing radiological support; and (2) MILCON funds were limited.

The DNA-ERDA agreement stipulated that ERDA would provide technical and scientific advice and assistance on radiological activities associated with cleanup, including, but not limited to:

a. Advice and assistance on the preparation of the radiological cleanup plan and the radiological safety program.
b. Interface with other Federal agencies concerning radiological matters.
c. Provision of on-atoll ERDA representation.
d. Performance of radiological support, to include: (1) Day-to-day field monitoring, dosimetry, and record keeping for health and safety. (2) Radiological classification of material for removal, disposal, or reuse. (3) Certification, on an island-by-island basis. (4) Establishment, operation, and maintenance of a field laboratory.

Item d of these ERDA commitments was contingent on reimbursement from DNA. In view of the $20 million ceiling which had been set by Congress and its charge to use all available economy measures, DNA's reimbursement to ERDA would of necessity be limited to the $1.5 million which had been estimated earlier. A compromise was reached whereby the military services would provide for radiological safety and the classification of debris and ERDA would only provide for classification of soil and management of the radiological laboratory

Field Command and ERDA-NV representatives conferred on 28-29 October 1976 to define the responsibilities of ERDA contractors and military personnel. To reduce project costs further, it was agreed that military technicians would assist in the ERDA contractor laboratory, in driving the in situ vans, and in maintaining and repairing radiation detectors and other equipment. ERDA-NV representatives advised that their radiological support would not be available in April 1977, as was required to meet the then-planned 1 March 1977 D-Day. They estimated it would require 6 to 9 months; i.e., until 1 October 1977, before the radiological laboratory would be operational.[305]

The major technical problem in completing the radiological cleanup plan concerned criteria for evaluating debris and soil against radiological cleanup requirements. Without adequate criteria, the type of equipment needed for field and laboratory measurements was uncertain, necessary survey procedures could not be developed, and there was no measure for determining and certifying the quality of cleanup. The need for precise criteria for the cleanup project was made even more critical by the planned periodic rotation of personnel throughout the life of the project.

The AEC Task Group had made recommendations on cleanup of both debris and soil, but these recommendations were too general and open to too many interpretations to serve as criteria for those in the field. With respect to debris, the AEC Task Group had recommended that "all radioactive scrap metal and contaminated debris. . .should be removed."[306] This recommendation was modified in the EIS Case 3 cleanup actions to the requirement that "radioactive scrap be removed from all islands in the atoll." Although this guidance might seem clear-cut at first glance, that was not the case. No material is totally devoid of radioactivity; and clearly not every level of radioactivity is sufficient to warrant disposal of the material containing it.

The ERDA radiological advisors to DNA on the Enewetak Cleanup were reluctant to recommend criteria for use in deciding which debris was radioactive and deserving of disposal and which was not. ERDA had criteria in existence governing the release of materials for uncontrolled use following use in contaminated areas, but these criteria were not suitable for the Enewetak debris situation. One reason was that much of the Enewetak debris was situated in areas with considerable background radiation, so that definitive measurements could not be made unless the debris were relocated to a low background area. Such a practice would have led to costly, unnecessary debris movement merely to make measurements. Numerous attempts were made to define "background" and situations when debris might qualify for disposal, but none were acceptable. A second reason why ERDA criteria were not suitable was that they only addressed surface contamination. Normally, activated contamination such as that found in much of the Enewetak debris was not encountered in ERDA operations. During one planning meeting on debris criteria, Mr. Tommy F. McCraw, of ERDA Headquarters, pointed out that ERDA's reluctance to provide advice stemmed in part from the fact that they had not been successful in negotiating a contamination threshold level with EPA. He also felt that, if criteria were more stringent than had been used at Bikini, the Bikinians would not understand. (Likewise, the dri-Enewetak would not appreciate any criteria which were less stringent than had been used at Bikini.) He further expressed concern that if any specific numbers were announced as criteria, they would be rejected by EPA.[307] Thus, the ERDA advice was that Field Command should develop radiological criteria, with whatever assumptions deemed suitable, and present it to ERDA for approval.

A concept was then formulated at Field Command for monitoring debris. The monitoring included definitive measurements for alpha, beta, and gamma radiation under various conditions. The criteria were specific, and they were forwarded to Headquarters DOE for review. A decision was reached that the criteria were acceptable, and that they should be set forth explicitly in Standing Operating Procedures for use on the atoll by cleanup forces.

With respect to contaminated soil, the AEC Task Group had recommended that it be removed if plutonium concentrations exceeded 400 pCi/g; removed on a case-by-case basis, considering all radiological conditions, if plutonium concentrations were in the range of 40 to 400 pCi/g; and not be removed if plutonium concentrations were less than 40 pCi/g.

Despite the specificity of the Task Group criteria for soil removal, there still were uncertainties concerning the area/volume of soil to which the plutonium concentrations were to apply. At one extreme, an "island average" could be used. At the other (impractical, but illustrative) extreme, a gram-by-gram decision could be made. Thus, the soil cleanup criteria also needed clarification so that techniques could be defined for assaying and removing soil.

The initial Field Command concept for evaluating soil was to gather and analyze samples in a manner similar to that which had been used for the Radiological Survey, but on a more closely spaced grid, and only in those portions of islands which appeared likely to have average concentrations exceeding 40 pCi/g based on survey data. The question Field Command sought to have answered by ERDA in meetings on developing a Radiological Cleanup Plan was how many samples would be required from any area to achieve a characterization which would satisfy certification expectations. Once ERDA chose an in situ method in lieu of the survey-type soil sampling method, the question changed in nature.

Another conference was held at Field Command on 28-29 December 1976.[308] It produced a Radiological Cleanup Plan which was modified slightly by Headquarters, DNA,[309,310] and used as an Appendix to the final CONPLAN 1-76.

In summary, radiological cleanup planning had required extensive effort over many months by Field Command and ERDA planners to resolve the many questions concerning concept and method of execution. The final

CONPLAN 1-76 was based on the EIS Case 3 radiological cleanup as approved by Congress and the JCS.[311] That plan still had to be modified somewhat in subsequent planning actions, however.

FIELD COMMAND OPLAN 600-77: 1977

Field Command OPLAN 600-77 was essentially an expansion of the 15 September 1976 Field Command CONPLAN 1-76; however, it could not be developed until MILCON funds had been appropriated and the Military Services had been formally tasked to support the project. Beginning in August 1976, Field Command began preparations to develop the OPLAN. The Plans and Operations Director, Colonel John V. Hemler, Jr., USA, assumed responsibility for preparing the plan. In actual practice, COL Schaefer, and COL Thompson, (both of the Logistics Directorate), who had finalized the CONPLANs, served with COL Hemler as tri-chairmen in presiding over the OPLAN development conferences. To develop the individual annexes of the OPLAN, functional working groups were established, each chaired by a Field Command staff official, including:[312]

Operations Group - LCDR R. F. Walters, USN
Radiological Subgroup - LTC M. L. Sanches, USA
Logistics Group - Mr. D. L. Wilson
Comptroller Group - LTC M. J. Worrick, USAF
Manpower Group - CPT L. C. Dudley, USAF
Communications Group - LTC R. H. Ludwig, USAF

On 10 September 1976, the Secretary of Defense had requested the JCS to task the Services for project support. It had been hoped that the first OPLAN development conference could be held later that month. However, it was 24 January 1977 before the JCS provided formal tasking.[313] Therefore, the first conference had to be postponed several times and finally began on 3 February 1977 in Albuquerque. The Army representatives still had not received their tasking when the first conference began.

FIRST OPLAN CONFERENCE: 3-4 FEBRUARY 1977

At the first OPLAN development conference, conferees came from the Service headquarters in Washington and their action-level commands; i.e., Army Forces Command, Commander Naval Surface Forces, Pacific (COMNAVSURFPAC), and Pacific Air Forces (PACAF). ERDA representatives came from their Washington headquarters and the Nevada

Operations Office. HQ DNA sent four representatives. Holmes & Narver's home office and its Pacific Test Division were both represented. The conference considered overall concepts and policies and identified potential problem areas which were resolved or assigned to specific representatives for action. While this conference was primarily an orientation and introduction for the second OPLAN conference, there were several significant results:[314]

a. ERDA-NV stated that the in situ vans would not be available for shipment until August 1977, and the Radiological Laboratory would not be available until October 1977. They agreed, however, to review their schedule since it was not responsive to the planned D-Day of 15 June 1977.
b. Navy representatives identified a source of nonreimbursable sealift for mobilization and resupply—COMNAVSURFPAC ships traversing the Pacific on semiannual deployments which could provide space for heavy equipment and other cargo.
c. Navy representatives advised that the Boat Transportation Team could support other on-atoll tenant requirements for inter-island transportation, within reason.
d. Although CONPLAN 1-76 encouraged a 1-year, unaccompanied tour, the Services planned to use 4- to 6-month TDY tours, which they would fund, in order to avert the costs of moving families.

SECOND OPLAN CONFERENCE: 21 FEBRUARY-9 MARCH 1977

The second OPLAN development conference was held at Enewetak Atoll from 21 February 1977 through 9 March 1977. The location had two advantages. It permitted conferees to become familiar with the field of operations, and it isolated them from distractions so that a great amount of work was accomplished in a short time. The conference had three principal objectives:

a. Development of a draft OPLAN.
b. Identification of personnel and materiel requirements for mobilization, so that these could be requisitioned on a priority basis.
c. Development of an operational schedule, to include firmly establishing D-Day (the beginning of camp construction and radiological surveys).

Under the direction of BG Lacy, the same Field Command triumvirate chairmen and working group organization employed in Albuquerque were used at Enewetak. A total of 120 representatives from the Services, other government agencies, and various contractors participated in the conference and the concurrent surveys.

Personnel from the 20th Engineer Brigade, Fort Bragg, North Carolina, working in three teams, surveyed cleanup worksites and provided detailed input for the operations annex of the OPLAN. Their surveys were organized according to the work assignments in CONPLAN 1-76: Team A surveyed the southern islands; Team B, the northern islands; and Team C, the crater containment worksite on Runit. Personnel from the 84th Engineer Battalion, U.S. Army Support Command, Hawaii (USASCH), surveyed Lojwa and prepared a detailed plan for construction of the forward camp to be located there. Personnel from the 485th Medical Detachment, Fort Sam Houston, Texas, conducted extensive entomological surveys to provide insect and rodent control data.[315] Navy and Air Force planners conducted surveys of the support facilities they would be utilizing.

The general tone of planning at this second OPLAN conference was more practical, less theoretical than previously, since the individuals involved were, in many cases, either those who would actually supervise the work or those to whom they would report. Recognizing that major surprises in actual contamination measurements would occur over the next 3 years, and to provide the cleanup project leadership with maximum flexibility in decision making once the situation became clearer, the planners translated the CONPLAN cleanup guidance for soil excision into:[316] "In general, the ERDA guidelines provide for removal of concentrations of plutonium soil exceeding 400 pCi/g, and for selective removal in the range of 40 to 400 pCi/g."[317]

For some reason not specified, the planners omitted reference to removal of the crypts on Aomon where contaminated material had been buried.[318] This omission later led to suggestions from some that the largest crypt need not be removed, suggestions which were not accepted by the Director, DNA. The CONPLAN text requiring containment of contaminated debris in contaminated soil-cement slurry[319] was expanded and revised into three OPLAN provisions.

The ERDA-NV input to the OPLAN clarified the conflicting guidance on soil cleanup in earlier planning documents. The AEC Task Group Report had, in one location, recommended that, once soil cleanup action was initiated, "the concentrations would be reduced to the lowest practical level."[320] In another location, and in the EIS, this suggested guidance was inappropriately worded to the effect that, where initiated, soil cleanup "would be to well below 40 pCi/g."[321] Now, ERDA planners interpreted this objective anew, providing guidance that the reduction should be "to some lower number which shall be determined by cost-benefit considerations but will usually not be below local background."[322] This interpretation permitted intelligent focusing of effort, made optimum use of precious cleanup resources, preserved the ecology of some islands, and made possible the cleanup work that the dri-Enewetak urgently needed.

With the selection of the in situ method, the radiological planning issue shifted from the number of soil samples per unit area to how many in situ measurements were needed and what size the in situ field of view should be. In developing the OPLAN, the issue was resolved by specific ERDA decisions. Measurements would be made at a specific height and on a specific grid spacing. Raw data would be converted to plutonium concentrations using a consistent set of reasonable assumptions, and the resulting numbers would be related to the revised soil cleanup criteria. (See expanded discussions in later chapters.)

OPLAN development indicated that the cleanup would require more people, more time, and more money than previously estimated.[323] While the CONPLAN estimated 600 military personnel, the OPLAN called for 866. In the CONPLAN, it was estimated that the project would take 28 months from D-Day, while the OPLAN developers estimated 34 months. Time estimates for camp construction and demobilization in both plans were furnished by 84th Engineer Battalion personnel; however, planning factors had changed considerably since the time the CONPLAN had been developed; i.e., tents and prefabricated buildings were eliminated in favor of more permanent facilities. Some of the additional time was required to construct additional billeting and recreation facilities required to support a population of 443 at Lojwa Camp, 122 more than estimated in the CONPLAN.[324] Additional construction time also was required because the many prefabricated units anticipated in the CONPLAN were not available. All but a few facilities would have to be constructed using standard building materials.[325,326] Too, some activities which were previously considered as part of the cleanup were redefined as demobilization functions.

There was an anticipated 3-month delay in availability of ERDA radiological support (15 September 1977 rather than 15 June 1977). In order to accommodate this delay and the delay in availability of the Lojwa Camp, the planners rescheduled mobilization and cleanup activities. Northern islands debris survey and removal were rescheduled to begin prior to, instead of concurrent with, contaminated soil operations and southern islands cleanup.[327]

Three alternatives for determining D-Day were considered:

a. D-Day of 15 June 1977, with mobilization actions as scheduled in the JCS-approved CONPLAN.
b. D-Day of 15 June 1977, with modifications to the CONPLAN schedule of mobilization actions to accommodate the delay in ERDA radiological support and Lojwa Camp availability.
c. Deferral of D-Day to accommodate the delay in ERDA radiological support and Lojwa Camp availability while maintaining the CONPLAN schedule for mobilization actions.

The critical factor in the selection of D-Day was the time required for mobilization of manpower and material. For a major project, a minimum of 180 days normally is required from the time personnel and supplies are requisitioned until they arrive at the work site. The Logistics and Manpower Working Groups insisted that even with Force Activity Designator (FAD) II, a relatively high military priority, and expedited action at all levels, an absolute minimum of 90 days was required. Even so, to meet a 15 June 1977 D-Day, the absolute latest date the mobilization effort could begin was 15 March 1977.

The first alternative, which required that base camps using tents be erected in 60 days, was clearly impractical for the more permanent type camp being proposed for Lojwa. The third alternative was strongly favored by ERDA and Army planners. Navy and Air Force planners were prepared to support either the second or third alternative although they, too, preferred the latter. The Manpower and Logistics Working Groups also preferred the third alternative, but believed that they could support the second if certain conditions were met: (1) the project must be designated as FAD II; and (2) mobilization must begin by 15 March 1977. Manpower and material for base camp construction must be requisitioned a minimum of 90 days before construction forces were due to arrive on D-Day. Since actual cleanup operations would not begin until after the mobilization phase was completed at D+5 months, manpower and equipment for cleanup could be ordered later; however, the manpower and material required for camp construction would have to be identified and requisitioned as soon as possible. This meant that mobilization could not be delayed until the OPLAN had been finalized and approved, but must begin immediately (March) if D-Day were to be 15 June 1977.

Based upon these considerations, BG Lacy selected the second alternative and approved starting mobilization on 15 March 1977. The deciding factor in establishing 15 June 1977 as D-Day was general agreement that the momentum established at the conference should be maintained. Other factors were avoidance of cost escalations and the need to demonstrate to the dri-Enewetak, and to the world, that the United States was about to fulfill its promises.[328,329]

To accommodate both the lengthened schedules and the 15 June 1977 D-Day, the operations schedule of the CONPLAN (Figure 2-7) had to be revised in the OPLAN. The determining factor in the CONPLAN schedule was contaminated soil removal and containment, which was estimated to require approximately 2 years. Since the actual extent of soil contamination, especially subsurface contamination, was unknown, the planners could only make a rough estimate of its magnitude. The OPLAN acknowledged this in several places:

"The cleanup guidelines for transuranic contaminated soil removal will continue to change and be amplified during the course of the operation."

"The general scope of work as defined by the Enewetak Radiological Study and the Engineering Study for a Cleanup of Enewetak has been changed and will continue to be adjusted to meet changing cleanup guidelines and circumstances."

"This operation will be constrained by the uncertainty of the scope of work. Should the scope of work increase as a result of conducting operations, it may impede accomplishment of the mission."[330]

Due to this uncertainty in the scope of work, the OPLAN developers, like the CONPLAN developers, did not include in the text any scheduled dates for milestones other than D-Day.

The new OPLAN operations schedules had to be hastily prepared and coordinated, with the result that minor errors in scheduling appeared in the timetable for mission accomplishment.[331] After the OPLAN was published, the schedules were refined and two new schedule formats were adopted, one for general briefing and the other for detailed planning and briefing. The general cleanup project schedule as of 15 March 1977 is shown in Figure 2-10. On some schedules; e.g., Figure 2-10, the mobilization phase is shown as extending from 15 March to 15 November 1977, a period

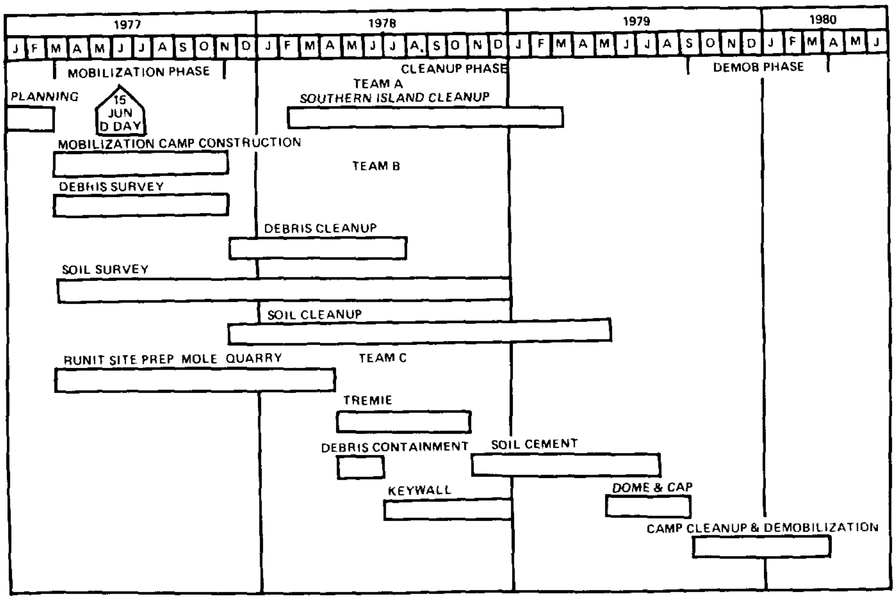


FIGURE 2-10. ENEWETAK CLEANUP PROJECT SCHEDULE - 15 MAR 77.

of 8 months. For the purposes of this documentary, this period may be viewed as a 3-month preparatory phase ending on D-Day (during which time personnel and material for the cleanup were identified, ordered, and transported to Enewetak), and a 5-month mobilization phase following D-Day (during which time the base camps were built or rehabilitated and all on-atoll preparations for the cleanup were made).

Comparison of the CONPLAN and OPLAN schedules reveals that the OPLAN allowed more time to prepare the more permanent type base camps (5 months versus 2) and more time to demobilize them (7 months versus 1). Although the 20th Brigade engineers generally confirmed the accuracy of the Engineering Study and CONPLAN workload estimates by conducting their own survey, they allowed only 22 months in the OPLAN for actual radiological cleanup and containment versus 24 months in the CONPLAN. However, the CONPLAN cleanup estimates included demobilization of the base camps while the engineers' estimates allocated time separately for that function. The OPLAN was based on excision and containment of about 79,000 cubic yards of contaminated soil (the estimate which appeared in the EIS). The planners believed that, if it became necessary to expand the scope of work to the possible totals of 125,000 to 200,000 cubic yards mentioned in the CONPLAN, additional money, manpower, resources and time would be required.

OPERATIONS PLAN ISSUES: MARCH-APRIL 1977

Several controversial issues arose during development of OPLAN 600-77. In reviewing the CONPLAN, the JCS planners had reduced the Force Activity Designator priority to FAD V, which is normally assigned to routine administrative missions. The Service logisticians at the OPLAN conference confirmed DNA's belief that supplies ordered with a FAD V would not be delivered in time to support a 15 June 1977 D-Day. At their request, DNA appealed the Joint Staff decision, and the project was authorized higher priorities for both mobilization(FAD II) and resupply (FAD III).[332]

OPLAN conferees also requested that DNA determine if special transportation rates for the project could be obtained from Military Airlift Command (MAC) and Military Sealift Command (MSC), based on the MILCON Appropriation Act which indicated that transportation would be furnished without reimbursement. The Assistant Secretary of Defense, Comptroller, advised DNA that the law did not apply to industrially funded DOD components such as MAC and MSC; therefore, no special transportation rates would be provided for the project.[333]

Air Force planners proposed to continue contracting out the airfield operation to H&N under a Field Command-MAC agreement as had been done since early 1976. The Air Force also planned to contract out the communications support operation to H&N. However, the Air Force General Counsel determined that this would be contrary to the MILCON Appropriation Act, which he interpreted to require use of military personnel for the specific cleanup functions the Air Force had been tasked to provide.[334] This interpretation, in its strictest sense, was upheld by the DOD Assistant General Counsel.[335] DNA and the other Services, however, did not construe the Act as precluding the Services from contracting for support for their specific cleanup functions, since the Act only specified that troops would be used to accomplish the cleanup. Support for those cleanup troops could be provided by whatever means the Services might choose, based on Service policy [336,337] The latter interpretation was applied by DNA, the Army, and the Navy in providing support for the project. This interpretation was also concurred in by the DOD Assistant General Counsel; i.e., the Air Force could not contract with H&N for the communications function because that specific operational function was assigned to the Air Force, but the Army could contract with H&N to operate the messhall for its troops on Lojwa because the Army's specific operational function was cleanup, which they were doing, not operating messhalls.

Only four major issues remained unresolved at the end of the second OPLAN conference:[338]

a. The Army believed that at least three landing craft, utility (LCUs) would be required. The Navy representatives did not believe they could man more than two LCUs. A strict limitation had been imposed by the Chief of Naval Operations on the number of Navy personnel to be provided for the project.

b. The Army believed that two doctors would be required, one for Enewetak Base Camp and the other to be stationed at Lojwa Base Camp. The Air Force, which was to provide medical services, contended that only one doctor would be necessary, as the medical evacuation (MEDEVAC) helicopters could transport patients from Lojwa to Enewetak where the facilities would be more complete. The Army was not so much concerned about emergency medical treatment as about the day-to-day supervision of all health and safety aspects that a doctor could provide at the primitive and hard-working Lojwa Camp.

c. The Army, which was to provide four helicopters, wanted them to be used for MEDEVAC and search and rescue (SAR) missions only, while Field Command believed they should be available to the CJTG for command and control purposes also.

d. DNA and ERDA had not agreed on the details of certification by ERDA.

Requirements for personnel and materiel were not complete by the end of the conference, but they had progressed well enough that most requisition actions could be initiated. On his return trip, BG Lacy briefed the CINCPAC staff on results of the conference and plans for the cleanup project.[339]

EARLY RETURN TO JAPTAN: MARCH 1977

During the second OPLAN conference, BG Lacy and Mr. Oscar DeBrum completed an agreement for the early return of approximately 50 dri-Enewetak to Japtan Island. These officials visited Ujelang Atoll on 25 February 1977 to coordinate with the people on plans for early return.[340]

On 15 March 1977, the two iroijs, Johannes and Binton, with over 50 dri-Enewetak, returned to Enewetak Atoll to live on Japtan during the cleanup project and to consult and advise on the cleanup and rehabilitation effort (Figure 2-11). Existing Quonset buildings on Japtan had been renovated to provide suitable temporary housing. Ceremonies and a banquet marked the event which was recorded by an American

FIGURE 2-11. EARLY RETURN OF THE PEOPLE TO JAPTAN.

Broadcasting Company television crew as well as other media representatives.

FINALIZING THE OPERATIONS PLAN 600-77

On 31 March 1977, LTG Johnson was relieved as Director, DNA, by Vice Admiral Robert R. Monroe, USN. Shortly after the change of command, the last OPLAN development conference was conducted in Albuquerque on 25-29 April 1977 to resolve outstanding issues and produce a version of the OPLAN which, while not having final approval, could be used for planning purposes. A number of comments had been received by Field Command on the items approved at the previous conference, and these and the four open items from that meeting were considered. Some of the suggestions were accepted or modified and some were rejected. The four outstanding issues were resolved as follows:[341]

a. The LCU issue had been coordinated informally by Field Command, Army, and Navy representatives between conferences and was easily resolved. The Army would provide three LCUs, instead of two, from its reserve at Okinawa, and the Navy would provide the additional crew.
b. The medical doctor issue also had been resolved informally before the conference by discussions among Field Command, PACAF, and USASCH. It was agreed that the Air Force would furnish two doctors, one for Enewetak Camp and one for Lojwa Camp.
c. The helicopter issue was resolved by the Army agreeing that, while the primary helicopter missions were MEDEVAC and SAR, the Army Element Commander could use them for command, control, and logistical purposes. The Army further agreed that, on a case-by-case basis, the helicopters could be made available to other elements, including the CJTG, for related missions.
d. The ERDA certification issue had been resolved at a DNA-DOE headquarters-level conference early in April 1977, at which the question of how DOE would certify radiological aspects of the cleanup was discussed. It was agreed that certification would be island-by-island, instead of for the atoll as a whole. Although the format for certification was left for future decision, the basic issue of DOE certification was agreed upon and an appropriate text for the OPLAN was established.

A number of other points were raised at the final OPLAN conference; e.g., law enforcement, administration, military justice, and civil affairs. These were resolved satisfactorily, and the OPLAN was officially approved for planning purposes by the Service, DOE and Field Command representatives. It was printed by Field Command as rapidly as possible and distributed in May 1977. On 15 Jun 1977 (D-Day), VADM Monroe approved the OPLAN for execution and the Enewetak Cleanup Project was officially begun.

CHAPTER 3

MOBILIZATION: 1974 - 1978

ENEWETAK CAMP REHABILITATION: 1974 - 1976

Before cleanup operations could begin it was necessary to prepare base camps for the cleanup forces and to mobilize the required manpower and materiel. The military base at Enewetak Atoll had been placed in caretaker status in 1968 by the USAF Space and Missile Test Center (SAMTEC). By 1 January 1974, when the atoll was transferred to the Defense Nuclear Agency (DNA), the facilities at the main base camp on Enewetak Island required extensive rehabilitation before they could be used to support a significant work force.

Operation and maintenance of the Enewetak Camp had been accomplished for SAMTEC by a contractor, Management and Technical Services Company, Inc. (MATSCO). The contract covered only minimum essential life-support systems for a small contractor force which maintained a nominal presence on the atoll. The contract was transferred to Field Command, DNA, which continued it in effect until a more dynamic base support system could be developed and financed. The Fiscal Year (FY) 1974 operating funds transferred to DNA by the Air Force barely covered the caretaker contract costs. The Air Force had agreed to accomplish essential repairs to the runway but had not budgeted for repair or replacement of other facilities, such as the water distillation and electrical power systems, which were on the verge of collapse.[1] Field Command promptly initiated several actions to rehabilitate these essential facilities (Figure 3-1 and 3-2).

In June 1974, four excess 800-kilowatt diesel generators were obtained from Kwajalein Missile Range to replace the turbine generators the Atomic Energy Commission had installed at Enewetak following Typhoon Olga. These were installed by the Corps of Engineers, Pacific Ocean Division (POD), and their contractor, American Electric Co. The replacement generators provided far more reliable power than the turbines though they used half as much fuel. The first of several new water distillation units was procured and installed to replace obsolete and unserviceable units. Since the communications system was a mixture of U.S. Navy and commercial equipment, Field Command obtained both U.S. Navy and factory assistance in repairing and replacing components. These actions were financed by FY 1974 DNA Operations and Maintenance (O&M) funds. FY 1975 O&M funds were requested for additional projects, including repair of the electrical distribution system

FIGURE 3-1. DELAPIDATED BUILDING.

FIGURE 3-2. DELAPIDATED BOAT DOCK.

($10K); replacement of an elevated water storage tank with a hydropneumatic system ($40K); replacement of several 5-ton air conditioning units ($15K); replacement of a dormitory water supply system ($40K); interim repair of piers ($20K); and repair of fuel fill lines and buoys ($2K).[2]

Rehabilitation of the mooring buoys and navigational aids in the lagoon was accomplished by the U.S. Coast Guard. The Coast Guard cutter BASSWOOD called at Enewetak on 30 July 1975 for the initial rehabilitation effort and returned periodically throughout the project.[3] Until December 1977, there was a Coast Guard LORAN (long-range aid to navigation) station at Enewetak which rendered invaluable assistance in several emergencies and which was a valued member of the Enewetak community.

The runway repair work accomplished by Air Force Systems Command in May 1974 was limited to patching potholes and applying a fog seal coat to the central 75 feet. These repairs began to fail in less than a month.[4] Field Command arranged to have an Air Force engineer inspect the runway on 4 September 1974[5] and to have POD inspect it on 18-25 September 1974 and recommend corrective action. There were potholes, loose asphalt, cracks, and severe raveling in the first 3,000 feet of the runway, plus depressions, cracks, and potholes over the entire airfield complex.[6] These conditions caused Saturn Airways, the Military Airlift Command (MAC) contract carrier which served Enewetak, to refuse to land at Enewetak after 9 October 1974 until the runway was repaired.[7] Emergency repairs were made by the base support contractor,[8] and air service was resumed on 6 November 1974;[9] however, the urgency of need for extensive runway repair had been made obvious. The POD report estimated repair costs at $500,000 for temporary repairs and $2,961,000 for major rehabilitation.[10] DNA could justify only temporary repairs since it was not certain then that the Enewetak Atoll Cleanup Project would be authorized by Congress.

In transferring the atoll to DNA, the Air Force had agreed to finance runway repairs necessary to give a full year of service. As the year ended, DNA was faced with a $500,000 minimum repair cost. The Air Force agreed to furnish $60,000. DNA obtained $300,000 in O&M funds from DOD and $140,000 by deferring an approved Johnston Atoll project to pay for Enewetak runway repairs.[11] Arrangements were made with POD to have the runway repaired by one of their contractors, Martin Zachary, who were then working at Kwajalein Missile Range. POD also prepared the necessary environmental assessment and permit to use the old quarry at Medren (Elmer) Island as a source of aggregate for the project.[12] When the project was delayed several months by paperwork and nonavailability of ships to move paving equipment to Enewetak, the runway was kept open by removing loose asphalt and patching potholes. In August 1975, the repair project began. The center section of the 3,000 feet of runway was replaced, depressed areas were filled, a seal coat was applied, and airfield markings were painted on the new surfaces. The repairs were highly satisfactory with the exception of the markings. Within 4 months, the paint was peeling in large flakes. This condition caused growing concern until DNA, in October 1976, had the markings repainted by its base support contractor.[13,14] After these rehabilitation and repair efforts, the runway handled heavy traffic, including C-5 cargo aircraft, for the duration of the cleanup project.

Other Enewetak Camp rehabilitation work which was accomplished by POD contractors in 1975 and 1976 included: rehabilitation of the electrical distribution system; repair of water storage tanks; and repair of the salt water pump station.[15] These projects were beyond the capability of the MATSCO base support work force. It appeared that, although POD charged an overhead fee for its services, it would cost less to use POD's contractors to design and execute the work than to augment MATSCO's capability. These projects took more time and money than the Commander, Field Command had anticipated; however, they vastly improved the essential support systems that would be needed throughout the entire project, and they provided Field Command valuable experience regarding the engineering problems, the logistical difficulties, and the high cost of working on the remote atoll of Enewetak.

CHANGE OF CONCEPTS AND CONTRACTORS: 1975 - 1977

The original concept was for the Corps of Engineers to include base camp rehabilitation, maintenance and operation in the contract for cleanup of the atoll. This concept had to be changed, however, based upon the Congressional decision to make maximum use of military manpower to accomplish and support the cleanup project. While much of the rehabilitation, operations, and maintenance work could be performed by military personnel, a number of jobs remained for which the military services were not manned, since they were normally performed by civil service or contract labor. These would have to be performed by a base support contractor at Enewetak Atoll. The existing MATSCO contract was suitable only for caretaker operations. A new contract was required to upgrade the Enewetak Camp from caretaker status and to provide base support during the cleanup project. Field Command attempted to develop a new contract with sufficiently detailed specifications for competitive bid, but which also was broad enough to allow for the unidentifiable exigencies which were sure to occur during the project.[16] It was a very difficult task, and there was considerable doubt that a satisfactory contract could be developed and awarded in time to support the project.

A more effective and less expensive means of providing contractor support—by extending the Johnston Atoll support system to include Enewetak Atoll—was proposed by Mr. David L. Wilson, of Field Command At Johnston Atoll, the Energy Research and Development Administration's Nevada Operations Office (ERDA-NV), under the Economy Act of 1932,[17] furnished Field Command the services of its contractor, Holmes & Narver, Pacific Test Division (H&N-PTD) to operate and maintain the Field Command base there. Field Command's atoll commander exercised operational control over H&N-PTD's engineering, repair, maintenance, and operations services, and established work requirements by issuing base regulations, annual work orders, and special work orders as required. Extension of this system to Enewetak Atoll would provide effective, flexible contractor support for the cleanup project. When the proposal was discussed with the Director of ERDA's Pacific Area Support Office (PASO), Mr. William J. Stanley, in September 1975, it was learned that he too had considered and supported the concept.[18] A formal evaluation and economic analysis was conducted which indicated that a savings of $200,000 per year could be realized by not entering into a separate Enewetak Atoll contract for the cleanup. One civilian and two military man-years previously devoted to administering the caretaker contract were to be saved. Also, adoption of the proposal permitted reallocation of resources between the atolls to accomplish priority tasks and facilitated maximum utilization of DNA resources to accomplish DNA missions in the Pacific [19,20] Use of H&N-PTD to design, engineer, and accomplish major repair and rehabilitation projects at Enewetak also resulted in significant savings over the use of POD contractors for such projects. After several months of negotiation, the proposal was approved for H&N-PTD to replace MATSCO as the Enewetak Atoll support contractor effective 1 April 1976.[21]

Preparations to upgrade Enewetak Camp from caretaker to standby status began in February 1976, when teams from Field Command and H&N conducted a survey of equipment and facilities. During his 10 February 1975 visit to the atoll, Director, DNA, Lieutenant General Warren D. Johnson, USAF, had ordered a general cleanup of the camp, including storage areas where unserviceable and serviceable excess material from the test period had been commingled and abandoned in great disarray. This cleanup was accomplished by the two-man Field Command team, Mr. John Armstrong and Staff Sergeant Clyde Rittenberry, USAF, in conjunction with their equipment survey. In a period of 24 days, they cleaned out and put in order 42 buildings, removing 170 dump truck loads of salvage and trash.[22,23]

The transition from MATSCO to H&N-PTD began in mid-March 1976 and, on 1 April 1976, H&N-PTD became the base support contractor for the duration of the project. Major (later Lieutenant Colonel) William L. Spicuzza, USA, was assigned as Commander, Enewetak Atoll by Field Command, effective 1 April 1976, to manage base operations and to exercise operational control over H&N-PTD activities at the atoll. During the following year, over $600,000 worth of rehabilitation work was accomplished by H&N-PTD including: repair of dormitories, shops, and warehouses; repair of petroleum storage and dispensing facilities; repair of the cargo pier; and activation of maintenance and supply facilities.[24]

While Enewetak Atoll was being reactivated in 1976, Johnston Atoll was being phased down to a lesser state of readiness due to President Ford's deletion of the "prompt" requirement from the mission of Johnston Atoll to maintain "readiness for resumption of atmospheric nuclear testing." A bargeload of supplies and equipment which had become excess to Johnston Atoll's reduced requirements was delivered to Enewetak in April 1976. In addition to much needed building materials, it included an aluminum-hulled landing craft to augment Enewetak's rusting fleet.[25] "Tiger teams" of H&N employees from Johnston Atoll were used to augment the Enewetak Atoll work force for Enewetak Camp rehabilitation projects.

The Air Force acknowledged its responsibility for programming and managing Enewetak Atoll communications facilities in February 1976. On 15 June 1976, seven Air Force enlisted personnel from the 1961st Communications Group, Clark AFB, Philippine Islands, arrived at Enewetak and spent the next 6 weeks rehabilitating the antenna system.[26] This was followed by an Air Force Communications Service survey of communications requirements and resources in September 1976.

Another reactivation project was establishment of the Enewetak Camp exchange by the Hawaiian Regional Exchange. This organization conducted a survey in October 1976 to determine requirements and resources for establishing outlets at the Enewetak and Lojwa Camps. The Enewetak exchange began operating on 8 February 1977 and was officially opened by the Commander, Field Command, DNA, Brigadier General Thomas E. Lacy, USAF, and the Regional Exchange Commander, Colonel Robert M. Sullivan, Jr., USAF, on 1 March 1977, during the second Enewetak Planning Conference (Figure 3-3).

CONSTRUCTION PROGRESSES: 1977

BG Lacy promised the Services that Enewetak Camp would be ready to support their mobilization forces by the planned D-Day, 15 June 1977. This required an accelerated construction effort by H&N-PTD H&N also had been tasked to assist in design and construction of the Lojwa Camp.

FIGURE 3-3. ENEWETAK EXCHANGE.

Engineers and draftsmen were sent from their corporate headquarters to assist in these efforts.

Normally, the Army Corps of Engineers or the Naval Facilities Engineering Command is the design and construction agent for projects funded by the Military Construction Appropriation. Authorization was obtained for the Director, DNA to be the design and construction agent for the Enewetak Cleanup Project.[27] The Commander, Field Command was authorized to act for the Director, DNA in obtaining H&N-PTD's services for design and construction of the Enewetak Atoll facilities.[28,29]

H&N-PTD again brought employees from Johnston Atoll to augment its Enewetak work force to complete rehabilitation of the Enewetak Camp. The work involved over 70 facilities including the dining hall, billets, laundry, power and water plants, recreation, supply, and maintenance buildings.[30] The total cost was almost $2,000,000 and was financed by a combination of Military Construction (MILCON) funds and Army and DNA O&M funds.[31] H&N had the essential elements of the Enewetak Camp ready by 15 June 1977. Two other projects were to be completed by the Army Element: (1) construction of billet spaces for the helicopter crew in one wing of the hangar; and (2) partitioning a portion of Building 24 for Army Element headquarters offices.

MOBILIZATION BEGINS: 15 MARCH 1977

Mobilization of military forces and material for the radiological cleanup of Enewetak Atoll began on 15 March 1977 with the requisitioning of personnel and supplies identified in the draft operations plan (Field Command's OPLAN 600-77), which had been developed in the preceding 2 weeks at the second Enewetak Planning Conference. However, U.S. Army Support Command, Hawaii (USASCH) did not receive supply requisitioning authority until 28 March 1977. The logisticians had concurred in establishing D-Day as 15 June 1977 only if they could begin requisitioning materiel immediately, in order to provide a minimum of 90 days' order and delivery time. To make matters worse, in the closing minutes of the second planning conference, the start of Lojwa Camp site preparation was advanced from D-Day to D minus 28 days. This left less than 9 weeks to mobilize men and materiel for that work.

First priority in ordering materiel went to building supplies for camp construction and to life support equipment to be installed in the camps. To minimize lead time, most of the items were to be ordered by H&N from commercial sources rather than through DOD supply channels. H&N-PTD established a logistics center at its offices on Hickam AFB, Hawaii. H&N-PTD moved in two office trailers to provide additional office space for the engineers, supply, and procurement personnel who were involved in designing facilities and ordering construction material. These personnel came from USASCH, from PTD's staff, and from H&N headquarters. It was found that so much time had elapsed since the Army bills of material for base camps were drawn up that they were outdated. Considerable research and interpretation were required before they could be used for requisitioning supplies.

Meanwhile, on 31 March 1977, 2 weeks into the mobilization effort, Field Command changed its office of primary responsibility for Enewetak matters from the Director of Logistics to the Director of Plans and Operations.[32] With this shift, the Enewetak Planning Group, which had been established under the chairmanship of the Director of Logistics to provide staff management continuity and coordination for the project, ceased to meet.

AIR FORCE COMMUNICATIONS ARRIVE: 16 MARCH 1977

To coordinate mobilization efforts, reliable radio communications were urgently needed at the atoll. The Air Force responded promptly and, on 16 March 1977, an installation team with replacement equipment arrived on a C-5 aircraft, the first of these giants to land at the atoll (Figure 3-4). The

FIGURE 3-4. USAF C-5 ON ENEWETAK.

Defense Communications Service terminal was relocated and rehabilitated to provide three voice circuits and one automated data circuit using 10-kilowatt, high-frequency transmitters. The Air Force communications team began operating the new system on 16 May 1977.[33]

HONOLULU SUPPORT: MARCH 1977

The nearest sources for most logistics support were in the Honolulu area. Logistics action officials of the agencies in Hawaii made an all-out effort to locate materiel required to begin base camp construction and operation, such as building materials, billeting, office, and shop equipment. They investigated every possible local source, including the Defense Property Disposal Region (Pacific), to assure maximum use of available resources at minimum additional cost. The success of the initial preparatory phase was due in large part to the personal efforts and cooperation of Honolulu-area action officials.

To coordinate mobilization actions at Enewetak Atoll, the first members of the Joint Task Group (JTG) Commander's staff deployed to the atoll on 5 April 1977. They were the JTG Logistics Officer, Lieutenant Colonel John R. Sitten, Jr., USA, who became the interim Atoll Commander, and

Master Sergeant J. S. Loggins, Engineer Construction NCO. Accompanying them was Captain Charles E. Day, USA, from the Field Command Hawaii Office, assigned on a 2-week temporary duty (TDY) basis to provide radiological safety support for the first joint effort of the project.[34]

FIRST ARMY-NAVY TEAM: 5 APRIL-17 MAY 1977

The first joint Army-Navy effort of the project was removal of aggregate from a stockpile on Enjebi (Janet) Island to Lojwa (Ursula) Island for use in construction of the forward base camp. It was accomplished by four Army equipment operators and five Navy boat operators assigned TDY to the atoll for the aggregate operation. Procedures for accomplishing and supporting the operation were developed by the atoll commander, the H&N site manager, and Field Command's chief logistician.[35,36] The team used base support equipment—scooploaders, dump trucks, and landing craft, mechanized (LCM-8)—to move the aggregate. The bulk-haul system, which had previously been used to deliver soil for ERDA's experimental tree farm on Enjebi, was used to transport the aggregate to Lojwa. With the bulk-haul system, the landing craft well deck was loaded directly with approximately 40 cubic yards of aggregate for each trip, instead of with one truck carrying only about 8 cubic yards of aggregate. This was the first use of bulk haul by a military team at the atoll. A year later, after extensive radiological safety testing, the procedure would be employed to improve capabilities for moving radiologically contaminated soil.

Work began on 8 April 1977 under the supervision of Chief Boatswain's Mate Roger Black. During the week, the team camped on Enjebi in trailer facilities originally established for the Lawrence Livermore Laboratory's experimental tree farm. The Enjebi trailer camp was operated and maintained by two H&N-PTD employees. On weekends, the team returned to the main base camp on Enewetak Island. CPT Day implemented the radiological safety program. Air samplers obtained from the Nevada Test Site were set up downwind of aggregate loading and offloading operations, and dust filter masks were worn by personnel in the area. When the operation was completed on 9 May 1977, a total of 1,300 cubic yards of aggregate was stockpiled on Lojwa for use by the construction forces.[37]

FIRST NAVY SEALIFT: 14 APRIL 1977

Much of the sealift for the Enewetak Atoll Radiological Cleanup Project was furnished by Commander, Naval Surface Forces, Pacific (COMNAVSURFPAC) and subordinate elements, including Commander, Amphibious Group Eastern Pacific, and Commander, Amphibious Group ONE. Their deployments of amphibious ships to the Western Pacific several times a year called at Enewetak Atoll throughout the project, bringing equipment and supplies. Without this extraordinary effort by COMNAVSURFPAC—and the total cooperation of all Navy echelons from the Office of the Chief of Naval Operations down to individual ships' crews—the project would have been in serious financial straits from the start.

The first such task group arrived from San Diego on 14 April 1977 (Figure 3-5). It included the USS ANCHORAGE, USS ST. LOUIS, USS ALAMO, and USS SCHENECTADY.[38] They delivered 2,588 measurement tons (M/T = 40 cu. ft.) of cargo, including a 90-ton crane, generators, trucks, causeway sections, and distillation units from the West Coast, and busses, shop vans, trucks, construction equipment, and building supplies from Pearl Harbor. All this materiel had been acquired and delivered to the ports of embarkation in less than 3 weeks by Field Command, H&N-PTD, USASCH, and Pacific Air Forces in order to take advantage of the no-cost sealift offered by COMNAVSURFPAC.

FIGURE 3-5. CONVOY ARRIVAL.

FIRST LOGISTICS CONFERENCE: 18-19 APRIL 1977

Field Command was responsible for coordinating mobilization efforts by the Defense Agencies, the Military Services, and other government agencies and contractors. On 18-19 April 1977, their representatives met at Headquarters, Military Traffic Management Command, Western Area (MTMCWA) in Oakland, California, to coordinate supply and transportation actions. The conference was called and chaired by Field Command's chief logistician and was hosted by the Commander, MTMCWA. The goal of the conference was to identify what cargo was available, when it was needed, and the most effective, economical means of getting it to Enewetak

Primary concerns were acquisition and delivery of equipment and supplies for the U.S. Army Element (USAE) to begin Lojwa Camp site preparation on 17 May 1977 and Lojwa Camp construction on 15 June 1977. The Military Sealift Command (MSC) ship American Racer, which was due to call at Enewetak on 31 May 1977, could deliver most of the material Almost 5,000 measurement tons of cargo were identified which would be available to ship on the American Racer. This ship was one of the deep-draft vessels which MSC used to deliver cargo between ports in the Pacific. It could not be offloaded directly at the Enewetak cargo pier, where the water was only 8 feet deep, but would have to be anchored in the lagoon and offloaded into lighters which could, in turn, be offloaded on the piers or beaches. The COMNAVSURFPAC representative agreed to expedite deployment of crews for the landing craft which were scheduled to arrive at Enewetak on 8 May 1977 so that they could be used to offload the American Racer. Field Command, U.S. Army Forces Command, and H&N-PTD representatives began developing plans for stevedores to offload the ship and for shallow-draft barge service for future resupply of the atoll.[39]

It was determined that items required prior to the ship's arrival could be provided by loan of some base support contractor equipment and by airlift of other critical items via scheduled MAC flights. Field Command also agreed to finance a special C-5 airlift to deliver four helicopters and other critical items from Hickam AFB in time to meet 17 May 1977 materiel requirements. The conferees also identified four landing craft, three Army LARCs (amphibious lighters), two other boats, explosives, and a variety of general cargo which would be available for a special Navy sealift in June 1977. The conference not only solved many mobilization problems but reinforced the momentum and positive working relationships generated in developing the OPLAN, and extended them to the supply and transportation agencies which would be supporting the project from the West Coast.

The Logistics Working Group used the 29 April 1977 OPLAN Resolution Conference to further refine plans for offload of the American Racer and implementation of shallow-draft barge service to Enewetak Atoll. It was agreed that H&N-PTD would offload Navy-operated landing craft at the beach, that the Racer's crew would operate its winches, and that the Army would provide one officer and 19 enlisted men from Fort Eustis, Virginia, to offload the ship.[40] The conferees also formally requested the Commander, MSC to provide shallow-draft barge service between Pearl Harbor, Johnston Atoll, and Enewetak Atoll.[41]

TRANSPORTATION UNITS ARRIVE: 3-16 MAY 1977

On 3 May 1977, six enlisted personnel from U.S. Navy Assault Craft Unit ONE (ACU-ONE) arrived at Enewetak Atoll to receive and put in service the first increment of landing craft which were to be delivered on 7 May 1977 by a Navy task group returning to the U.S. from Naha, Okinawa. The convoy consisted of the USS MONTICELLO, the USS VANCOUVER, and the USS SAN BERNARDINO. They delivered one landing craft, utility (LCU), three LCM-8s, one warping tug, three 90-foot causeway sections, and other equipment[42] totaling 4,493 measurement tons. The craft were promptly inspected and serviced by the ACU-ONE team. Sea trials of the LCM-8s were conducted during the next week, and they were put into service for lightering and support of Lojwa Camp construction.

Another early arrival was the Air Force airfield team, which landed on 10 May 1977. It was operational by 15 May 1977 when the next C-5 aircraft arrived at Enewetak and offloaded four UH-1 helicopters and other critical Army equipment. Maintenance and flight crew members accompanied the helicopters to prepare them for use. The Air Force communications installation team and their equipment redeployed to Yokota, Japan, on the same aircraft.[43] On the same day, the petroleum supply ship, USNS RINCON, delivered fuel to top off the diesel, gasoline, and aviation fuel (JP-4) storage tanks.[44]

ADVANCE PARTY ARRIVES: 17 MAY 1977

On 17 May 1977, an advance party consisting of the Commander, JTG (CJTG), the base camp construction forces, and the support teams arrived. By the original CONPLAN, their arrival was to be the event signalling D-Day—the first deployment of camp construction forces. Under the OPLAN, D-Day was established as 15 June 1977.

Originally, the first CJTG was to have been Colonel Howard B. Thompson, USA, who had been in charge of Field Command's planning office in Hawaii for the previous 2-1/2 years. However, because his 3-year assignment to Field Command was almost completed before the project was funded and mobilized, the assignment fell to Colonel Edgar J. Mixan, USA. He assumed command on 17 May 1977 and activated the JTG. Lieutenant Colonel Charles W. Focht, USA, and CPT Day, from the Field Command Hawaii Office, arrived in the advance party to serve as Chief, Engineering Division (J-3), and Chief, Radiation Control Division (J-2), respectively. Other JTG headquarters staff members in the advance party included Major Gerald G. Garner, USA, Chief, Administration Division (J-1) and Captain Randolph A. Flint, USA, Morale and Welfare Officer.[45]

The advance party included members of the Air Force Medical, Postal, and Petroleum, Oil, and Lubricants (POL) Teams. The H&N first aid station in Barracks 462 was used as a dispensary until a larger facility was completed. The POL Team remodeled an abandoned facility into an office and fuels laboratory and serviced the fuel trucks and trailers which had been delivered on the first sealift (Figure 3-6). APO 96333 was opened by the Air Force Postal Team on 6 June 1977.

The largest contingent of the advance party was the USAE of one general construction platoon, supported by a skeleton staff and

FIGURE 3-6. POL & LABORATORY AREA.

commanded by Captain James T. Scullary, USA. Their mission was to construct concrete slabs for the buildings at Lojwa Base Camp.[46]

The date, 17 May 1977, marked another arrival at Enewetak Atoll. On Japtan Island, a baby boy was born, the greatgrandson of Iroij Johannes Peter. He was the first dri-Enewetak to be born on the atoll since the people were removed in 1947.

These events and the status of mobilization efforts were reported in weekly situation reports (SITREPs) from the CJTG to Field Command. Field Command extracted the items of general interest and issued its own weekly SITREP to all activities concerned with the Enewetak Cleanup Project and Rehabilitation Program.[47,48]

LOJWA CAMP CONSTRUCTION: MAY-NOVEMBER 1977

During Congressional hearings, a Senate staff member had advised DNA that a recent study by the Army indicated that the military depots had on hand a number of tents and prefabricated base camp components that could be used in the cleanup project to minimize costs of camp construction. Under the original concept in CONPLAN 1-76, the base camp at Lojwa was to employ these tents, prefabricated buildings, field kitchens, and latrines for approximately 400 troops. CONPLAN 1-76 projected that it would take 2 months for construction of this prefab camp.[49]

After the CONPLAN was finalized in September 1976, the Services were contacted to determine actual availability of the base camp components, such as the Air Force special purpose portable kitchen and mess hall. The Air Force advised Field Command that there were not enough complete, serviceable units on hand for the cleanup project. During the second Enewetak Planning Conference, it was learned that the prefabricated base camp components were not in depot stocks, but consisted of drawings and bills of material. Additionally, the Army planners determined that tents would not be satisfactory for a 3-year project and that more comfortable and durable facilities would be required. They developed preliminary plans for a camp which would take a minimum of 7 months to construct, at an estimated cost of about $3.4 million. This was reduced by $500,000 when the Army was able to provide a power plant from their Nontactical Power Generation Program.

The design and construction of the camp was a joint effort by 84th Engineer Battalion personnel in Hawaii and H&N, based on a Field Command-USASCH memorandum of agreement dated 7 March 1977. At the first design conference on 19 March 1977, it was agreed that the battalion would construct all general purpose buildings on Lojwa, provide the power plant, and identify requirements for water distillation, laundry, and food service. H&N-PTD would design, procure and install the distillation, laundry, food service, and cold storage equipment.[50]

Design efforts in Hawaii were well coordinated until the battalion deployed to Enewetak, and the H&N design effort was transferred to their Anaheim, California, office. After that separation, coordination was somewhat impaired and some supply and construction problems arose.[51]

On 19 May 1977, the USAE began clearing brush and surveying sites for construction of Lojwa Camp. ERDA-NV had declared the island radiologically safe for construction operations, including earth moving. Air samplers were placed downwind of all earthmoving activities as recommended by ERDA-NV.[52] On 23 May 1977, personnel from Company B moved to Lojwa, established a temporary camp using tents, and began constructing slabs. Until the American Racer arrived, they made the most of available assets, borrowing a bulldozer, concrete mixer, and other equipment from Field Command. H&N set up a temporary mess hall using the only building on the island, refrigerator vans on loan from MSC, portable distillation units on loan from the Marine Corps, and water storage bladders on loan from an Army depot. Company B built a field shower system and established field latrines. The troops slept in tents and on beds obtained as excess from Kwajalein Missile Range. These facilities were expanded from time to time to satisfy an ever-growing population at Lojwa Camp. Use of the Lojwa Camp during its construction saved 4 hours a day which would have been used commuting by boat from Enewetak Camp (Figures 3-7, 3-8, 3-9).[53]

Construction of Lojwa Camp was hampered by unforeseen supply and construction problems. There were no Army supply personnel on the atoll when the first loads of building materials arrived, and the Army supply officer did not arrive until after construction had started. Numerous delays and work stoppages occurred, caused by a lack of critically needed items. In some cases, these were on the atoll, but no record of their arrival or location existed. Sometimes a search of Lojwa, Runit, and Enewetak Islands permitted identification and location of critical items. Sometimes a method was found to continue without them. For example, the troops fabricated window hinges from beer cans until the real articles could be found. Most hardware and lumber were plentiful, but plumbing and some electrical items were in extremely short supply due to demands in the Eastern United States following an unusually cold winter. The pipe shortage delayed placing of some concrete slabs which were to contain sewer pipes, until the troops devised a means of working around the problem. These shortages also delayed completion of water, sewage, and electrical systems to service critical facilities, such as the mess hall and latrines.

FIGURE 3-7. LOJWA CAMP.

FIGURE 3-8. LOJWA BUILDING CONSTRUCTION.

FIGURE 3-9. LOJWA INDUSTRIAL AREA.

The coral rock, high humidity, and heat at Enewetak caused construction problems which had to be overcome. For example, the first concrete placed at Lojwa set up so quickly that the crew could not work it out to a smooth surface. They learned that a vapor barrier was required to reduce the loss of water into the crushed coral surface which, when combined with the temperature of the mix (80° F), caused it to set too quickly.

To expedite Lojwa Camp construction, all common framing and trusses were prefabricated at Enewetak Camp. Despite difficulties in transporting the larger sections to Lojwa, the procedure was generally successful. As construction continued toward completion, the troops gained valuable on-the-job training and experience.[54]

MILITARY SEALIFT COMMAND SUPPORT BEGINS: 31 MAY 1977

MSC support of the Enewetak Radiological Cleanup Project began with the sailing of the American Racer from the Military Ocean Terminal, Bay Area, Oakland, California, on 14 May 1977. The ship was delayed for repairs at Pearl Harbor and arrived at Enewetak on 4 June 1977.[55] It carried 7,423 measurement tons of supplies and equipment, including

1,578 measurement tons of Army rolling stock (vehicles, vans, and construction equipment).

There was concern that expertise was not available on Enewetak to offload the American Racer; therefore, an Army stevedore team from Fort Eustis was provided to assist offloading the ship into landing craft. However, since the team's previous experience was limited to offloading ships alongside cargo piers, its value to the Enewetak operation was limited. Fortunately, H&N-PTD's riggers and stevedores were well experienced. They operated the ship's winches when it developed that the ship's crews could not, and they took charge of the more hazardous and complex tasks. Because of this experience, the Fort Eustis team was not requested for subsequent offloading operations.

Lightering was accomplished with landing craft operated by the U.S. Navy Element (USNE), whose Officer-in-Charge, Lieutenant Commander J. E. Hopkins, USN, arrived on 7 June 1977 with 18 additional maintenance and operations personnel.[56] Everyone on atoll who could be spared from other duties, including 40 men of the USAE, was employed in offloading and storing the cargo. It still required 8 days to complete offloading the ship.[57] It took even longer to put some of the cargo into operation. Most of the new vehicles arrived in mothballed condition. Although many critical items still had not arrived, enough equipment and supplies had been received that the USAE could increase its camp construction force on Lojwa from two to four platoons.[58]

D-DAY, 15 JUNE 1977

The day prior to D-Day was marked by the arrival of the USAE Commander, Lieutenant Colonel Lee W. Tucker, USA; the interim U.S. Air Force Element Commander, Major H. Rumzrek, USAF; 50 more construction troops; and nine more Air Force support personnel. They were welcomed by Director, DNA, Vice Admiral Robert R. Monroe, USN, and Commander, Field Command, BG Lacy, who had arrived the previous day accompanied by Mr. Roger Ray, of ERDA-NV, and Mr. Earl Gilmore and Mr. Frank Drake, of H&N, (Figure 3-10).

D-Day arrivals increased the atoll population from 336 to 394. Following the D-Day ceremony, the Director and his party departed for Johnston Atoll for an inspection visit. The following day, seven members of the news media arrived to cover mobilization activities. Additional troop arrivals by 17 June 1977 increased the atoll population to 536.[59]

Among the D-Day arrivals were Staff Sergeant Charles H. Freeman, USA, and his laundry team from the 613th Field Service Company at Fort McClellan, Alabama. They used the washers and dryers ordered for self-

FIGURE 3-10. D-DAY ARRIVALS.

service laundromats until the industrial laundry equipment arrived. Under a sign reading "Freeman's Inc. Free Laundry," they began providing laundry service on 17 June 1977. The initial team not only did the organizational clothing and linens for which they were responsible but provided individual laundry service for other cleanup project personnel, washing, drying, and folding some 800 bundles of laundry per month (Figure 3-11).

ORGANIZING THE JOINT TASK GROUP: JUNE 1977

Upon the arrival of the Military Service Element commanders, COL Mixan began organizing the JTG to accomplish its mission (Figure 3-12). His efforts were greatly complicated by the Joint Staff decision (in the CONPLAN) to give Commander, JTG "supervisory authority" rather than command authority over the Military Service Elements.[60] The effect of this decision was to exclude the CJTG from the chain of command of the three Military Service Elements assigned to accomplish and support the cleanup project. He assigned missions and tasks, but had only limited ability to control the timing or manner of their execution. Most of the Service Element commanders, as well as the JTG commanders, found supervisory authority to be a poor substitute for command authority.[61,62,63,64,65]

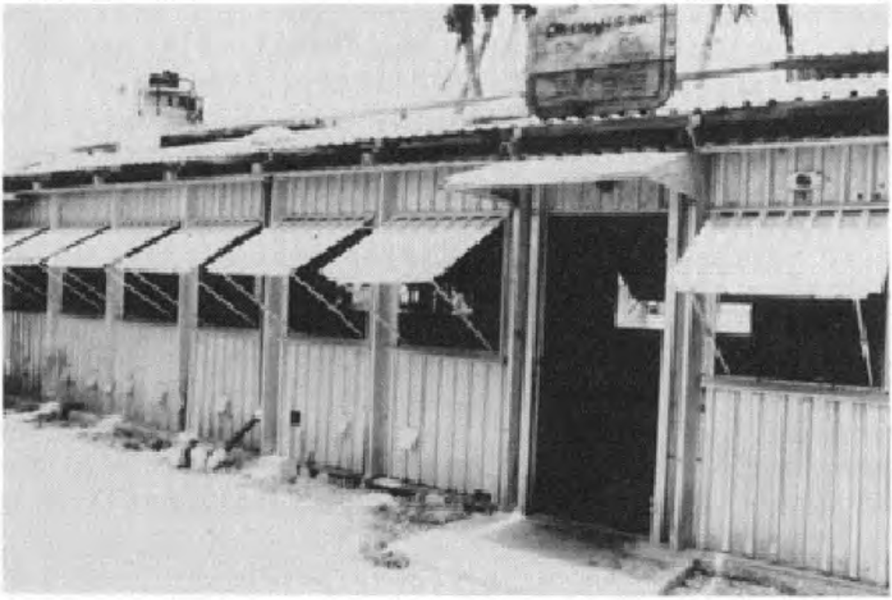


FIGURE 3-11. FREEMAN'S, INC. FREE LAUNDRY.

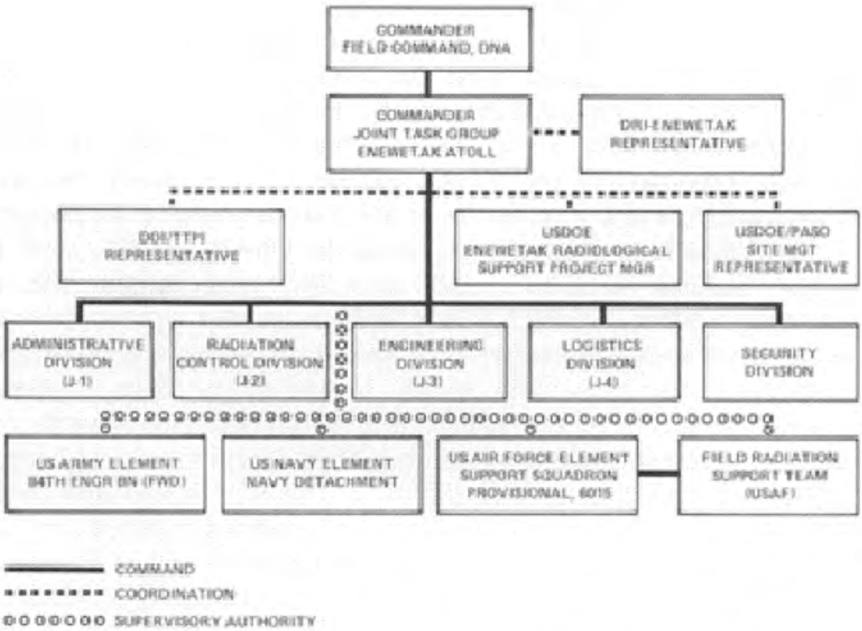


FIGURE 3-12. JOINT TASK GROUP ORGANIZATION.

The absence of a clear line of command authority was partially overcome by the professionalism and common sense of most of the key officers assigned during the project. One of the principal points of friction regarding command authority was the relationship between the JTG staff officers and the officers of the Service Elements. Often the responsibilities for planning the cleanup operations overlapped. Priorities for accomplishing tasks were subject to differing interpretations. Differences included resource utilization and availability, logistics support, time lags for off-atoll procurement, resupply means and scheduling, weather, emergency situations, and other considerations which were perceived differently in terms of their potential impact on mission accomplishment. In actuality, to complete the project successfully the Director, DNA, the Commander, Field Command, and the CJTG assumed command authority they did not have, and the Service Elements acquiesced in this assumption of authority in a cooperative spirit, recognizing that it was essential to effective operation.[66,67,68]

One area of particular concern to Field Command and all three JTG commanders was the lack of a senior Army Element command echelon at Lojwa. The majority of the Army cleanup forces were located on Lojwa, yet the Army Element command base was on Enewetak Island. The USAE commanders shared this concern to some degree, and studied numerous alternatives to alleviate the situation. Solutions considered included moving the majority of the USAE headquarters and the commander to Lojwa, moving the S3 operations office there (except for an Operations Liaison Officer to coordinate with the JTG staff), putting the USAE Executive Officer at Lojwa, and developing another command cell utilizing additional personnel from higher headquarters. At one point, the USAE Commander proposed to the CJTG that he move virtually the entire USAE headquarters to Lojwa, but after full consideration of the impact on the daily coordination requirements among the USAE, the JTG staff, and the other Service Elements and agencies, this option was not implemented. After detailed consideration of the advantages and disadvantages of each alternative, the USAE commander believed mission accomplishment would be best served by the senior Army Company Commander on Lojwa also serving as the Lojwa base commander.

The organization problem was aggravated by the manner in which the JTG staff was mobilized over a period of months. It was activated too late to work together as a team to formulate policies, procedures, and instructions prior to the arrival of the Service Elements and other agencies reporting for duty on the atoll. There was a need for rapid development and publication of local policies. Had this been accomplished prior to deployment to the atoll, the Service Elements and personnel would have entered an environment which was well organized relative to specific guidelines and procedures, and control would have been established more readily.[69]

A significant organizational shortcoming during the first year was the lack of a JTG deputy commander/chief of staff to relieve the commander of administrative burdens. With much of the work either incomplete in definition or in an experimental phase, the CJTG had to devote his time and efforts to the operational mission. Eventually, this need was recognized, and a lieutenant colonel position was established, although too late for the initial year of the project.[70]

Despite these and other organizational shortcomings and command and control problems, the on-atoll organizational structure for the cleanup forces proved to be workable and effective. It resulted in highly successful accomplishment of the complex mission, on time and within budget.

FIELD RADIATION SUPPORT TEAM DEPLOYMENT: 28 JUNE 1977

The Field Radiation Support Team (FRST) was formed on 19 June 1977 at Hickam AFB. FRST personnel were given a 4-day basic radiological indoctrination course at the 25th Infantry Chemical-Biological-Radiological School, Schofield Barracks, Hawaii. Initial FRST personnel deployed to the atoll on 28 June 1977, where they began a 3-week specialized training course in local radiological hazards, the method of cleanup operations, and the instrumentation peculiar to their Enewetak mission. Experience showed that the 4-day basic indoctrination course in Hawaii was unnecessary and, after January 1978, all Enewetak-related training for replacement FRST personnel was accomplished on atoll.

The on-atoll specialized FRST training for the first increment was interrupted for an urgent on-site investigation of a suspected radiological burial site near the Erie shot ground zero on south Runit. This investigation, described in Chapter 4, diverted some FRST members from training classes to on-site work. By the time the investigation was completed, other operations had progressed to the point where the initial FRST increment received most of its specialized training by field testing the equipment and procedures the radiological planners had devised for the cleanup project, rather than by classroom training.[71]

Most of the radiation safety and detection equipment obtained for the cleanup was state-of-the-art commercial equipment. The radiation detection equipment was chosen because the one electronics package could be used to measure alpha, beta, or gamma simply by attaching the appropriate probe and adjusting the high voltage setting. The commercial protective masks were chosen to comply with Occupational Safety and Health Administration's requirements for field of view for heavy equipment operators, and because the face plates were set out from the face to provide more air circulation within the mask and hence greater wearer comfort, an important factor in the tropical climate. M17 standard military masks were not used because of possible plutonium migration through the filter cartridges and the tight facial contact. The anti-contamination suits chosen were light-weight and cotton, thus providing protection with minimal discomfort. None of these items had been used by troops in a tropical atoll environment, but they were well tested and proved excellent choices at Enewetak.[72]

ENEWETAK RADIOLOGICAL SUPPORT PROJECT DEPLOYMENT: 28 JUNE 1977

ERDA-NV office provided two distinctly different types of support to the Enewetak Radiological Cleanup Project:

a. Base operations and maintenance support were furnished through ERDA-PASO, directed by Mr. Stanley, and through H&N-PTD, whose General Manager was Mr. Donald J. Brush. The ERDA-PASO Site Representative position at Enewetak was manned by personnel from their Hickam AFB office on a rotational, temporary-duty basis.
b. Radiological support for the cleanup project was managed by ERDA-NV as a project; i.e., the Enewetak Radiological Support Project (ERSP). The ERSP Project Manager was Mr. Roger Ray, then Assistant Manager for Environment and Safety, ERDA-NV. ERSP was organized as shown in Figure 3-13. Staff support was furnished by ERDA-NV and ERDA-PASO as required. On-site operations were directed by the Project Manager or, in his absence, one of the Deputy Project Managers serving on rotational assignments. They were assisted from time to time by technical representatives from the ERDA-NV office.

Three ERDA-NV contractors were assigned to the ERSP project:

a. EG&G, Inc. equipped, maintained, and operated van-mounted radiation detection measurement and data recording systems. EG&G also performed the reduction, analysis, and interpretation of data from these systems.
b. Eberline Instrument Corporation (EIC) equipped, maintained, and operated field analytical and instrument calibration laboratories.
c. Desert Research Institute (DRI) assisted in the on-site interpretation and mapping of data collected by EG&G. DRI also provided advice as to sampling areas and arrays as requested by the Project Manager.[73]

To comply with Congressional direction, enlisted specialists from the Navy and Air Force were assigned to maintain radiological equipment and to assist in the laboratory and in field survey work.

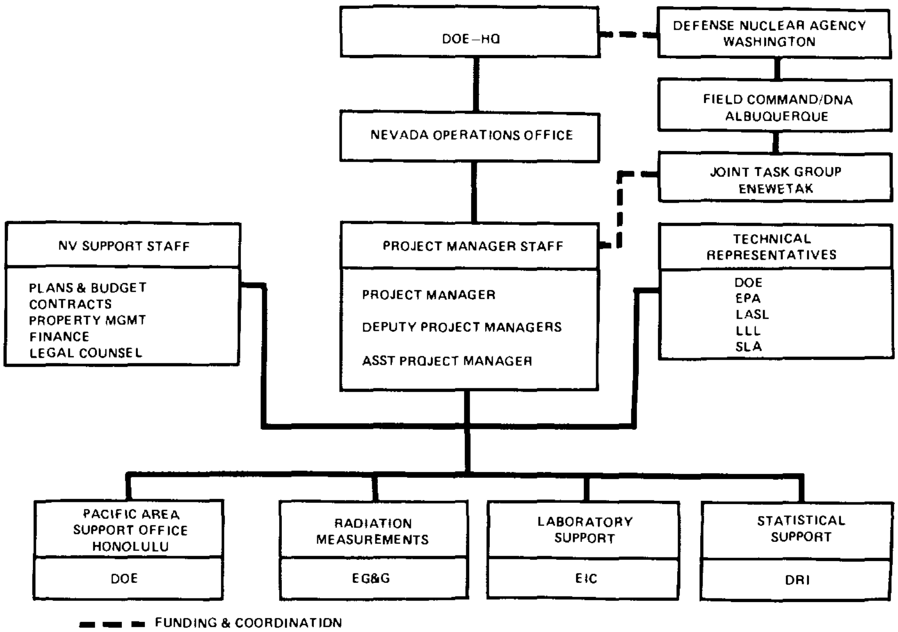


FIGURE 3-13. DOE-ERSP ORGANIZATION.

On 21 June 1977, Mr. Albert E. Doles, of EIC, and two Navy and two Air Force enlisted men deployed to the atoll and began establishing a temporary laboratory facility at Enewetak Camp. Its initial capability was limited to counting alpha, beta, and gamma radiation in soil and air sampler filters, pending delivery of the laboratory's trailers (Figure 3-14). On 27 June 1977, three Air Force Precision Measurement Equipment Laboratory maintenance technicians arrived, established their shop, and began calibrating the instruments.[74]

On 1 July 1977, the first in situ van (IMP) (Figure 3-15) arrived by air. Inspection revealed a leak in the container of liquid nitrogen required to cool the van's germanium detector. The liquid nitrogen plants which Field Command had obtained from the Air Force had not yet arrived. A Dewar flask of liquid nitrogen was flown from Hawaii and, on 15 July 1977, the IMP was in operation on Enjebi.[75]

The first DRI statistician, Ms. Madaline Barnes, arrived at the atoll on 12 July 1977. The laboratory trailers arrived on 25 July 1977. Two more EIC employees and the rest of the Navy and Air Force personnel arrived the following week and began putting the trailers in order. The Radiation Laboratory was operational on 24 August 1977, although construction on some of its major facilities continued until 18 October 1977.[76]

FIGURE 3-14. TEMPORARY RADIOLOGICAL LABORATORY.

FIGURE 3-15. IN SITU VAN (IMP).

SOUTH RUNIT MOBILIZATION: JUNE-JULY 1977

Since containment of contaminated soil and debris was to be accomplished on northern Runit, certain basic facilities were to be established on the uncontaminated southern end of the island to support that operation. Preliminary design concepts for construction of crater containment support facilities at the Runit work site were developed by personnel of an Army Engineer Brigade at the Second Enewetak Planning Conference. The equipment specifications assumed that new commercial equipment would be procured with MILCON funds, despite Congressional and DOD direction to make use of existing DOD equipment. Identification and location of suitable substitutes in DOD equipment pools required an exhaustive effort by Field Command engineers and logisticians and by Headquarters DNA supply personnel. Much of the needed equipment was found in Navy inventories. Not all of the substitutes were fully satisfactory when put into operation; however, most of the Runit crater containment operation was performed with existing DOD equipment, despite significant maintenance and operational problems, described in Chapter 8.

Construction of facilities on south Runit was severely constrained until it could be determined if there was a contaminated burial site near the Erie ground zero, and until the south end of the island could be declared radiologically clean. Until this was accomplished, troops erecting the administrative building were required to wear full-face masks, suits, gloves, and rubber boots. Despite the 90-degree heat and the discomfort of wearing anticontamination gear, the crew had completely framed and roofed the structure before the area was declared safe and the restrictions were lifted on 15 July 1977 (Figure 3-16).[77,78] Meanwhile, a decontamination building, latrine, and concrete slabs for a boat ramp had been prefabricated at Enewetak Camp for installation on south Runit.[79] Much of the aggregate for Runit site construction was hauled from the stockpile at Enjebi. As in the case of Lojwa, Runit construction was significantly slowed by lack of certain critical building materials.

MOBILIZATION CONTINUES: JULY-NOVEMBER 1977

Building materials which arrived at the ports of embarkation after the American Racer sailed were delivered by a special COMNAVSURFPAC sealift consisting of the USS POINT DEFIANCE and USS FREDERICK. The ships called at Oakland, California, for that cargo, after loading landing craft and other Navy cargo at San Diego and demolition material at Seal Beach, California. More equipment and supplies were loaded at Pearl

FIGURE 3-16. RUNIT FACILITIES.

Harbor, Hawaii. The two ships arrived at Enewetak on 25 July 1977 to deliver 7,650 measurement tons of cargo which included four landing craft (two LCM-3s and two LCM-6s), one personnel boat (landing craft, vehicle, personnel-LCVP), the radiation laboratory trailers, two liquid nitrogen plants, vehicles, construction equipment, and other equipment and supplies.[80] The major role played by these no-cost sealifts, and the full cooperation of the Navy in providing them, bears mention again.

The MSC awarded Dillingham Tug and Barge Corporation the contract for bimonthly shallow-draft barge service between Pearl Harbor, Johnston Atoll, and Enewetak Atoll. The first shallow-draft barge, which arrived on 23 August 1977 (Figure 3-17), carried 3,448 measurement tons of Army, exchange, and Field Command cargo from Oakland, and 647 measurement tons of Field Command cargo from Pearl Harbor. The only deck space left was that required for access to the reefer vans.[81] Even so, many critical items had not been received in time for shipment on the barge or the special Navy sealift. It was time to review the status of undelivered orders and the cargo available for the next Navy sealift.[82]

Supply and transportation representatives of the agencies involved in the cleanup project met at Headquarters MTMCWA in Oakland, California, on 27-28 July 1977 to identify and resolve problems associated with marshalling the remaining undelivered Army equipment and shipping it to Enewetak. Approximately 9,000 measurement tons of rolling

FIGURE 3-17. SHALLOW-DRAFT BARGE.

stock and outsize cargo were ready for release by the depots. The U.S. Army Material Development and Readiness Command Logistics Control Activity took action to have it shipped to San Diego in a roll-on/roll-off configuration to facilitate loading and offloading. Also, Army and Field Command cargo in Oakland was to be transshipped to San Diego to be loaded on the September 1977 Navy sealift. Unresolved was a required delivery date on atoll for the four Army LARCs waiting at Rough and Ready Depot, California, for movement down the Sacramento River and onward to Enewetak. Field Command agreed to resolve the matter before the next major conference in mid-August 1977.[83]

The Armed Forces Radio and Television Service stations at Enewetak Camp and Lojwa Camp were installed in late July and early August 1977 by technicians from the Television-Audio Support Activity of the U.S. Army Electronics Command, Sacramento Army Depot, California. The system provided for broadcast of video tapes and FM radio (Figure 3-18). The Enewetak Camp video station began broadcasting on 11 August 1977, and the Lojwa Camp station went on the air a few days later.

On 29 July 1977, Brigadier General Grayson D. Tate, USA, replaced BG Lacy as Commander, Field Command, DNA. Later that week, Colonel Charles J. Treat, USA, reported for duty with Field Command's Logistics Directorate, and became the Special Assistant for Enewetak Operations. His addition to the management staff was to prove of inestimable value.

FIGURE 3-18. ARMED FORCES RADIO & TELEVISION STATION.

On 12 August 1977, representatives to the logistics-comptroller conference from the JTG and the 84th Engineer Battalion arrived early to brief BG Tate and the Field Command staff on the current status of mobilization, critical problem areas, and conceptual plans for cleanup operations. After these briefings, BG Tate and COL Treat attended a 2-day conference in Las Vegas, Nevada, on radiological cleanup criteria. They returned to Albuquerque in time to participate in most of the Logistics-Comptroller conference on 17-18 August 1977.[84]

The August 1977 conference at Field Command was called to review mobilization progress to date, and to coordinate actions to complete mobilization and to support the beginning of cleanup operations. The engineer battalion representative estimated that, due to shortages of material to complete life-support systems, the Lojwa Camp construction was 60 days behind schedule for the planned beneficial occupancy on 15 November 1977—the date scheduled for transition from the Mobilization Phase to the Cleanup Phase of the Enewetak Project. A similar problem was developing in the construction of the south Runit site. The engineer predicted that, if the critical supplies were airlifted and if additional construction troops were provided, beneficial occupancy could be achieved by 1-15 January 1978. DNA initiated action during the conference to airlift almost 50,000 pounds of critical material from Travis AFB, California.

Plans for brush clearing, soil and debris cleanup, and crater containment were reviewed, and equipment requirements were adjusted based on recent operations experience. Requirements were cancelled for 49 items, some of which had already arrived on atoll and had to be shipped back to the United States, and 14 new items were added by the engineers.

It appeared that manpower would have to be adjusted also. The construction engineers were due to be replaced by combat engineer cleanup forces on 15 November 1977. The construction engineers could be retained until their 179-day TDY limitation expired in December 1977; however, if the combat engineers' arrival was delayed an equal time, that would have delayed the start of cleanup. It was decided to retain some individuals in the construction forces having critical skills and to change the mix of the replacement forces arriving 15 November 1977. In addition to the four combat platoons scheduled to begin soil and debris cleanup and the two platoons scheduled for Runit site construction and operations, one extra construction platoon would be deployed. Some of the combat platoons would be used to assist in completing construction, while the others would begin cleanup operations. The engineers predicted that, if the additional construction platoons were not provided, beneficial occupancy would be delayed until mid-February 1978.[85]

Based on arrangements made at the logistics conference, COMNAVSURFPAC ships picked up cargo from the Military Ocean Terminal, Bay Area and delivered it to San Diego for later shipment by Navy amphibious ships to Enewetak Atoll. Two LARCs, which had been towed down the Sacramento River from Rough and Ready Depot, and several thousand measurement tons of other cargo were moved by the USS OGDEN on 18 August 1977.[86] Two weeks later, two more LARCs and additional cargo were delivered to San Diego by the USS MOUNT VERNON (Figure 3-19).

On Enewetak Island, the first fatality of the cleanup project occurred on 19 August 1977. Hull Technician Victor J. Priest, USN, was welding on the bow ramp of a landing craft when preservative in the void area inside the ramp exploded, ripping a 6-foot hole in the ramp and killing him. The accident was investigated by Commander, Amphibious Group Eastern Pacific. Memorial services at the base chapel the following Sunday were attended by over 200 military and civilian personnel, including Iroij Johannes Peter and many of the dri-Enewetak.[87,88]

On 29 August 1977, the USS BOLSTER delivered a YC barge and two smaller barges from Pearl Harbor for use in intra-atoll transportation. The JTG Logistics Officer took advantage of the ocean transport by having the YC barge loaded with over 100 measurement tons of cargo from Kwajalein Missile Range.[89]

FIGURE 3-19. ARMY AMPHIBIOUS LIGHTER (LARC).

On 13 September 1977, a detachment from Underwater Demolition Team Eleven, commanded by Lieutenant Commander J. F. Sandoz, USN, arrived to begin channel clearance and underwater demolition work (described in the next chapter). In addition, this team supervised the storage, in an explosives bunker on Medren, of 181 measurement tons of explosives delivered by the Navy ammunition ship, USS HALEAKOS, on 22 September 1977.[90,91]

On 28 September 1977, a Navy task group consisting of the USS MOUNT VERNON, USS MOBILE, and USS DENVER arrived at Enewetak to deliver 6,617 measurement tons of cargo, including two LARCs. Despite heavy afternoon rains, they were offloaded in 14 hours.

The second shallow-draft barge arrived on 2 October 1977 with subsistence, cement, attapulgite, and other supplies.[92] The USS MOLALA arrived on 3 October 1977 and delivered another YC barge.[93]

On 12 October 1977, the Navy Water-Beach Cleanup Team arrived at the atoll and set up a base of operations in Building 4 near the other Navy activities. The team consisted of one officer and 15 enlisted personnel from Harbor Clearance Units One and Two; and one officer and three enlisted personnel from Team 21, Explosive Ordnance Disposal Mobile Unit One.[94]

On 21 October 1977, the USS FORT FISHER delivered 3,161 measurement tons of cargo, including two more Army LARCs. The last

Navy task group during the Mobilization Phase arrived on 3 November 1977. The USS JUNEAU and USS ALAMO arrived from Okinawa and offloaded two LCUs, and three LCM-8s.[95] During the Mobilization Phase, these Navy opportune sealifts delivered over 29,600 measurement tons of cargo at no cost to the project, a savings in sealift costs of well over $1,600,000.

The delivery of on-atoll critical building supplies, and the use of H&N-PTD journeymen to complete some utility systems and other critical facilities significantly improved the status of Lojwa Camp construction By mid-October, USASCH was able to report that they were slightly ahead of the original construction schedule. The camp's 420,000-gallon steel water tank was on hand and was being assembled. In the process, Private First Class Kelvin W. Tea, USA, placed over 15,000 bolts, one of the more formidable tasks in Lojwa Camp construction. Completion of the fresh water and salt water distribution systems was still being delayed by a nationwide shortage of pipe. Consequently, food service, shower, latrine, and sewer facilities would not be completed by the scheduled 15 November 1977 mobilization completion date.[96]

PERMITS: 1975 - 1977

In addition to delays in camp construction, extended delays were encountered in obtaining three Corps of Engineers' permits for the project. There was some doubt that permits were necessary, since the Environmental Impact Statement documented the concurrence of those concerned with the cleanup project actions to be covered by the three proposed permits. Nevertheless, DNA decided to obtain them and, in October 1975, POD agreed to expedite action to provide permits for: (1) disposal of noncontaminated debris in the lagoon; (2) clearance (by coral demolition) of channels into certain islands; and (3) crater containment of contaminated soil and debris. POD's costs in providing permits would be financed from cleanup design funds already allocated.[97] It turned out to be more than a simple paper transaction.

The U.S. Fish and Wildlife Service, in their action on the permits, requested that DNA meet several conditions, including revegetation of cleared areas; replacement of soil removed in excising plutonium concentrations on Runit; avoidance of seabird nesting grounds during the nesting season; periodic radiation sampling in terrestrial and aquatic resources; and semiannual reports to the Fish and Wildlife Service on radiation found within fish and wildlife.[98] Field Command advised that the Environmental Impact Statement covered all of the conditions except the semiannual sampling and reporting of radiation in fish and wildlife, and Field Command objected to this condition on numerous grounds.[99]

In formulating the crater containment permit, a standard provision was included by the Corps of Engineers which would have required DNA to maintain the structure in good condition indefinitely. (The general rationale for this position was: Cactus Crater presently exists on the northern end of Runit Island; Cactus Crater extends below the water table, thus it is filled with water; since Cactus Crater is filled with water, even though it is located partially on the reef, the probability exists for migration of its water to and from the lagoon due to tidal action, thereby making it subject to the laws governing the introduction of materials into navigable waterways; a plan to fill Cactus Crater with a concrete slurry mixture equates to building a structure on a navigable waterway; the standard provision requires that anyone building a structure on a navigable waterway must commit themselves in writing to perpetual maintenance of the structure.) DNA objected to this provision as being inappropriate and pointed out that it was directly contrary to all U.S. commitments, directly contrary to the national-level decisions made after 3 years of debate, and in violation of Congressional guidance. Agreement was reached eventually that DNA would maintain the structure until the project was complete, and thereafter would assure that periodic monitoring of the site was accomplished by some Federal agency until the United States terminated its trusteeship responsibilities.[100]

Resolution of all these issues took an inordinate amount of time, and it began to appear that either the permits would have to be ignored or the absence of permits was going to halt work on the project. The channel clearance permit was finally issued on 31 August 1977, 2 weeks before blasting began.[101] The lagoon disposal permit was issued on 3 November 1977.[102] The crater containment permit was not issued until 9 November 1977, the week before the Mobilization Phase officially ended and the Cleanup Phase began.[103]

OPERATION SWITCH I: NOVEMBER 1977

Most military personnel were replaced after serving 4-6 months TDY at Enewetak. Replacement of the personnel who arrived in May and June 1977 began in October 1977, and the turnover in November was near-total. Over 400 personnel were replaced in that month in an exchange termed Operation Switch. It required extensive planning and close coordination by the JTG, the Service Elements, and Field Command's Pacific Support Office, which scheduled the airlift and coordinated Operation Switch actions in Honolulu.

Operation Switch also created increased demands for billeting at Enewetak Atoll. Building 686 on Enewetak was pressed into service as overflow billets, and incoming personnel who were scheduled to work in the north were sent promptly to Lojwa Camp. There were some problems in retaining necessary skills to assure continuous operational capability during the exchange—and, as was obvious, the loss of experience, continuity, and working relationships was staggering. In general, however, Operation Switch I was very successfully executed.[104]

MOBILIZATION/CLEANUP OVERLAP

Although 15 November 1977 was identified, for scheduling and record purposes, as the end of the Mobilization Phase and the beginning of the Cleanup Phase, in practice, mobilization and cleanup efforts overlapped by several months. Some cleanup operations began long before 15 November 1977, and some mobilization efforts were not completed until much later.

During the first week of December 1977, seven navigational aids were installed by personnel of the U.S. Coast Guard Enewetak LORAN Station, with technical guidance by Mr. Steve Guishikuma of the 14th Coast Guard District, and with boat support by the USNE. Navigational lights were installed at the Enewetak personnel pier, on the derelict concrete ship off Japtan, on the Point Oscar survey platform, on the east end of Biken (Leroy) Island, and on the landing ramps at Runit, Lojwa, and Enjebi.[105,106] These aids significantly increased the safety of boat operations at dawn and dusk, and for any emergency boat operations required during the hours of darkness.

As was previously noted, Lojwa camp construction was seriously behind schedule, and CJTG was urging that work be accelerated to provide beneficial occupancy as scheduled by 15 November 1977. Through many well-conceived and well-directed actions, this was achieved, although some facilities were incomplete. The power plant, distillation plant, billets, and most other major facilities were complete; however, the dining hall was not used until 25 December 1977, when the first meal served was Christmas dinner. Burnout latrines and water trailers were used until planned facilities were finished.[107] Temporary water lines and other makeshift facilities were gradually replaced, some as late as February 1978, as camp construction phased into camp maintenance (Figure 3-20).

Through superb teamwork as well as many outstanding individual efforts, mobilization for the Enewetak Radiological Cleanup Project was a success. By 15 November 1977, the base camps were ready to support the cleanup forces. The equipment to locate, remove, and dispose of contaminated material was on hand, and the forces were deployed and ready to begin cleanup operations.

FIGURE 3-20. COMPLETED LOJWA BASE CAMP.

CHAPTER 4

RADIATION SAFETY AND CLEANUP PREPARATIONS

NONCONTAMINATED SCRAP REMOVAL BY CONTRACTOR

Most of the noncontaminated material to be removed during the cleanup project was located on the three islands designated for residence: Japtan (David), Medren (Elmer), and Enewetak (Fred). This material consisted primarily of buildings and equipment acquired by the base support contractor during the nuclear test period. The Defense Logistics Agency agreed to have its Defense Property Disposal Service (DPDS) conduct a sale of this material and return a proportionate amount of any proceeds to the base support contract.[1] The scrap was monitored by Field Command, DNA to assure that it was free of radioactive contamination, marked for identification to bidders, and then transferred to DPDS. The invitation for bid was issued in November 1976[2] and, on 11 January 1977, 24 prospective bidders were flown to Enewetak for on-site inspections.[3] Sixteen bids were received, the successful one being $544,000. To minimize interference with the early returnees' settlement of Japtan, scrap removal was to be complete on that island by 4 May 1977. Scrap removal on the remaining islands was to be complete by 30 November 1977 to minimize interference with Joint Task Group (JTG) cleanup operations.[4]

The contractor began work in March 1977 and, after several extensions due to unforeseen circumstances, completed his operations on 11 September 1978. Within 18 months, with a work force of approximately 20 people working 10 hours per day, 7 days per week, and with government logistics and intra-atoll transportation support, the contractor removed most of the excess buildings, salvage material, and scrap from the three residential islands. The material removed amounted to well over 55,000 cubic yards, weighing in excess of 38,000 long tons.[5] It was estimated that the scrap removal operation reduced the noncontaminated cleanup effort for the JTG by 117,971 man-hours.[6] While the salvage contractor was starting cleanup operations on the southern islands and the base camps on Enewetak Island and Lojwa (Ursula) were being readied, radiological survey work began in the northern islands.

GROSS AERIAL SURVEY

OPLAN 600-77 called for the use of an Army helicopter to carry an Energy Research and Development Administration (ERDA) contractor's

(EG&G) Radiation and Environmental Data Acquisition and Recorder (REDAR) system over the islands to perform a gross radiological survey before field surveys with the in situ vans began. The system was designed to detect and record surface radiation from americium-241 (Am-241). It was believed that a REDAR survey might facilitate the in situ survey and possibly reduce the areas to be surveyed by the vans. The REDAR was installed on a UH-1 helicopter during the week of 20 June 1977. Transponders were set up on Enewetak and Biken (Leroy) Islands, and the system was checked out.[7]

Survey flights were conducted during the next 2 weeks. Several passes were required to survey the larger islands. A total of 35.6 hours were flown for the survey before it was completed on 8 July 1977.[8] The survey was largely unsuccessful as REDAR did not have the sensitivity necessary to refine areas for in situ soil surveys. It was also thwarted by heavy vegetation covering large parts of many islands. Consequently, it was of little benefit in improving the 1973 radiological survey data.

ERIE SITE SURVEY

Runit (Yvonne) was the last island scheduled for contaminated soil survey and cleanup. The northern end of the island, which had been contaminated by many nuclear detonations, was to be used for contaminated soil and debris stockpiles and crater containment operations. The southern end of the island, which was to be used for the quarry, rock crusher, and other support activities, was radiologically nonhazardous, with one possible exception.

In May 1956, a nuclear device, Erie, had been detonated from a 300-foot tower near the ocean beach just north of the runway on the southern end of Runit. Experimental specimens had been scattered west of the tower at distances of 120 to 300 feet. In order to find the specimens, the soil in that area had been removed to depths up to 5 feet and deposited to the north in thin layers. The depression was later backfilled but pertinent reports did not indicate what had happened to the debris produced by the detonation. A 1958 drawing showed an area of contaminated rubble some 200 feet wide from the Erie ground zero (GZ) to the ocean beach. By 1977, much of this land area had eroded away and contaminated debris was scattered on the beach. The 1973 radiological survey by the Atomic Energy Commission (AEC) listed a suspected contaminated debris burial site in the vicinity of the Erie GZ. This suspicion had to be resolved before work could begin to locate the rock crushing facility in the area.[9]

A special team was deployed on 30 June 1977 to investigate the Erie Site. It consisted of two radiological specialists from Field Command, two men from U.S. Army Armaments Research and Development Command with magnetometers to help locate buried debris, a U.S. Army Element (USAE) survey team and backhoe operators, plus 16 members of the newly arrived Field Radiation Support Team (FRST). The survey team located the GZ and established five radials from it with stakes placed at 50-foot intervals. A backhoe was used to dig a trench beside each stake to obtain soil samples and locate any buried debris. Trenches were dug as deep as 6 feet depending on levels of coral rock and ground water. Each trench was checked with an SPA-2 micro-R meter for evidence of contaminated debris. Soil samples were taken from the sides of the trenches at 1-foot intervals (Figure 4-1) and were analyzed by Eberline Instrument Corporation (EIC) in their laboratory at Enewetak Camp.

Stringent radiological safety measures were established for the survey. A hot line was established near the personnel pier. Air samplers were positioned downwind of all earth-moving operations. During the engineer survey phase, all personnel crossing the hot line wore rubber boots and double surgical masks. During the trenching/soil sampling phase, all personnel in the area wore boots, anti-contamination (anti-C) coveralls, gloves, full-face respirators and hoods, with tape over all openings where dust might enter. Due to heat stress and discomfort produced primarily by the respirator, personnel were able to work only approximately 2 hours in the morning and 2 hours in the afternoon. After a few days' operations, it was noted that personnel were not fully recovering from the previous day's fatigue. Thereafter, workers in full anti-C suits were given hourly breaks. Temperature readings of over 90°F were commonplace as early as 1000 hours. Because of the heat, two FRST members were removed from the survey before it was completed on 11 July 1977.

The survey effort disclosed that there was no contaminated burial site at Erie GZ. The average surface and 1-foot depth activity was 24 picocuries per gram (pCi/g), well below the 40 pCi/g guideline for any surface soil cleanup action. Some subsurface hot spots of 150 to 282 pCi/g, well below the then current 400 pCi/g guidelines for required cleanup, were found. These were roped off during Runit site construction. Concurrent with the survey, contaminated debris found south of the permanent hot line was collected and stockpiled north of that line by USAE personnel working in full anti-C suits.[10,11]

The Erie site survey provided a valuable field test of radiological control and safety measures and equipment. By participating in the survey, Field Command's radiological planners, Dr. Edward T. Bramlitt and Lieutenant Colonel Manuel L. Sanches, USA, and the JTG Radiological Control Division staff, were able to observe and experience directly the application of their plans. This permitted further refinement of the radiological control and safety procedures which were to be used for the project.

FIGURE 4-1. ERIE SITE INVESTIGATION.

RADIOLOGICAL ENVIRONMENT

The nuclear testing at Enewetak Atoll dispersed radioactive materials in varying quantities over most of the northern islands. The decay of these materials produces ionizing radiation in the forms of alpba and beta particles and gamma rays. As a result of the Enewetak Radiological Survey of 1973 and some subsequent field surveys, the residual radioactivity had been quite well characterized with regard to the types of isotopes present, the levels, and the pattern of distribution.

In general, the residual radioactivity could be grouped into three categories, based on its source: (1) unfissioned nuclear fuel—the device material not consumed in fissioning during detonation; (2) fission products—the radioactive elements created when the nuclear fuel fissioned; and (3) induced radioactivity—materials that became radioactive through the capture of neutrons released as a result of the detonation.

The most important of these categories from the standpoint of the cleanup was the unfissioned nuclear fuel. The principal radioisotope was plutonium-239 (Pu-239), which has a half-life (the time required for a given element to lose half of its radioactivity) of approximately 24,000 years. In addition, varying amounts of Pu-238, -240, and -241, along with Am-241, were present. These elements, collectively termed transuranic elements because they are above uranium on the atomic number scale of elements, were spread in forms ranging from microscopic- to centimeter-sized particles. The predominant decay method of transuranics is by emission of alpha particles; however, some beta particles and gamma rays are emitted also. (Indeed, the gamma rays produced from the radiological decay of Am-241 were of particular interest during the cleanup, as described in this chapter and Chapter 7.) While the transuranics constituted little problem in their undisturbed state, they would be a potential hazard once cleanup began.

Although the detonation of fission devices produces hundreds of fission products, the vast majority have very short half-lives and decay very rapidly. Only two fission product elements that had been deposited on the islands remained in sufficient quantity to be of concern. These were strontium-90, which has a half-life of about 27 years and decays by emission of beta particles, and cesium-137 (Cs-137), which has a half-life of about 30 years and decays by emission of both beta particles and gamma rays.

The induced radioisotopes resulted when various elements in the immediate proximities of the GZ captured neutrons that had been released at the instant of detonation. The capture of a neutron by the nucleus of the element creates an unstable condition (i.e., the element becomes radioactive) which ultimately becomes stable again through radioactive decay. The only induced radioactive isotope of significance remaining at the time of cleanup was cobalt-60 (Co-60). Normally, cobalt is found in small quantities in metals such as steel and iron; thus, the Co-60 on the islands was generally associated with the metallic debris. Co-60 decays by emission of energetic gamma rays accompanied by beta particles.

The biological effects of all types of ionizing radiation are similar. However, the probability that damage to the body may occur from radiation varies among the types of ionizing radiation because of the physical characteristics of each form. In addition, the degree of damage that may occur depends upon factors such as the amount of tissue exposed (whole-body versus partial-body), the quality and quantity of radiation received (dose), and the time over which it is received (dose rate).

Alpha particles are relatively large and heavy and thus have a very short range over which they can travel—about 3 cm in air, and fractions of a millimeter in tissue. Thus, they ordinarily do not constitute an external hazard to people because normal clothing and the outer layers of skin prevent the irradiation of any vital internal tissues. However, if alpha-emitting material is deposited within the body in vital tissues (through inhalation, ingestion, or entry into an open wound), the ensuing alpha radiation can cause considerable localized cellular damage (within the organ where located) because all the energy is dissipated over a very short distance. For this reason, alpha-emitting materials such as the transuranic elements are classed as internal hazards.

Beta particles are much smaller than alpha particles. They also can travel over a greater range—tens of centimeters in air and a few millimeters in tissue. Because of this, beta particles can be a moderate external hazard in that the outer layer of skin can be penetrated and living tissues can be exposed, resulting in "beta burns." The burn produced is similar to the burn caused by thermal energy (sun, fire) or chemicals, but it is not accompanied by immediate pain. When deposited internally, beta-emitting materials can also cause damage to the tissue in which they are located. This damage is less localized than that caused by alpha particles because of the greater range over which the energy is dissipated.

Gamma radiation, since it is a wave form with no mass, has great range and is able to penetrate to all tissues of the body. It thus constitutes both an external and internal hazard for the whole body. This is in contrast to alpha and beta particles, which are primarily partial-body or specific organ hazards.

The characterization and extent of the potential problems at Enewetak were well defined, both because of the extensive knowledge and detailed records of the test period and because of the surveys done to characterize the radiological environment. Based upon this understanding of the situation, an extensive radiation protection program was developed. To protect against exposure from alpha and beta radiation, personnel protective equipment was used, personnel monitoring and decontamination procedures were established, and a variety of administrative procedures were formulated. To protect against exposure to gamma radiation, rigorous precautions were taken to assure that the gamma-contaminated areas were well defined, access to them was strictly controlled, and the time any individual could spend in such an area was limited. The radiation protection program and its remarkable effectiveness is discussed in the subsequent sections. No other aspect of the Enewetak radiological cleanup operation received the attention, priority, and detail that the radiation safety (radsafe) program received.

STANDARDS AND GUIDANCE

Army Regulation (AR) 40-14, 20 May 1975, was adopted as the basic standard for personnel radiation exposures at Enewetak. This document implements the guidelines contained in Title 10, Code of Federal Regulations (CFR), Part 20 and Title 29, CFR, Part 1910.[12,13] These basic radiation standards, which were adopted for the Enewetak Cleanup Project, include:

a. The accumulated dose equivalent of radiation to the whole-body, head and trunk, active blood-forming organs, gonads, or lens of the eye will not exceed:
   (1) 1.25 rems in any calendar quarter, nor
   (2) 5 rems in any calendar year.
b. The accumulated dose equivalent of radiation to the skin of the whole-body (other than hands and forearms), cornea of the eye, and bone will not exceed:
   (1) 7.50 rems in any calendar quarter, nor
   (2) 30 rems in any calendar year.
c. The accumulated dose equivalent of radiation to the hands and wrists or the feet and ankles will not exceed:
   (1) 18.75 rems in any calendar quarter, nor
   (2) 75 rems in any 1 calendar year.
d. The accumulated dose equivalent of radiation to the forearms will not exceed:
   (1) 10 rems in any calendar quarter, nor
   (2) 30 rems in any calendar year.
e. The accumulated dose equivalent of radiation to the thyroid, other organs, tissues, and organ system will not exceed:

(1) 5 rems in any calendar quarter, nor
(2) 15 rems in any calendar year.

f. Individuals under 18 years of age, females known to be pregnant, and occasionally exposed individuals will not be exposed to a whole-body dose equivalent of more than:
(1) 2 millirems in any hour, nor
(2) 100 millirems in any 7 consecutive days, nor
(3) 500 millirems in any calendar year, nor
(4) more than 10 percent of the values in b, c, d, and e above, for other areas of the body.

g. Individuals over 18 years of age, but who have not yet reached their 19th birthday, will not be occupationally exposed to ionizing radiation exceeding 1.25 rems dose equivalent to the whole-body in any calendar quarter, nor 3 rems in the 12 consecutive months prior to their 19th birthday.

Basically, AR 40-14 addresses external radiation exposure. It does not provide guidance on concentrations of radionuclides in air. For this, the guidance contained in National Bureau of Standards (NBS) Handbook 69, as implemented through 10CFR20, was established as the Enewetak guideline.[14] However, since these values were calculated assuming a 40-hour work week and since the estimated Enewetak work week was 60 hours, all values were reduced by an appropriate correction factor to reflect the longer potential exposure time.

These standards were maximum limits. With them as a basis, and with the detailed picture of the Enewetak radiation situation as a background, the Radiation Control Division (J-2) staff developed detailed specific procedures for specific operations. This development of standing operating procedures (SOP) proved to be an evolutionary process, as modifications to existing SOPs and new SOPs were written even in the last few months of the project.

The most significant point concerning the above numerical radiation standards is that they were not regarded as allowable dosages. Instead, every aspect of every operation was founded upon the "ALARA" principle—that doses should be kept "As Low As Reasonably Achievable." In fact, actual doses received did not even approach the established standards in any area.

RADIOLOGICAL CONTROL ORGANIZATION

There were basically three levels of on-atoll radiological control administration: (1) the Radiation Protection Officer (RPO); (2) the Radiation Control Committee (RCC); and (3) the FRST.

The RPO is defined by AR 40-14 as "the individual designated by the commander to provide consultation and advice on the degree of hazards associated with ionizing radiation and the effectiveness of measures to control these hazards." The J-2 officer on the JTG staff, an Army colonel or lieutenant colonel (Nuclear Medical Science Officer), was designated as the RPO for Enewetak Atoll. He was assisted by the J-2 staff of radiation specialists.

The RCC was established to review procedures involved in the handling of radioactive materials, to make recommendations concerning protective measures required in radiologically controlled areas, and to monitor the implementation of the Enewetak Atoll radiological protection program. The RCC met at least once a quarter and was chaired by the JTG Deputy Commander/Chief of Staff. Other committee members included the J-2, who was also the recorder, the Engineering Management Officer (J-3), the Assistant J-3 (Atoll Safety Officer), Service Element Commanders, the Staff Surgeon, the Enewetak Radiation Support Project (ERSP) manager, and the FRST Noncommissioned Officer in Charge (NCOIC).[15]

The FRST consisted of 33 USAF personnel who operated the atoll radiation protection program and, at each work site, implemented the procedures contained in the SOPs. Specific functions included hot line control; air sampler operation; issuing, collecting, and reading supplementary personnel dosimetry devices; monitoring personnel and equipment; supervision of radsafe procedures—and changes thereto—on site; and directing decontamination of personnel, facilities, and equipment as required.

To implement the general guidance in the basic documents, and to tailor that guidance to the situations existing at Enewetak, the J-2 and his staff developed 18 SOPs and 12 Enewetak Atoll Instructions (EAIs) which, when approved by the RCC and CJTG, provided the workers with the specifics of what to do and how to do it in the field of radiation safety to the end that personnel exposures were as low as reasonably achievable.

RADIATION SAFETY AUDIT AND INSPECTION TEAM

To provide an independent assessment of the radiological protection program, the Director, DNA chartered a "Radiation Safety Audit and Inspection Team" (RSAIT) and gave it widest authority to probe into all aspects of the radsafe program. The team was headed by the Director, Armed Forces Radiobiology Research Institute (AFRRI), and included members (generally health physicists) from each of the Services and ERDA/Department of Energy (DOE)

The RSAIT performed the broadest range of inspection functions relating to radiation safety (and environmental and occupational safety) on the atoll. They reviewed all procedures established to ensure radiation safety and then visited the atoll and inspected the practices actually in use to ensure that the procedures were adequately implemented. Visits were scheduled as frequently as would be useful (initially quarterly, eventually about three per year), and the duration of each inspection visit was scheduled to allow thorough observation of actual working conditions at the site of each radsafe operation on the various islands of the atoll. Formal written reports were provided to Director, DNA; Commander, Field Command; and each of the Services immediately upon conclusion of each trip. Director, DNA and Commander, Field Command were given personal briefings. Intensive follow-up action was taken on each item in the RSAIT reports. The RSAIT made ten inspection visits to the atoll and one visit to Field Command during the cleanup, as shown in Figure 4-2.

In retrospect, the RSAIT concept was a well-conceived and vitally important aspect of the radiological cleanup operation. By its unquestioned competence and vigorous activity, it gave confidence at every command echelon that important radsafe aspects were not being overlooked.

The RSAIT process also provided significant benefits to the cleanup force by its activity in the areas of environmental safety and occupational safety. In fact, a review of the RSAIT reports shows that the team generally viewed radsafe precautions as tending toward the excessive while environmental and occupational safety precautions needed constant attention.

RADIOLOGICAL PROTECTION PROCEDURES

One way of protecting an individual from unnecessary exposure to radiation is to keep him away from the radiation: restrict access to radiation areas to only those personnel whose duties require it. Each northern island was designated a controlled radiation area until the CJTG made the determination that, based on recommendations of the RCC after their careful review of detailed radiation measurements, the island was safe to decontrol. Except for emergencies, access to radiologically controlled islands was gained only with the approval of the RPO and was made only at designated entrance points. All personnel entering controlled islands were required to wear a dosimetric device; e.g., a film badge, a pocket dosimeter, and/or a thermoluminescent dosimeter (TLD) (Figures 4-3, 4-4, and 4-5). An access log, by date, was maintained at the entrance point to each island to record identification data on each individual, including his dosimeter and/or film badge number. One or more members of the FRST

VISIT	DATES	DIR, DNA TASKING	RSAIT REPORT
First	2-9 Aug 77	Dir, DNA Msg, 170010Z Jun 77[16]	DNA Ltr, w/incl 23 Aug 77[17]
Second	31 Oct- 7 Nov 77	"	DNA Ltr, w/incl 5 Nov 77[18]
Third	7-15 Feb 78	"	DNA Ltr, w/incl 13 Feb 78[19]
Fourth	11-19 Apr 78	"	DNA Ltr, w/incl 17 Apr 78[20]
Special* (Bulk-Haul)	4-12 Jul 78	"	DNA Ltr, w/incl 18 Jul 78[21]
Fifth	1-8 Aug 78	"	DNA Ltr, w/incl 8 Aug 78[22]
Sixth	6-13 Dec 78	Dir, DNA Ltr, 27 Nov 78[23]	DNA Ltr, w/incl 12 Dec 78[24]
Seventh	3-10 Apr 79	Dir, DNA Ltr, 29 Mar 79[25]	DNA Ltr, w/incl 9 Apr 79[26]
Eight	7-15 Aug 79	Dir,DNA Ltr, 27 Jul 79[27]	DNA Ltr, w/incl 14 Aug 79[28]
Special†	16-21 Sep 79	Dir, DNA Ltr, 27 Jul 79[29]	DNA Ltr, w/incl 24 Sep 79[30]
Ninth	4-12 Dec 79	Dir, DNA Ltr, 27 Nov 79[31]	DNA Ltr, w/incl 12 Dec 79[32]

*For purposes of assessing radsafe aspects of "bulk-haul" procedure for soil.
†A second phase of this Eighth RSAIT trip visited Field Command, 16-21 September 1979, to inspect radsafe documentation.

FIGURE 4-2. RSAIT VISITS.

FIGURE 4-3. FILM BADGE.

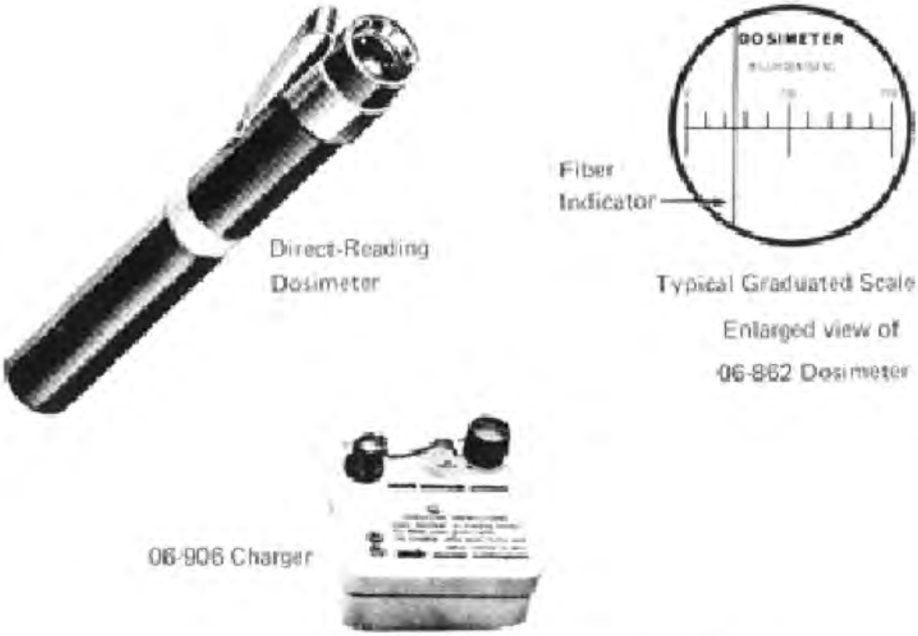


FIGURE 4-4. DIRECT READING DOSIMETER.

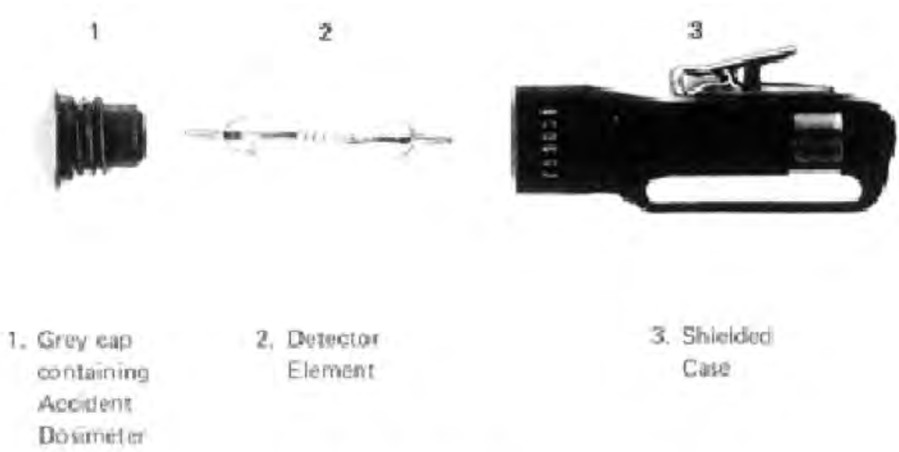


FIGURE 4-5. RADIAC DETECTOR.

supervised island access and insured that the above procedures were followed. Personnel leaving a controlled island were monitored, logged, and decontaminated if necessary. Contamination levels, both before and after decontamination, were recorded in the access logs. No vehicle or other item of equipment was allowed to leave a controlled island until it was monitored and, if required, decontaminated. Where necessary, contaminated items were packaged and appropriately labeled.[33]

Because of the nonuniform distribution of the contamination on many of the controlled islands, hot lines were established which separated the contaminated area from the clean area. In these cases, personnel arrived and departed in the clean area, and the hot lines served as the island access point. Hot lines were established upwind, or within 90 degrees of upwind of the work site, as close to the site as practical, and in a clear area. The hot line was positioned in an area where the background dose rate was less than 50 microroentgens per hour (μR/hr) and the concentration of transuranic elements in the soil was less than 40 pCi/g.[34] Here, an additional access log was kept to provide a record of personnel data, dosimeter numbers, and applicable personnel protection level. FRST members insured that individuals entering the radiologically controlled area were wearing the proper protective equipment for that area. When processing out of the controlled area, all personnel, equipment, and vehicles were monitored and decontaminated as necessary. Protective equipment was removed following the procedures outlined in Army Field Manual, FM 3-15, Nuclear Accident Contamination Control.[35]

Because of the large size of the contaminated area on some islands, a clean spot within the hot area was occasionally designated as a break area. The siting requirements for a hot line—upwind and in contamination-free area—were met. After being monitored by the FRST and decontaminated as necessary, personnel could eat, drink, and smoke within the break area.

Another way of keeping exposure to a minimum is to keep the radiation away from the individual. When an individual entered a radiation area, several procedures were used to minimize exposure.

The most basic, and most important, of these made use of the wind. From the day personnel arrived on the atoll until the day they left, continuous indoctrination and instruction emphasized staying upwind from any contaminated area, any soil-moving operation, and any dust-producing operation. For example, personnel were instructed to walk on the upwind shoulder of the road so that any dust raised by a passing vehicle would be blown clear. The "upwind" policy was substantially aided by: (1) the steadiness of the northeast trade winds, which made the upwind sectors quite predictable for most days during large portions of the year; and (2) the strength of these trade winds (15-25 knots on the average) which guaranteed that the upwind sectors would be clear. The operational procedures for each phase of the cleanup effort at each work site were structured to keep every individual at the site—with rare exceptions in essential cases—upwind of any possible dust.

The next policy designed to keep the radiation away from the individual made use of physical barriers between the individual and the source of radiation, and decontamination to remove radioactive materials from areas where they were not desired.

There were four basic levels of personnel protection (I through IV) used at Enewetak Atoll and two sublevels within levels II and III. The levels ranged from no extra equipment (i.e., normal work clothing) to complete encapsulation of the individual within protective clothing and mask. The level required was that most appropriate for the potential hazard, and this potential hazard was continuously evaluated at each work site on each island by the FRST personnel assigned to that site.[36] Personnel protection levels are shown in Figure 4-6, and examples are illustrated in Figures 4-7 and 4-8

The "action levels" noted in Figure 4-6 served as indicators of the radiological status of the situation and also as alerting points at which specific activities should occur, thus the term "action level." The first action level was set at *one-tenth of the basic standards* noted previously, and the second at one-half of the basic standards. If an action level was reached, the FRST members performed the actions specified and alerted the RPO to the potential hazard development.

As a matter of basic policy, eating, drinking, and smoking were rigidly controlled to ensure that no contamination could enter the body by these routes. Likewise, careful attention was paid to any cut, wound, or break in the skin to ensure it could not become a pathway for internal contamination.

During soil excision and removal operations, the greatest potential for inhalation of contaminated dust existed because of the possible resuspension of soil. The level of protective clothing worn during soil removal operations depended on the type of activity in progress.[37] In cases where personnel were required to be downwind of soil moving activities and in areas where air sampling could not be adequately performed, personnel assumed level III or IV protection, depending on ground contamination levels (see Figure 4-6), and they were monitored at least hourly as well as at the completion of the operation.

Decontamination is the process of removing radioactive material from personnel to eliminate further radiation exposure or from equipment to prevent the spread of radioactive material to clean areas. An individual leaving a radiation area was monitored at the hot line for contamination.

LEVEL	PROTECTIVE CLOTHING	PERSONNEL MONITORING AREAS	ACTION LEVELS PERSONNEL	ACTION LEVELS AIR	ACTION LEVELS GROUND
I	NONE	BOOTS HANDS HAIR	Alpha < 60 cpm Beta < 200 cpm Gamma < 15 μR/hr	Alpha < 55 cpm/hr Beta < 3250 cpm/hr	Alpha < 300 cpm Beta < 540 cpm Gamma < 2000 μR/hr
II	A. RUBBER BOOTS B. RUBBER BOOTS AND SURGICAL MASKS *	AS ABOVE PLUS ARMS AND LEGS			Alpha < 3000 cpm Beta < 7200 cpm Gamma < 2000 μR/hr
III	A. RUBBER BOOTS, GLOVES (AS APPROP) FULL FACE OR HALF FACE POS PRESSURE RESPIRATOR B SAME AS IIIA PLUS ANTICONTAMINATION CLOTHING	WHOLE BODY		Alpha < 5500 cpm/hr Beta < 325,000 cpm/hr	
IV	SAME AS IIIB EXCEPT GLOVES ARE NOW RE-QUIRED, A FULL FACE MASK IS REQUIRED, AND ALL OPENINGS IN CLOTHING ARE TAPED SHUT	WHOLE BODY	Alpha < 300,000 cpm Beta < 7200 cpm Gamma < 2000 μR/hr		Alpha < 300,000 cpm Beta < 7200 cpm Gamma < 2000 μR/hr

*Although surgical masks are shown as a minimum level of "respiratory protection," they served other purposes, as described in the text.

NOTES: 1. Abbreviations: cpm - counts per minute, μR/hr - microroentgens per hour.
2. Alpha and beta action levels refer to measurements taken over the area of the appropriate probe.
3. Action levels for air refer to samples taken using the Roots M102 air sampler. For Staplex air samplers multiply the alpha values by 2.8 and multiply the beta values by 4. For RAS-1 samplers, divide the alpha values by 2 and multiply the beta values by 2. Filters should be monitored at least every two hours.
4. Table assumes the following probes are used: For alpha - AC-3, for Beta - HP-210.

FIGURE 4-6. PERSONNEL PROTECTION LEVELS.

FIGURE 4-7. PERSONNEL PROTECTION LEVEL II.

FIGURE 4-8. PERSONNEL PROTECTION LEVEL III.

The individual was decontaminated if skin contamination exceeded 200 disintegrations per minute (dpm) alpha per 100 square centimeters at contact, or 400 dpm beta per 15 square centimeters at 1 inch. Equipment released to a clean area for any reason required decontamination if it exceeded limits based on draft American National Standards Institute (ANSI) Standard N328-1976, as amended by DOE-Nevada Operations Office (DOE-NV); i.e.:

a. Alpha: 1000 dmp/100 square centimeters fixed, or 20 dpm/100 square centimeters removable.
b. Beta: 5000 dpm/100 square centimeters fixed, or 200 dpm/100 square centimeters removable.
c. Gamma: 15 μR/hr.

Because of the potential for contamination, a laundry facility for cleaning washable personnel protective equipment was built at Lojwa. This facility, operated by the USAE under supervision of the FRST, had holding tanks and provisions for air and waste water sampling. FCRR SOP 608-10, Decontamination Laundry Procedures, 2 July 1978, provided detailed guidance on the operation and monitoring of this facility.

Radiation measurement, in itself, does not reduce exposure or contamination. Rather, it provides data which may be used to determine the requirements for preventive or remedial action. Such measures include monitoring, dosimetry, air sampling, and bioassay. Each is discussed in the following paragraphs.

Monitoring of personnel, vehicles and equipment was used to determine the extent of decontamination required, if any, upon exit from a controlled area as described above. Monitoring also was used to document the clean status of equipment released for general use and retrograded from the atoll.

Personnel dosimetry is the means by which the beta/gamma dose to which an individual has been exposed may be determined. At Enewetak, the primary dosimetric device—as prescribed by AR 40-14—was the film badge, issued and evaluated by the U.S. Army Lexington-Blue Grass Depot Activity (LBDA). The film badge program was administered in accordance with AR 40-14, and the dosimetry results were recorded on DD Form 1141. Initially, visitors to the atoll who toured radiologically controlled islands were issued self-reading pocket dosimeters which could be evaluated on atoll, instead of film badges which required weeks to process.

The high heat and humidity conditions at Enewetak, combined with generally wet working conditions, damaged a considerable percentage of the film badges in the initial months of the project. Typically, this damage was such that, if low doses had been received by the wearers, they would have been obscured by the damage. Higher doses still would have been readable. To alleviate this problem, an assistance visit to Enewetak by LBDA representatives led to the suggestion of sealing the film badges inside two plastic bags, with a small packet of desiccant in the inner bag. This method reduced, but did not eliminate, the film damage problem.

Another solution was the addition of U.S. Navy TLDs as supplemental dosimeters. Since these were hermetically sealed devices, intended for use underwater by Navy divers, the TLDs were unaffected by the Enewetak heat and humidity. In addition, they could be read on atoll. Beginning in May 1978, they were issued to and worn in parallel with film badges by all workers on radiologically controlled islands. TLDs also replaced self-reading pocket dosimeters as the dosimetric device for visitors.

Where film badges were damaged or lost, and in those cases in which supplemental dosimetry was not used, administrative doses were computed based on actual occupancy data and island background dose rates. This method was approved by the Army Surgeon General in accordance with AR 40-14.[38]

One of the most important aspects of the Enewetak radsafe precautions was the air sampling program. Two of the principal functions of the air sampling program were to provide a basis for the FRST to establish respiratory protection levels and to provide documentation of airborne radionuclide levels in work environments. NBS Handbook 69 and 10CFR20 establish a maximum permissible concentration (MPC) in air for insoluble plutonium of 40 pCi per cubic meter (pCi/m^3) of air in restricted radiation areas based on an occupancy of 40 hours per week. Since "occupancy" on Enewetak's controlled islands theoretically could be as high as 60 hours per week, this MPC was adjusted downward proportionately to 27 pCi/m^3. On Lojwa, the forward base camp, the MPC was adjusted for a 168-hour week (24 hours a day for 7 days a week). At Enewetak Atoll, action levels were established at 10 percent and 50 percent of the adjusted limits, or 2.7 pCi/m^3 and 13.5 pCi/m^3 for controlled islands. When the first action level was reached (based on air sampler filter readings), nasal swipes were taken from all personnel in the area who were not wearing respiratory protection, and the RPO was informed. If the 0.5 MPC action level was reached, nasal swipes were taken, respiratory protection was required if work was to continue, and the air sampler filter was expeditiously transferred to the Rad Lab for analysis.[39]

The workhorse for air sampling throughout the project were the Roots-Tecumseh M102 gasoline-engine-driven air samplers (Figure 4-9). These were procured as surplus and salvage items from the DOE Nevada Test Site and shipped to the atoll. Keeping sufficient numbers of these air samplers functional to support operations proved to be such a problem, due to their age, the salt-spray environment, and the difficulty in obtaining parts, that two engine repairmen were added to the FRST to keep these machines running. From a total of 85 air samplers shipped, an operational high of 42 was reached in December 1978.[40] Although continuous attention and high-priority efforts were required, an adequate supply of operational air samplers was always maintained.

Optimal operation required one sampler located upwind of any potential dust-generating operation and one to four samplers placed immediately downwind of the area. The number downwind was determined by the size of the area of operations.[41]

Five lapel air samplers were obtained from Sandia Laboratories, Albuquerque, in December 1978 for an experimental program of representative sampling of air in the individual's breathing zone. When the effort was terminated in May 1979, about 245 cubic meters of air had been sampled and no detectable activity had been found.

The gasoline-engine-driven air samplers were quite noisy in the close confines of the soil-haul watercraft, and severe maintenance problems were experienced from the continual exposure to salt spray. For the LCUs, it was a relatively simple matter to obtain electrically operated samplers since these relatively large craft had 110-volt AC power available. The LCM-8s were more of a challenge. These craft had only 24-volt DC electrical systems. An AC to DC converter was tried to enable use of a 110-

FIGURE 4-9. ROOTS-TECUMSEH AIR SAMPLER.

volt Staplex air sampler, but it placed too great a drain on the boat's batteries. In April 1979, a member of the 7th RSAIT brought a 24-volt DC Staplex sampler to the atoll. This proved successful and, in mid-June 1979, six more were procured so that one could be placed on each LCM-8 soil-haul craft, replacing the noisy gasoline-driven model.

The bioassay program was used to detect and document internal deposition of radioactive material which might have occurred through inhalation, ingestion, or skin penetration (i.e., wounds). The two principal bioassay techniques used were the nasal smear (nose swipe) and urinalysis. Procedures also were developed for taking and analyzing fecal samples to document radiological uptake as the result of ingestion, but no samples were taken since fecal analyses were not required. Nasal smears were used in plutonium-contaminated areas as the primary method of checking the adequacy of respiratory protection. Nasal smears were taken when dirt was found inside the mask, indicating the possibility of a leak; when the alpha activity on an air sampler filter exceeded one-tenth of the MPC for unprotected personnel; whenever personnel entered a radiation area with the incorrect protective equipment; or when a procedural violation occurred, such as smoking in a radiation area or removing a mask. The action level for nasal smears was 60 cpm, or about 100 dpm per sample.

While the nasal smear gives an immediate but rough indication of a plutonium hazard and is a measure of particles trapped in the nose, it does not indicate if any or how much may have passed into the lungs. The urinalysis provides a better picture of total uptake. Any individual who had previous experience as a radiation worker prior to arrival at Enewetak submitted a "preemployment" urine sample. This served as a baseline, so that any previous uptake would not be assessed as being of Enewetak origin. All individuals who spent more than 30 days on radiologically controlled islands submitted "postemployment" urine samples upon departure from the atoll. All samples consisted of the individual's total urine output for a 24-hour period. Samples were shipped to the Occupational and Environmental Health Laboratory at Brooks AFB, Texas, for analysis.

RADIOLOGICAL PROGRAM RESULTS

Overall, the radiation protection program at Enewetak achieved its goal of maintaining personnel radiation exposures as low as reasonably achievable. The results are highlighted below.

Throughout the project, exposures to gamma radiation were minimal. Of over 12,000 individual dosimetry records, only four exceeded 0.050

rem, and the highest of these was 0.070 rem. In August 1978, two film badge readings of 0.400 and 0.430 rem were recorded. In-depth investigations revealed that, in all likelihood, these did not represent valid doses to individuals but that they resulted from the film badges having been placed on or near contaminated debris or a calibration check source overnight. Even counting these doses, the two individuals received a total of less than 0.6 rem each during their tours at Enewetak (one for a year and the other for 6 months). Administrative dose assignments were designed to be higher than the actual dose received and the highest administrative dose assigned in any month was 0.020 rem.[42]

Over the entire project, only two skin exposure (beta) doses were reported, both at 0.014 rem. Such a dose is a negligible fraction of the annual limit of 30 rem for skin exposure.

Throughout the cleanup project, over 760,000 cubic meters of air were sampled on the controlled islands plus more than 211,000 cubic meters at Lojwa. Nearly 5,200 air samplers filters were analyzed by the lab. No significant airborne radioactivity of any type (including beta) was detected. It is clear from these results—as it was from resuspension experiments performed during early RSAIT visits to the atoll—that the Enewetak contamination situation was not conducive to creation of a resuspension hazard.

There were several cases where field instruments indicated that action levels had been reached; however, in each of these cases, laboratory analysis showed that the readings were not caused by resuspension of radioactive materials present on the atoll but by short-lived isotopes naturally present in seawater. During times of heavy surf, these naturally occurring, alpha-emitting substances (primarily radon and daughter decay products) separated from the sea spray and were collected on the filters. Since these isotopes decayed in a few hours, the filters gave no reading upon subsequent laboratory analysis. Use of an air sampler at the Enewetak Rad Lab verified the presence, nature, and short life of these isotopes. Following this identification, the FRST field procedure was changed to include a second reading, after a delay of one-half hour, for filters showing action levels.

Throughout the project, over 1,100 nasal smears were taken and analyzed as a part of the overall radsafe program. The results showed no cause for concern. About 40 percent of the samples showed no detectable activity. Of those that did show activity, the highest was 3.64 dpm (1.64 pCi), less than one-tenth of the "action level," which was established at 50 dpm and which itself was one-tenth of the maximum allowable level of 500 dpm.

Over 2,000 urine samples were analyzed during the project, primarily for total or gross beta (GB), Pu-239, and potassium-40 (K-40). K-40 is a naturally occurring radioisotope which enters the body through diet. A normal adult man has a tissue concentration of K-40 on the order of 1600 pCi/g per kilogram; thus, levels up to several thousand pCi are normally measurable in urine. On a random basis, some samples were analyzed specifically for Cs-137, Co-60, or Co-57 The GB count was indicative of any beta-emitting isotopes (Cs-137, Sr-90, and Co-60) which might have been taken up at Enewetak. If any results had indicated possible significant uptake of beta-emitters, specific tests for Sr-90 or Cs-137 would have been made. "Significant uptake" was defined as a GB value on the order of 5 nanocuries (nCi) (5,000 picocuries) per liter and a GB-to-K-40 ratio exceeding three.[43,44] The highest GB value reported was 3.6 nCi. In this case, the corresponding K-40 value was 3.2 nCi, so the GB/K-40 ratio was 1.13. The highest GB/K-40 ratio was 3.05. In that case, the GB value was 0.351 nCi. Thus, there was no significant uptake of beta-emitting isotopes.

Plutonium concentration was reported in terms of pCi per 24-hour urine sample. As a trigger level, the American Health Physics Society Plutonium Bioassay Committee has proposed that, if the plutonium concentration exceeds 0.20 pCi per 24-hour sample, a second sample should be taken for verification. None of the 2,000 24-hour urine samples even approached this level. All but six of the 2,000 samples had readings below the minimum detectable activity (MDA), and the six that exceeded the MDA were one reading at 0.05 pCi, two at 0.06, two at 0.08, and one at 0.11 pCi. In each case where the MDA was exceeded, dose estimates were made. The estimates indicated that no significant doses were sustained. Moreover, a second sample was obtained from each individual and, in each case, the sample was less than MDA.

Extensive recording of all radiation safety data was accomplished. In addition to recording personal doses in each individual's military records, a permanent computerized data base of all radsafe information has been established at DNA's Field Command in Albuquerque.

In summary, the exhaustive data accumulated over the 3 years of the project do not indicate any area or instance of concern over radiological safety. All doses, internal and external, were minimal.

ENJEBI ISLAND SURVEY BEGINS: 15 JULY 1977

Before radiological cleanup could begin, the techniques for locating and removing contaminated material were to be thoroughly tested and refined in the field by cleanup forces. The techniques to be tested included debris survey by the FRST, in situ soil survey by DOE-ERSP, and brush removal and contaminated soil excision by the USAE. It was planned that the tests would be conducted during the mobilization phase so that the techniques would be perfected by the time the cleanup phase began on 15 November 1977. The planners believed, in a practical sense, that the tests would constitute the beginning of radiological cleanup on the island where they were conducted and, considering the input of cleanup resources, that the island selected would receive priority for radiological cleanup once the cleanup phase began.

Development of priorities and schedules for island-by-island cleanup began after the first OPLAN conference in February 1977.[45] The planners considered such factors as channel access, terrain, extent of work required, and planned island use by the dri-Enewetak. After several months of deliberation, it was decided that pilot tests of the cleanup techniques would be conducted on Enjebi.[46,47] It afforded sufficient variety and quantity of work to develop and test thoroughly the basic techniques for radiological surveys and cleanup. Channel access conditions were well known from recent operations there, and little additional work would be required for additional clearance. Beach trafficability was good, and the terrain was suitable for the various tests. In addition, Enjebi was considered to be one of the safer northern islands for the development of techniques and initial training of raw personnel.

Following procedures outlined in OPLAN 600-77, DOE-ERSP used measurements from the 1973 Radiological Survey and the recent gross aerial survey to identify plutonium concentrations on Enjebi which were likely to require soil cleanup.[48] The exact boundaries and extent of the concentrations were to be identified by fine surveys conducted in conjunction with iterative removal of contaminated soil from the areas.[49] On 15 July, the newly arrived in situ van (IMP) was deployed to Enjebi for development and testing of the fine survey techniques. ERDA's research support vessel, the Liktanur I, was anchored just off the island to provide preliminary logistical support.[50] FRST and Army engineer elements deployed the following week to participate in the Enjebi survey.

IN SITU SOIL SURVEY PROCEDURES

The IMP was a mobile soil assay system mounted in a tracked vehicle (Figure 4-10). The system was self-contained to the extent that all radiological data could be acquired and most of the data processed in the van. Final data processing and map overlays were done at the base camp laboratories. EG&G Corporation, under contract to ERDA, provided both the equipment and the technicians. The IMP drivers were military enlisted personnel.

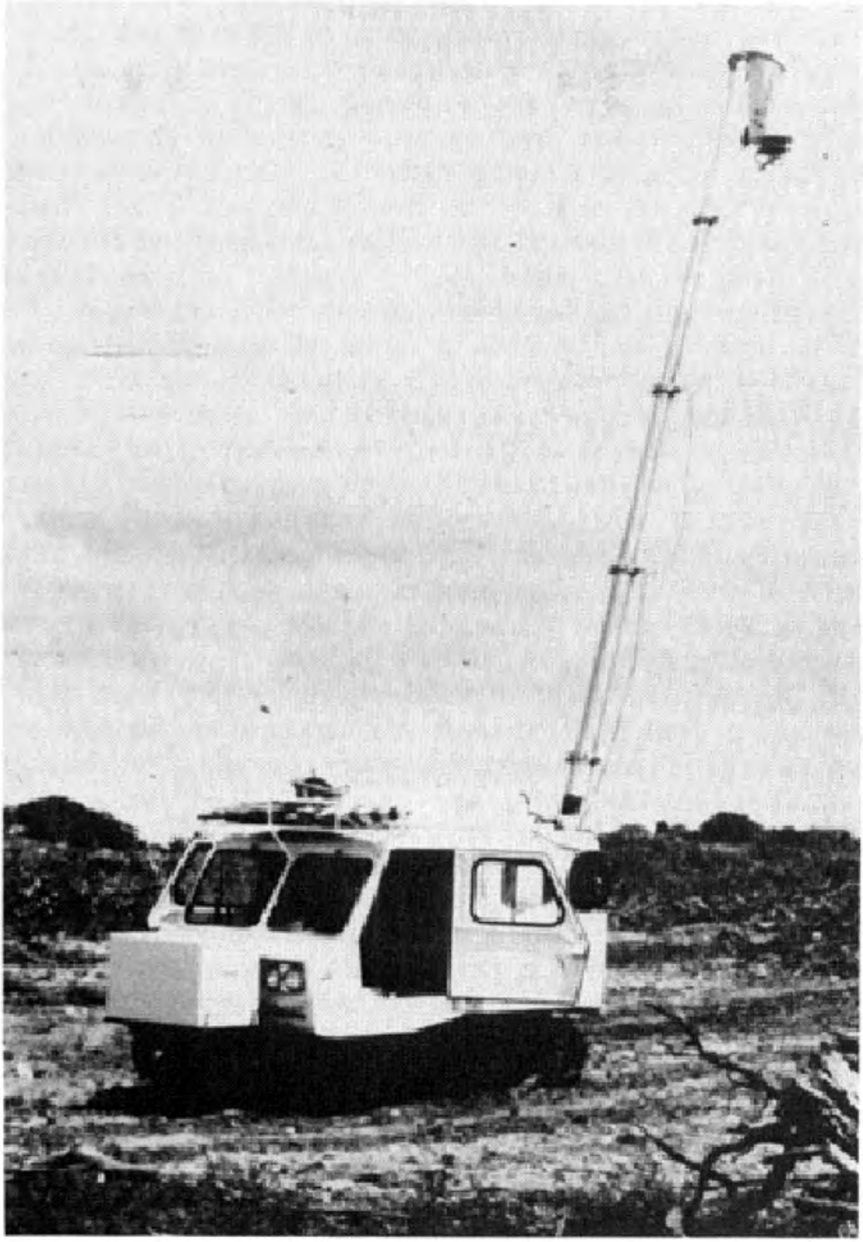


FIGURE 4-10. IN SITU VAN (IMP).

Since plutonium is an alpha emitter, and since there is no efficient way to detect and measure alpha contamination in soil over large areas, the IMP system was designed to detect gamma radiation from Am-241—a daughter product of plutonium—in the soil. The detection was done by means of a planar intrinsic detector made of germanium. The detector was suspended approximately 6 meters above the surface of the earth using a retractable boom mounted on the rear of the van. The germanium detector was cooled by liquid nitrogen. Other equipment on board the IMP included a high voltage power supply, amplifier, analyzer, calculator, printer, and tape recorder. Sensitive electronics equipment was installed in an enclosed space in which temperature control was maintained by a small, self-contained, air-conditioning system mounted on the IMP. Gamma spectra from the detector were analyzed and recorded. The average concentration of Am-241 in the top 3 centimeters of soil within the detector's field of view (a 21-meter diameter circle) was determined from the 60 kilo-electron Volt (keV) readings. Radiation at 60 keV is the most prominent line of the spectrum of americium and is, therefore, the best indicator of intensity of radiation and quantity of americium. At a few selected points where IMP readings were made, soil samples were taken for analysis in the Enewetak Radiation Laboratory. The concentrations of Pu-238, -239, and -240 and of Am-241 were determined from these soil samples and the ratios of plutonium to americium derived. Conversion factors then permitted estimates of plutonium and total transuranic concentrations in the soil to be calculated from the americium measurements made by the IMP.[51]

To survey a large area, such as one of the islands, the IMP traveled from point to point along a surveyed grid, making a measurement at each grid intersection. Soil samples were taken at intersection points and analyzed for plutonium-americium ratio. Data from the entire area were statistically analyzed, and lines (isopleths) were drawn on maps through points having the same numerical values of average concentrations of either plutonium or total transuranics. The isopleths were based on the 70 percent upper bound; i.e., the probability is at least 0.7 that the true average concentration is no greater than the upper bound. After soil was removed, the process was repeated to determine the concentration values of the newly exposed surfaces. Figure 4-11 is a schematic diagram of the measuring-analyzing-recording system in operation.

The IMP system had the advantages of being mobile and of providing quick answers to questions concerning the plutonium concentrations in a particular area. Once a ratio between americium and plutonium or total transuranic elements had been established for a large area, the only time required to obtain a concentration was that needed to reach the point being

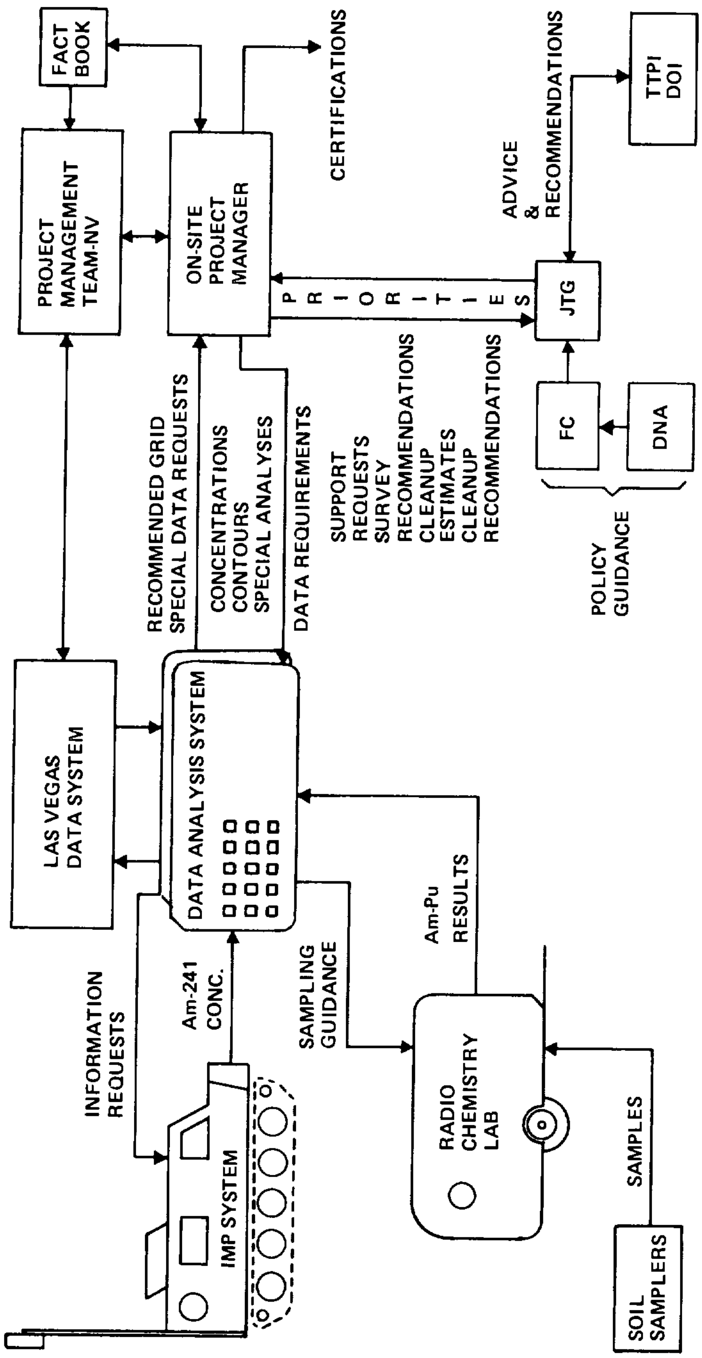


FIGURE 4-11. IN SITU SYSTEM SCHEMATIC.

investigated, set up, and make the measurement. Once located in an area of interest, measurements typically could be made at the rate of two per hour, including travel time between adjacent 50-meter grid points. This contrasted markedly with the 3-7 days required to analyze a sample chemically in the laboratory.

The principal weaknesses of the IMP were mechanical ones—difficulties experienced in maintaining the germanium detector and the vehicle itself. Consequently, three IMPs were used in the cleanup project, with the objective of having two active and one on standby at all times.

SUBSURFACE SOIL SURVEYS

An intrinsic weakness of the IMP was that it only measured radioactivity generated close to the surface. It was known that some of the soil contamination was subsurface, due to the decontamination methods used during the nuclear test period. All known or suspected burial sites were surveyed by the DOE-ERSP using subsurface sampling techniques. Samples were taken—on reestablished grid patterns and at predetermined depths in each area of interest—by laboratory technicians under the direction of EIC. The samples were placed in 1-gallon cans, marked, and transported to Enewetak Island where the ERSP radiological laboratories were established. A portion of each sample was then chemically analyzed for transuranic content. The laboratory analysis for each sample took up to 10 days to complete The remainder of the sample was archived at the Las Vegas, Nevada, office of ERSP

BRUSH REMOVAL EXPERIMENTS

Use of the in situ system required lanes to be cleared of sufficient brush to allow visual survey and radiological monitoring for debris which might affect IMP readings. Much of the surface of the islands was covered with dense thickets of Scaevola and Messerschmidia, 6 to 8 feet tall. It had been planned to cut the vegetation at ground level without disturbing the surface soil. Brush removal experiments at Enjebi during the last week of July 1977 indicated that such precision could not be achieved with the equipment on hand.[52] Coordination with forest and agriculture industry officials indicated that even their specialized equipment would disturb the soil.

During these experiments, a 1,000-by-1,000-foot area on Enjebi was surveyed for debris by the FRST, after which the USAE attempted to cut the brush with bulldozers. This only mashed down the vegetation and disturbed the soil beneath the tracks to depths of over 6 inches on a straight line and over 2 feet on turns. Next, a 100-meter-long, 2-inch-diameter chain was fastened to two bulldozers and dragged through the area. The chain slid over the more dense vegetation requiring those areas to be reworked, which caused even more soil disturbance. The vegetation matted in place, requiring greater attenuation adjustments in the in situ readings.[53]

This problem was finally solved by using the bulldozer with the blade above the surface level, and by piling the vegetation in windrows outside the survey area. There, after several weeks of drying, it was doused with diesel fuel and burned.[54]

The volume of brush to be removed was directly dependent on the grid spacing of the in situ survey. A 25-meter grid required complete clearing of the area to be surveyed. A 50-meter grid required only that lanes be cleared along the grid lines. It was determined that the slight soil disturbance caused by bulldozing was acceptable, since the current surface was not the original surface of fallout deposition. Acts of man and nature over the past 20 years had altered the original fallout surface. The surface that really mattered would be the surface left after radiological cleanup was complete.[55]

A CHANGE IN PRIORITIES: AUGUST 1977

By the end of August 1977, brush clearing and debris survey techniques had been thoroughly tested, a grid survey system which used Site Oscar as the benchmark for master triangulation coordinates for the atoll had been established, Enjebi soil samples had been taken, and in situ survey procedures had been developed and were being validated in the ERSP Rad Lab.

The radiological survey of Enjebi was well underway when BG Tate and COL Treat made their first visit to Enewetak. The purpose of their visit was to see the atoll firsthand and discuss cleanup plans with the JTG Commander, who had been with the project a little over 3 months, and the ERSP Project Manager. Radiological tasks and priorities were discussed, including work priorities for the FRST, priorities for ERDA's in situ survey and refinement of the scope of work on selected northern islands, iterative radiological cleanup techniques to be employed when cleanup of particular areas were initiated, and characterization of a program for determining the overall scope of work that needed to be accomplished on Runit in accordance with the requirements of the EIS.[56]

BG Tate was most concerned about defining the scope of work and assuring that resources would be available to complete the items specifically required in the EIS; i.e., removal of plutonium from the Aomon burial crypts and removal of plutonium-contaminated soil over 400 pCi/g from Boken, Lujor, and Runit. He identified these as priority requirements while other soil cleanup, such as Enjebi, would be contingent on availability of resources consistent with completion of these priority requirements. He shared the concern of others that the cleanup program defined in the EIS might not be completed for lack of resources.[57] BG Tate believed that he needed more detailed information about the radiological condition of the islands specified in the EIS in order to confirm and refine the soil volume estimates developed from the 1973 AEC Survey, and he felt that those islands must be surveyed as soon as ERSP personnel could finish validating their in situ system methodology.

BG Tate was especially concerned about the extent of effort that might be required to clean Runit, and he asked that action be expedited to characterize the nature and scope of work required there. BG Tate and the ERSP Manager agreed that.

a. ERSP would expedite the development and testing of the in situ system.
b. As soon as possible, ERSP would conduct in situ surveys of Lujor and Boken so that these priority requirements could be defined early and cleanup could begin on schedule. This was to be followed by surveys of Enjebi and the other northern islands to provide data for case-by-case decisions regarding their cleanup should resources still be available after cleanup of the Aomon crypts, Lujor, Boken, and Runit (the islands discussed in the EIS) was complete.
c. The ERSP manager would recommend experts to assist in formulating a program to characterize the nature and scope of work to clean up Runit to the levels addressed in planning documents, including the EIS.[58]

These actions were initiated to allay some of BG Tate's concern about the JTG's ability to complete all of the work defined in the EIS. They were intended to provide better estimates of all of the priority radiological cleanup requirements so that soil cleanup would focus on the priority islands, rather than on Enjebi, which was not a priority requirement and which could consume precious time and limited resources. Instead, as will be seen in Chapter 6, these actions were links in a chain of events and challenges which served to delay the start of soil cleanup for many months.

CHANNEL CLEARANCE: SEPTEMBER 1977

Channel clearance operations commenced on 15 September 1977 when U.S. Navy Underwater Demolition Team Eleven (UDT Eleven) cleared the approaches to Ananij (Bruce), Aomon and Lujor by chain dragging. Later that week, explosives were used to complete clearance of the beach approach to Ananij and to clear a channel into Runit (Figure 4-12).[59]

On 21 September 1977, UDT Eleven established a temporary camp at Enjebi and proceeded to complete the channel clearance mission in the northern half of the atoll, including channels into Enjebi, Bokoluo (Alice), and Louj (Daisy). They returned to Enewetak Camp 4 days later and completed their work in the southern islands.

UDT Eleven completed an estimated 45 to 60 days channel clearance and demolition work in 16 days. They used 41,400 pounds of explosives in nine separate demolition operations to improve channels and access to landing beaches on four islands, and they employed chain drag procedures to clear obstacles from eight channels. In addition to completing all tasks assigned in the OPLAN, the team placed marker buoys on ten landing beach approaches, resurveyed four channels after explosive clearance operations, and left a wealth of lagoon and channel information for use by the JTG.[60,61]

A week after the channel into Lujor was cleared, it was put to use. On 22 September 1977, several members of the FRST were diverted from the debris survey of Enjebi to begin the radiological survey and characterization of Lujor. By then, additional in situ vans had arrived so that the ERSP was able to begin the characterization of Lujor while continuing the Enjebi soil survey, although at a slower pace than originally planned.

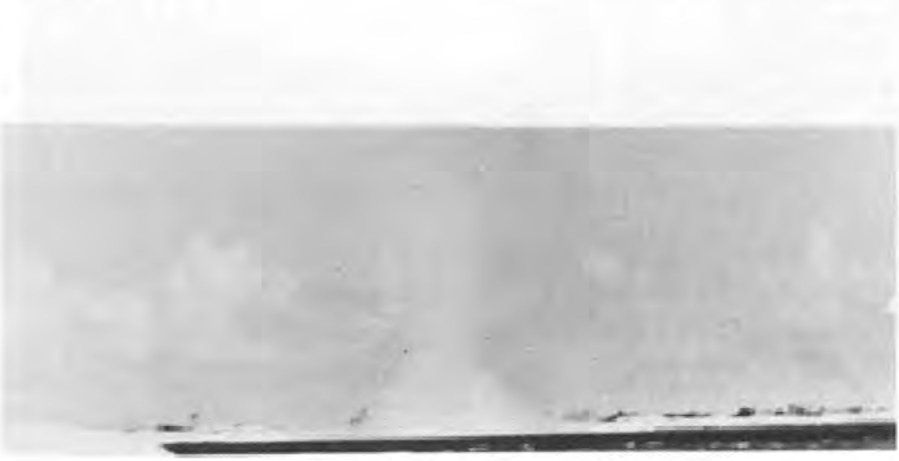


FIGURE 4-12. RUNIT ISLAND CHANNEL.

On 1 October 1977, ERDA was reorganized. Those components involved in the Enewetak project were assigned to the newly established Department of Energy (DOE) with little change except in name and office symbol; e.g., ERDA-NV became DOE-NV.

EXPLOSIVE ORDNANCE DISPOSAL

Air Force explosive ordnance disposal (EOD) personnel assigned to the FRST had the primary responsibility for recovery and disposal of all unexploded munitions found on land. The EOD team used extensive field searches employing metal detectors, as well as reports from work crews involved in both debris and soil removal, to pinpoint locations of unexploded munitions. When such items were discovered, they were marked and reported through command channels. FRST EOD personnel surveyed the munitions and placed inactive munitions in designated disposal areas. When the survey disclosed that the munitions were dangerous and unmovable, they were detonated on the spot, following all required safety precautions. By 8 October 1977, the FRST had collected 300 rounds of munitions along the southwest beach of Enjebi (Figure 4-13).

FIGURE 4-13. MUNITIONS COLLECTED ON ENJEBI.

They were destroyed by multiple demolition on 19 October 1977.[62] Later, as the cleanup progressed, the seven EOD specialists on the FRST were released, and the U.S. Navy EOD detachment assumed the entire EOD function.

From the start, unexploded munitions in offshore areas had been the responsibility of this Navy EOD Detachment. As was the case on land, the munitions were either collected for disposal at a later time or detonated on the spot if determined dangerous. The Navy EOD team began their survey, cleanup, and disposal of unexploded ordnance on Medren where the scrap contractor was due to begin operations; then they proceeded to clear the shallows off Enjebi [63,64] A summary of types and amounts of discovered unexploded munitions is shown in Figure 4-14.

US ORDINANCE	ENJEBI	MEDREN	ENEW	BOKOM-BAKO	JAPTAN	AEJ	UNK	TOTAL
2" PROJECTILES	3							3
3" PROJECTILES	11	1					41	53
5" PROJECTILES	24		10				19	53
8" ROUNDS							1	1
16" ROUNDS							19	19
37 MM ROUNDS							38	38
40 MM ROUNDS			1				13	14
60 MM ROUNDS							16	16
75 MM ROUNDS	3		1				18	22
81 MM ROUNDS			1				18	19
105 MM ROUNDS			1				6	7
120 MM ROUNDS							7	7
155 MM ROUNDS							10	10
50 CAL SM ARMS	100		2 cases					102
BLASTING CAPS							1308	1308
BOMB, PRACTICE MK43							7	7
GRENADE, HAND M2	2	2	1				9	14
BOMB DEPTH, AN MK 41/47							1	1
FLARE, 22 MM							39	39
							Sub Total	1733
ASSORTED US & JAPANESE								
FUSE, PROJECTILE	1495		1		1		1112	2609
PROJECTILE, SMALL ARMS	2152						2631	4783
FLAME THROWER, TANK							1	1
FLARE							11	11
POWDER, CNA							1	1
BOMB, PRACTICE, M43			2		3		2	7
							Sub Total	7412
JAPANESE								
7 CM ROUNDS	32	5	1				74	112
25 MM ROUNDS							1205	1205
58 MM ROUNDS	480	107				1	592	1180
50 MM ROUNDS							91	91
81 MM ROUNDS	1		11	1			38	51
90 MM ROUNDS							5	5
GREN, HAND	4	1					3	8
MINE, ANTI BOAT	10						39	49
MINE, OTHER	6						30	36
FUSES	475	10					201	686
KNEE MORTARS	74						72	146
							Sub Total	3569
UNK								
GREN, HAND	2							2
60 MM MORTARS							15	15
81 MM MORTARS	12							12
M 25							1	1
CAPS, ELECT							4285	4285
							Sub Total	4315
								17029

FIGURE 4-14. UNEXPLODED MUNITIONS SUMMARY.

OTHER PREPARATIONS

Shortly after their arrival on 12 October 1977, the Navy Water Beach Cleanup Team began demolition test shots on one of their major objectives, the steel outer pilings of the Medren pier. The inner pilings were sound enough to be used in reconstruction of the pier by the TTPI Rehabilitation Program contractors. However, the outer pilings were in poor condition and had to be removed by explosive cutting as near to the lagoon bottom as possible.

On 29 October 1977, the Army and Navy Elements began a test of the causeway pier-barge transportation concept. At near high tide, a two-causeway pier was inserted against the beach on Enewetak Island, using two Army bulldozers as deadmen. A YC barge was docked perpendicular to the pier, and a transition ramp was placed between the barge and pier. A loaded, all-wheel-drive, 5-ton dump truck was driven from the beach, across the pier, up the ramp, and onto the barge with relative ease. Tests with a 20-ton dump truck were halted when its radiator was damaged during an attempt to drive onto the pier.[65]

That same day, the FRST and USAE began clearing brush from the causeway between Aomon and Bijire (Tilda) where the Aomon burial crypt was located. Magnetometer surveys of the area gave several positive readings, indicating buried metal. Excavations made during the following week confirmed these readings by revealing contaminated metal debris. The high water table in the causeway precluded excavations below 6 feet.[66,67]

With the beginning of the Cleanup Phase (15 November 1977) fast approaching, and with BG Tate's direction to shift the priority from Enjebi to Lujor, Boken, Aomon and Runit, the JTG developed a revised plan in October 1977 to begin simultaneous debris and soil cleanup first on Lujor, then on Boken, then on Aomon, and other islands. In conjunction with these operations, debris was to be removed from several smaller islands where there was no contaminated soil, such as Taiwel (Percy) and Bokenelab (Mary).[68] CJTG forwarded the plans and schedule to Field Command and began preparations to implement them on 15 November 1977.[69] It was assumed by CJTG that the soil cleanup criteria for Lujor, Boken, and Aomon would be firmly established by the beginning of the Cleanup Phase. However, developments at the Washington level relative to the application of Federal guidelines and soil removal criteria were generating challenges to the cleanup concept (discussed in Chapter 6), and the Director, DNA directed Commander, Field Command to hold the execution of soil cleanup in abeyance. He was determined that scarce soil cleanup resources would not be squandered cleaning islands in an order of priority which lacked the full consideration of all of the interacting elements.

By 15 November 1977, contaminated debris surveys in preparation for cleanup were complete on Enjebi, Lujor, and Boken, and initial soil surveys had been made on those islands. The initial FRST surveys of the Aomon crypts had been made, to the extent available equipment permitted. Heavy seas, wind, and rain in recent weeks had delayed some operations; however, the JTG was prepared to begin cleanup operations.[70]

OPENING CEREMONY FOR CLEANUP: NOVEMBER 1977

On 15 November 1977, BG Tate conducted an opening ceremony for the cleanup phase on Lujor. One-half cubic yard of pipe and angle iron (Master Index No. 311) was monitored by the FRST and found to be safe for disposal in the lagoon. The USAE loaded the debris on a dump truck which was then loaded on a landing craft. The USNE piloted the landing craft to Dump Site Bravo where the debris was dropped in the lagoon.[71]

During this visit, BG Tate reviewed the status of the project, inspected ongoing operations, discussed problems, and directed that action be initiated to develop plans for the Demobilization Phase. Demobilization was not covered in the OPLAN.

Two unfortunate events marred the opening week of cleanup operations. The Harbor Clearance Unit was engaged in cutting the outer pilings of the Medren pier using underwater explosives. The operation proceeded without mishap until the night of 17 November 1977, when the wooden decking of the pier caught fire. The fire was probably caused by a hot fragment, thrown during that day's demolitions, which lodged in the wood of the pier and smoldered for hours before igniting the decking. Before the fire was extinguished, approximately 60 percent of the wooden portion of the pier was destroyed. Fortunately, most of the destroyed material was not planned to be used in rehabilitation of the pier.[72]

The night of BG Tate's departure, the second fatality of the project occurred. Private Vincent Holmes, USA, collapsed while playing basketball and was taken to the Enewetak Clinic, where he died of cardiac arrest. The aircraft carrying BG Tate's group returned to Enewetak the next morning from Kwajalein Missile Range to carry the remains to Hickam AFB. Memorial services were held at the Enewetak Base Chapel on 20 November 1977.[73]

These were only the beginning of a series of unfortunate events. The project had scarcely begun before it was interrupted by two severe storms.

TYPHOON MARY: DECEMBER 1977

The first indications that Typhoon Mary might strike Enewetak Atoll came on 24 December 1977. Reports from the U.S. Navy's Fleet Weather Central on Guam indicated that the storm, which had formed several hundred miles northeast of Enewetak, might approach the atoll in the next few days. The JTG began making preparations for the storm as well as for the Christmas holiday. Additional landing craft were positioned at Lojwa, sensitive laboratory equipment was moved to the three-story masonry barracks, and other actions to minimize storm damage were initiated. Plans were made to evacuate if that became necessary. Constant communications were maintained with Commander in Chief, Pacific Command; DNA; Field Command; and other command posts to keep all concerned apprised of the status of the storm and of preparations for evacuation.

At 1830 hours on Christmas day, as Typhoon Mary continued to approach, Commander, Field Command, decided to evacuate the atoll.[74] By 1900 hours, the order was being implemented. By 2330 hours, all personnel at Lojwa Camp had been evacuated to Enewetak Camp by landing Craft. When seas in the deep passage became too high for boat traffic, helicopters were used to bring the dri-Enewetak from Japtan to the main base. Fifty-four people were airlifted from Japtan between 2300 hours on 25 December and 0500 hours on 26 December 1977. The helicopters were then lashed down and secured. Landing craft were beached on the leeward shores of Medren and Enewetak Islands and moored to bulldozers and other heavy equipment.[75]

U.S. Air Force C-141 Starlifter aircraft from the 610th Military Airlift Support Squadron, Yokota, Japan, began arriving at first light, 0755 hours, on 26 December 1977. Eight hundred and twenty nine personnel, including the dri-Enewetak, were combat-loaded on four C-141s and flown to Guam. As it happened, the evacuation took place during the peak of the storm at Enewetak. At that time, Typhoon Mary was 120 miles south of the atoll, its closest point of approach. The wind was reported at 50 knots, with gusts to 60 knots, and there were 15-foot seas outside the reef and 5- to 6-foot waves in the lagoon.

The CJTG, COL Mixan, and 20 other military and civilian personnel remained at Enewetak to make immediate repairs to life-support facilities and reopen the airfield for the return of the evacuees. Since the storm came no nearer, damage from Typhoon Mary was relatively light. As the storm moved on to the west, plans were made to begin returning the evacuees to Enewetak on the next day.[76]

The evacuees began arriving at Guam at approximately 1145 hours on 26 December and were taken to the Anderson AFB gymnasium. There, customs, central locator, and American Red Cross services were provided. Following in-processing, personnel were fed at the base dining hall and tranported to billets. Billets were provided at Anderson AFB, three Navy bases, and four local hotels.

Lieutenant Colonel Edwin Dodd, the JTG J-2, was designated Commander of the Evacuation Element. At Guam, Colonel David N. Gooch, USAF, Commander of the 43rd Combat Support Group, Anderson AFB, directed local support activities and provided office space and facilities for the Enewetak Evacuation Control Center. At the center, communications were established with Enewetak, Field Command, and other involved activities to plan and coordinate return of the evacuees. The first return airlift was scheduled to depart Guam at 0500 hours on 27 December. The control center began attempting to locate and notify the returnees of the departure time the previous afternoon before some of them had been able to find billeting. A sudden change in circumstances made early return advisable. Typhoon Mary had changed course and was headed toward Guam.

The first returning aircraft departed Guam the next morning on schedule. That flight carried life-support and equipment repair crews and other essential support personnel. The aircraft were configured for normal passenger seating for the return flights. Three flights the following day returned 391 personnel to Enewetak. The next flights were delayed by typhoon alert conditions on Guam. On 30 December, the last of the returnees arrived.[77]

Typhoon Mary damage at Enewetak facilities was limited to broken windows and wind-damaged doors, siding, and roofing, plus damage to two pilings on the personnel pier. The most serious loss was three causeway sections, which broke loose from their moorings at Billae (Wilma) and were carried out to sea. Typhoon Mary damage was modest because the storm center passed well to the south of the atoll, and the winds and seas approached the base camp islands from the ocean side rather than the lagoon side. Thus, the heavy waves generated by the shallow lagoon floor were directed away from the eastern islands where the base camps were located and the lagoon side of these islands where most of the JTG's watercraft were moored. As a result, the base camps and watercraft were relatively protected. The atoll was not so fortunate for the next storm, which came from the opposite direction.

TROPICAL STORM NADINE: JANUARY 1978

By 6 January 1978, Enewetak Atoll had nearly recovered from the effects of Typhoon Mary when, shortly after noon, the wind rose out of the northwest to 20 knots, with gusts to 30 knots. Sea conditions in the lagoon became choppy, and heavy rain squalls intermittently swept across the atoll. Reports from the Navy's Fleet Weather Central in Guam forecast similar conditions for the next 24 hours. The weather was thought to be resulting from a normal storm system and was not considered to be cause for undue concern. However, as a precautionary measure, the Friday cargo aircraft was grounded at Enewetak.

At 1830 hours that evening, a Boston whaler, which was used to carry crews to and from the LCU anchorage in the lagoon, was caught by a heavy swell, parted its mooring at the Enewetak personnel pier and was driven onto the beach. Conditions were worsening and it was decided to leave the crew on the LCU until morning. During the night, another LCU, which was loaded with 70 tons of contractor scrap from Medren, began to drag anchor wire from its winch drum. The weight of the loaded LCU gradually overcame the winch brake and, by 2200 hours, the LCU was on the beach.

Weather and sea conditions remained the same through 7 January, except for a brief respite that afternoon. The lull was used to deliver essential supplies to Lojwa Camp via LCU. No damage had been reported to facilities at either base camp; however, all cleanup operations had come to a standstill. At this point, the weather was still believed to be the result of a normal storm system.

On 8 January, conditions improved slightly, and two more boat runs were made to Medren in support of scrap removal operations. However, the next forecast from Fleet Weather Central upgraded the system to a tropical depression centered about 150 nautical miles south-southwest of Enewetak, with winds near 26 knots gusting to 30 knots. Hazardous surf conditions of 7 to 10 feet were forecast for Sunday (9 January) and Monday. The tropical depression was expected to pass Enewetak about 0100 hours on Sunday.[78]

On 9 January, conditions gradually worsened. The Navy Element secured all beached craft as well as possible. That afternoon, the tropical depression was upgraded to tropical storm status and code named Nadine. At 1545 hours, one of the landing craft at Lojwa Camp broke loose and drifted north. The wind had shifted to the southwest and was coming across the lagoon, building up waves and smashing them directly on the lagoon beaches of the inhabited islands. Winds rose to 40 knots, and seas rose to 12 feet. The cargo pier, normally 4 to 6 feet out of the water, was under 2 to 3 feet of heavy seas. Patrols reported extensive damage through the night. The garbage pier was completely demolished, the personnel pier was damaged, doors were blown away, windows were blown in, and the perimeter road became blocked with rocks carried in by the waves. Power was lost on the south end of Enewetak and personnel billeted there were relocated to the three-story barracks.[79]

The C-141 cargo plane, which had been unable to take off due to weather, was tied down to heavy equipment and remained undamaged. The boats were not as fortunate. During the night, two LCUs and two LCM-8s broke loose from their moorings off Enewetak and Lojwa Islands and drifted north. At first light on 10 January 1978, LCU-1552 was reported beached at Bijire and LCM-8295 at Aomon. Lojwa Camp personnel were able to beach LCM-8126 alongside LCM-8295 at Aomon and secured both to D8 bulldozers. LCM-6743 was beached on the ramp at Lojwa. At about 1245 hours, a Military Airlift Command aircraft overflew the atoll and reported sighting LCU-1505 on the reef south of Runit and LCM-8217 on the reef south of Lujor. Only two landing craft remained operational, the LCU loaded with scrap and an LCM-6 which had been intentionally beached at Enewetak. During attempts to put the LCM-6 in the water, the craft broached into the stern of another boat and was damaged to the extent it was inoperable. High winds prevented helicopter flights from carrying volunteer crews to salvage the other watercraft.

By 11 January, the worst was over. At first light, Navy repair crews were delivered by helicopter to the LCM and LCU which were aground on the northeast reef. The craft were further secured and temporarily repaired for removal from the reef.[80] An Army LARC mechanic, who happened to be at the atoll to provide preventive maintenance until the full LARC crews arrived, organized a volunteer crew and put one of the LARCs into operation to pull the two landing craft from the reef. This was the first of many times that this amphibious vehicle proved its enormous value and versatility.

Damage to Lojwa Camp was minimal, demonstrating again that the decision to construct more substantial facilities than the originally planned tents was a wise one. Food supplies had run low at Lojwa, but helicopters soon remedied that situation. At Runit, the old personnel pier was destroyed, but the newly constructed buildings were intact.[81]

The total damage to base camp facilities by Tropical Storm Nadine (Figure 4-15) was estimated at less than $100,000. However, the damage to watercraft was more severe. By extraordinary efforts, including special airlifts of personnel and equipment, the Navy had most of them back in action the following week when debris cleanup operations resumed.[82]

FIGURE 4-15. DEBRIS FROM TROPICAL STORM NADINE.

CHAPTER 5

DEBRIS CLEANUP

DEBRIS CLASSIFICATION

There were three basic classes of debris identified in the Environmental Impact Statement (EIS):[1]

a. Hazardous debris, consisting of items with hazardous radiation levels and items which were physical hazards such as dilapidated structures, derelict boats, and open manholes.

b. Obstructive debris, consisting of items which interfered with the proposed use of the islands, such as concrete pads.

c. Cosmetic debris, consisting of items which were neither hazardous nor obstructive but were simply unsightly.

Items were classified during the Enewetak Engineering Survey and identified in the Master Index to the survey report by location, classification, planned disposition, and agency responsible for disposition. In planning the Enewetak Cleanup Project and the Enewetak Rehabilitation Program, it was originally agreed that the Defense Nuclear Agency (DNA) would remove only hazardous debris and that the Trust Territory of the Pacific Islands (TTPI), as the rehabilitation agent for Department of the Interior (DOI), would remove obstructive debris. Cosmetic debris was not to be removed.

During joint TTPI-Field Command engineering surveys in 1976, the original agreement was modified to provide that the Department of Defense would remove all obstructive debris as well as hazardous debris on the nonresidential islands, in exchange for which DOI/TTPI would accomplish an equal amount of hazardous debris removal on the residential islands of Japtan (David), Medren (Elmer), and Enewetak (Fred). The exchange benefited both agencies. It limited DOI/TTPI work to three noncontaminated southern islands; it limited Field Command's radiological safety and control responsibilities on the nonresidential islands to cleanup project personnel; and it minimized duplication in staging and supporting work forces on the northern islands. As a result of these agreements, the Master Index was revised to indicate DNA responsibilities for removal of both obstructive and hazardous debris.

Hazardous debris was further classified as to radioactivity into three categories. The categories were determined by the disposal method authorized by Enewetak Standard Operating Procedures[2] which were based on American National Standards Institute draft Standard N328-1976, Table 1[3] as amended by the Department of Energy-Nevada

Operations Office (DOE-NV). The radiation measurements were net measurements, with the local soil used as the background reference. All measurements were averaged over 1 square meter, provided no individual reading exceeded three times the limit value. The numbers in the standard are given in terms of the absolute unit of disintegrations per minute (dpm). For operational purposes these were converted to counts per minute (cpm) under the area of the probe used for the measurement. Each category was assigned a color/disposal code to be used in marking the material with spray paint and to facilitate documentation and disposal, as follows:

Color (Disposal) Code	***Category***
Red (C - Crater)	Gamma radiation measurements, taken within 1 foot of the object, which were greater than or equal to 100 μR/hr.
Yellow (L - Lagoon)	Gamma radiation, measured within 1 foot of the surface, which was greater than 15 μR/hr but less than 100 μR/hr; or beta radiation which exceeded 5,000 dpm/100 cm^2 at contact or 540 cpm under the HP-210 probe; or alpha radiation which exceeded 1,000 dpm/100 cm^2 or 300 cpm under the AC-3-7 probe at contact.
Green (R - Release)	Of no radiological interest, that is, it was below all the limits for disposal as radioactive debris.

Red debris was disposed of by encapsulation in Cactus Crater. Yellow debris was disposed of at designated lagoon disposal sites. Green debris was disposed of by one of several methods authorized for noncontaminated material since it met the requirements for release and reutilization without control.

Within the Yellow (lagoon disposal) group, consideration was given to leaving certain debris in place if the only contaminant was beta radiation in excess of the Green debris limits. The Radiation Control Committee evaluated the measurements and made case-by-case recommendations based on the degree of hazard and effort required to remove the item.[4]

DEBRIS SURVEYS

The Enewetak Engineering Survey and Master Index generally identified all the major items on each island. However, to identify the exact location and current radiological condition of each item to be removed once the Joint Task Group (JTG) had established itself on the atoll, a detailed survey was conducted as the first step in the cleanup of each island. This detailed survey was conducted by the Field Radiation Support Team (FRST), under the supervision of the Radiation Control Division (J-2) HQ JTG. Individual survey teams were made up of a team leader, two or more radiation monitors, two data recorders, a surveyor, a truck driver, and one or more helpers. Team equipment included meters for detection of alpha, beta, and gamma radiation, radiation check sources, paint, poles with flags for marker stakes, tools (hammers, machetes, crowbars, etc.), surveying instruments, maps, photographs, camera and film, log books, chalk board, and the Master Index List for the island.

These surveys were planned to cover 15 acres per day. After bench marks were located or established, teams identified boundaries of the designated area which were marked by pole and flag. Parallel paths were selected to form a grid across the area at distances which would permit adequate inspection of the area between paths. Monitors and recorders walked the paths searching for debris. Paths varied depending on terrain features and vegetation. Operation of exposure-rate meters by monitors gave a measure of background radiation. When debris or concrete structures were encountered, the radiological character was determined, and the items were marked with red, yellow, or green spray paint as appropriate. These markings indicated to the debris cleanup team how each item was to be treated for cleanup and disposal.

DEBRIS RECLASSIFICATION

In March 1978, it was discovered that some concrete structures had been marked with green paint (i.e., no radiological interest) although the debris surveys bore readings which indicated they should have been marked with yellow paint for lagoon disposal. Investigation revealed that the survey teams had misinterpreted the debris classification directive which contained units of measure unlike those on the field instruments. The directive was revised, and all mismarked debris was located and remarked.

The resurvey resulted in reclassification of several concrete structures on Enjebi (Janet), Boken (Irene), Aomon (Sally), and Bijire (Tilda) from green to yellow. The estimates of contaminated debris removal were increased thereby from 7,300 to 19,000 cubic yards. The increase for Enjebi alone was 7,700 cubic yards. Much of the contamination which resulted in the reclassification was surface beta. Several methods, including sandblasting and chipping, were employed to remove the surface contamination and leave otherwise harmless structures intact.[5,6]

DEBRIS CLEANUP PROCEDURES

Debris cleanup procedures were determined by the radiological condition of the item and the disposition code shown in the Master Index[7] for that item (Figure 5-1). When items were not listed or when special procedures were required, determinations were made at the appropriate level of command. Most debris cleanup simply required collection and disposal.

The U.S. Army Element (USAE) was responsible for collection of debris located on land; i.e., inland from the high tide line. Debris was picked up by hand or with various types and sizes of engineer equipment, loaded on trucks, and offloaded at stockpiles (Figure 5-2). Stockpiles were established for reutilization, burning, or transport by boat. Oversize debris

CODE = RECOMMENDED DISPOSITION
(EXTRACTED FROM ENGINEERING STUDY MASTER INDEX)

01 = PROJECT NO LONGER REQUIRED.
02 = ACCOMPLISH BY SALVAGE CONTRACT.
03 = REMOVE TO CONTAMINATED BURIAL SITE.
04 = LEAVE IN PLACE.
05 = BURY DEBRIS AT EXISTING LOCATION.
06 = REMOVE DEBRIS TO ON ISLAND DISPOSAL AREA.
07 = REMOVE TO OPEN WATER DISPOSAL AREA.
08 = BACKFILL.
09 = DISMANTLE - STOCKPILE FOR DESIGNATED FUTURE USE (I.E., REHAB OF BUILDINGS, FIREWOOD, ETC.).
10 = NOT USED.
11 = REMOVE DEBRIS AND BACKFILL.
12 = SALVAGE AND LEAVE RUBBLE IN PLACE.
13 = SALVAGE AND REMOVE RUBBLE TO DISPOSAL AREA. LEAVE BASIC STRUCTURE AS IS.
14 = REMOVE HAZARDS, I.E., CUT OFF STUBS, ETC.
15-19 = (CODES NOT USED).
20 = DNA USE DURING CLEANUP AND LEAVE AFTER CLEANUP.
21 = DNA USE DURING CLEANUP AND REMOVE AFTER CLEANUP.
22 = DNA USE DURING CLEANUP AND REMOVE, BUT LEAVE SLAB.
23 = DOI USE DURING CLEANUP AND LEAVE AFTER CLEANUP.
24 = DOI USE DURING CLEANUP AND REMOVE AFTER CLEANUP.
25 = DOI USE DURING CLEANUP AND REMOVE, BUT LEAVE SLAB.
26 = DNA USE FOR PARTS AND REMOVE SLAB.
27 = DNA USE FOR PARTS AND LEAVE SLAB.
28 = DOI USE FOR PARTS AND REMOVE SLAB.
29 = DOI USE FOR PARTS AND LEAVE SLAB.

FIGURE 5-1 HAZARDOUS DEBRIS DISPOSITION CODES

FIGURE 5-2. DEBRIS LOADING OPERATION.

was disassembled or broken up for collection and transport using engineer tools or demolitions.

The Water-Beach Cleanup Team (WBCT) of the U.S. Navy Element (USNE) was responsible for collection of debris located offshore; i.e., from the high tide line on the beach out to a depth of 15 feet in the water at low tide. During the course of the project, five methods were successfully used to extract debris from the offshore areas (Figure 5-3). As in the case of land operations, it was often necessary, prior to removing the debris from the water, to reduce it to a size which could be handled by the personnel and equipment available. These activities were conducted by the USNE's Explosive Ordnance Disposal (EOD) personnel who assisted WBCT debris removal operations.

The basic method of debris extraction from offshore areas was by manual removal (Figure 5-4). When the debris was small enough to be handled by one or two divers, they would remove and carry the debris to beach stockpiles. Once on shore, debris was transported to larger stockpiles by the USAE for subsequent removal to dump sites. This procedure was used on virtually all islands of the atoll.

A second method involved the use of divers offshore in combination with a D8 dozer with winch onshore. This method was used when the debris was larger than could be handled by one or two divers and in areas inaccessible to Navy watercraft. The cable from the winch was connected

METHOD	EQUIPMENT/PERSONNEL	CAPACITY	WHEN USED	REMARKS
1	WBCT divers - no special equipment.	NA - Small items only.	Anytime when current permitted diving.	Used on all islands.
2	Dozer w/winch or trucks, bucket loaders, w/cable, WBCT divers.	N/A	Large pieces of debris located in areas inaccessible to LCM-8, but within winching distance of an island.	Slow operation, restricted to pulling capacity of winch* or other equipment.
3	LCM-8 w/winch and A-frame. WBCT divers.	5-20 CY**	Large pieces of debris located in area accessible to LCM-8.	Slow operation, restricted to lift capacity of winch.* Often offloaded directly at dump site.
4	USAE LARC-LX w/winch. WBCT divers. LARC crew.	10-25 CY**	Debris located in area inaccessible to modified LCM-8 and out of winch range from nearest island. In remote areas.	Slow operation, restricted to pulling capacity of winch.* Often offloaded directly at lagoon dump site.
5	2-90 ft Navy causeway sections connected to form 180 ft floating platform. One Army 12½-ton crane. Crane operator. WBCT divers.	200-300 CY**	Debris located in area accessible to floating platform and warping tug or LCM-8.	Most efficient use of resources and time. Restricted to lifting capacity of 12½-ton crane.*

*When debris was larger than could be accommodated, US Navy underwater EOD personnel explosively sectioned the debris.
**Dependent upon debris configuration and cargo space.

FIGURE 5-3 OFFSHORE DEBRIS COLLECTION METHODOLOGY

FIGURE 5-4. MANUAL DEBRIS REMOVAL.

to the debris by WBCT divers, and the debris was winched from the water to the shore. Other USAE equipment was also used to pull the debris to the shore. Again, USAE transported the debris to beach stockpiles.

The third method involved the use of a modified landing craft, mechanized (LCM-8) equipped with a powerful winch and A-frame (Figure 5-5). As in the second method, divers connected the winch cable to the debris and the debris was hoisted aboard the LCM-8 (Figure 5-6). When the space was full (approximately 5-20 cubic yards), the LCM-8 either moved the debris to a beach stockpile area where USAE equipment offloaded the craft or moved the debris directly to an authorized lagoon dump site.

The fourth method employed to collect offshore debris utilized the Army lighter, amphibious resupply, cargo (LARC-LX). This method was used where the debris was located far from operational sites, where there were accessibility problems for the modified LCM-8 craft, or when the debris could not be winched to the nearest island. As in other procedures, divers connected the winch cable from the LARC-LX and the debris was pulled on board (Figure 5-7). When the cargo space was full, the LARC-LX either moved debris to dump sites or to beach stockpiles (Figure 5-8). This method proved to be highly successful during the final stages of debris cleanup operations.

The fifth and final method again combined USAE and USNE resources and was by far the most efficient debris removal method in the offshore

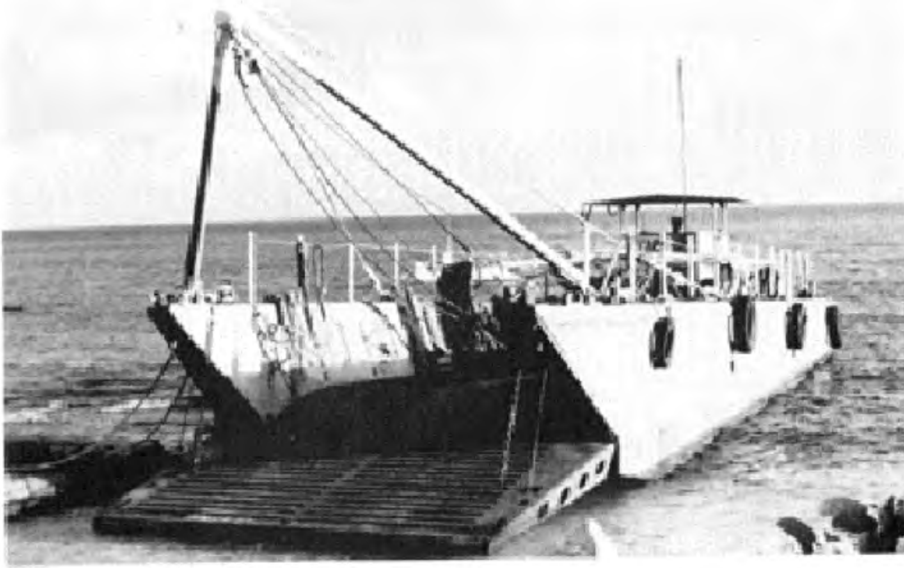


FIGURE 5-5. LCM-8 WITH WINCH AND A-FRAME.

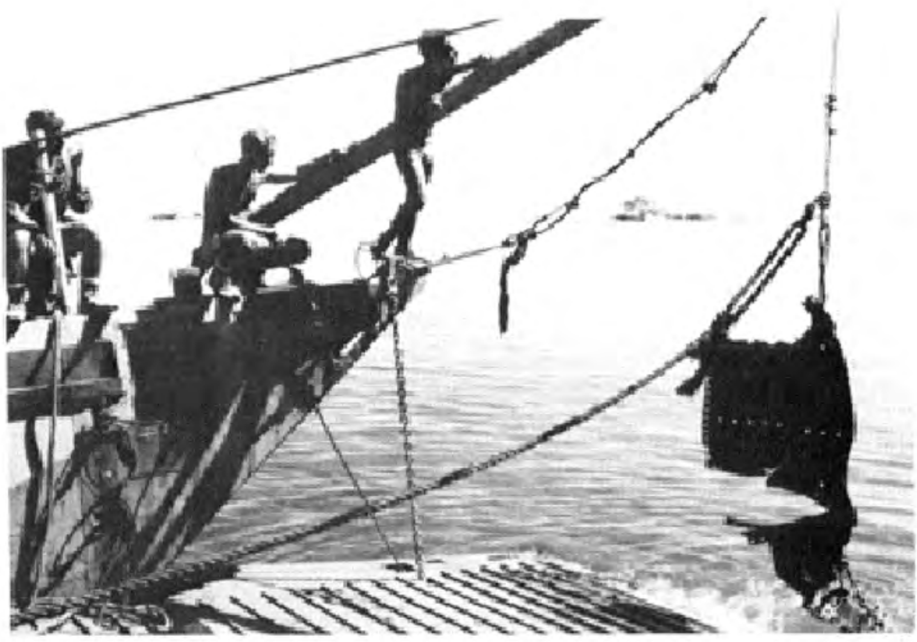


FIGURE 5-6. DEBRIS LOADING, LCM-8.

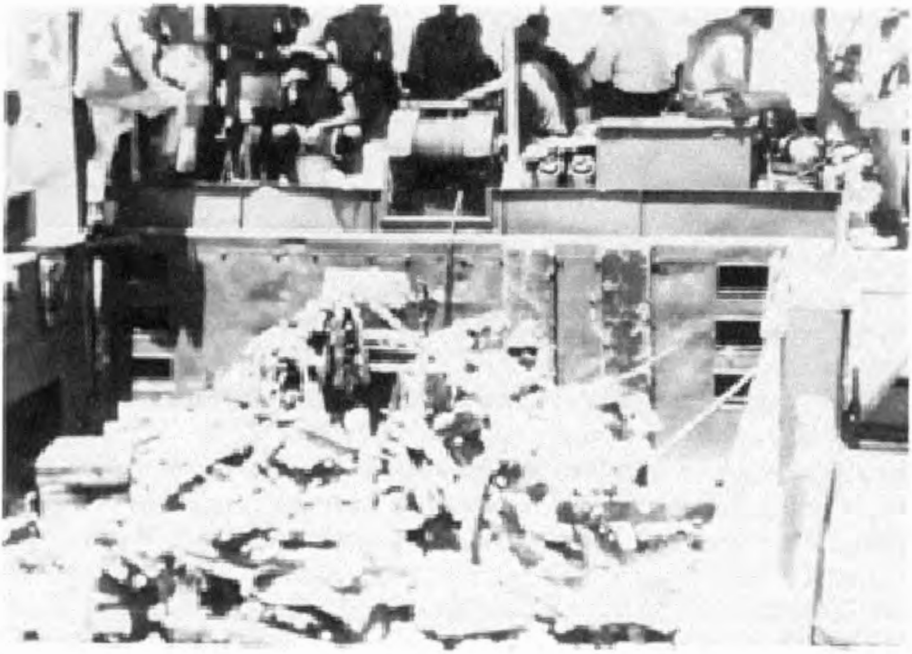


FIGURE 5-7. DEBRIS LOADING, LARC-LX.

FIGURE 5-8. DEBRIS STOCKPILE ON BEACH.

to the debris by WBCT divers, and the debris was winched from the water areas. This method employed two 90-foot causeway sections joined to form a 180-foot floating platform, and a 12-1/2-ton crawler crane with a clamshell which was positioned on this floating platform (Figure 5-9). The platform was moved to the vicinity of the debris by Navy watercraft and anchored. WBCT divers located and marked the debris. Thereafter, the crane operator removed the debris from the water and placed it on the floating platform. In this method, approximately 200-300 cubic yards of debris could be loaded on the causeway, and the causeway then transported by a warping tug or LCM-8 to an authorized lagoon dump site where the crane offloaded the debris. This method eliminated double and triple handling and was used extensively during the offshore cleanup of the island of Enewetak in August and September 1979.

Extensive use of explosives was required in the disposal of debris. It had been estimated that 219,297 pounds of various munitions would be required. However, 362,864 pounds were bought and stored in bunkers on Medren for use, and 345,050 pounds were actually used by Army and Navy demolition teams in the cleanup.

Debris items which could not be collected and removed, such as concrete bunkers, were sealed or otherwise treated to eliminate hazards. These special procedures are described in subsequent sections covering the islands where such cleanup was required.

FIGURE 5-9. FLOATING PLATFORM DEBRIS REMOVAL.

DEBRIS TRANSPORT

Debris identified for disposal by crater containment or lagoon dumping was transported to the disposal sites by various modes depending on access channels, beach trafficability, and available resources. The transport procedures evolved as experience was gained (Figure 5-10).

The earliest method used was to transport loaded 20-ton dump trucks to disposal sites on either LCM-8s and/or LCUs (landing craft, utility). The 20-ton trucks (average capacity 10 cubic yards) were loaded at the beach stockpiles, driven onto an LCM-8 (one per boat) or LCU (six per boat), and transported to the disposal site. Red debris was offloaded at Runit by dumping the contents into trenches prepared to stockpile contaminated debris. Yellow and green debris were offloaded by two 12-1/2-ton cranes aboard a barge anchored at the lagoon disposal site (Figure 5-11). This method was very hard on the trucks and was extremely time-consuming for the relatively small amounts of debris moved.

When islands were inaccessible to naval craft, the debris trucks were loaded on the LARC-LXs and transported to the lagoon dump sites or to Runit as appropriate. The LARC-LX could transport only one 20-ton truck per trip. This method was also very time-consuming.

A bulk-haul method using LCM-8 landing craft was developed to transport debris to lagoon disposal sites. The LCM-8 decks and bulkheads were lined with heavy lumber. Debris was loaded into the boats directly from dump trucks or by bucket loaders from beach stockpiles The boats were offloaded by the barge-mounted cranes at the dump sites. An average of 30 cubic yards per trip could be moved by this method, which was used extensively during the cleanup of Enjebi.

A second bulk-haul method employed an LCU landing craft containing a plate steel box which originally had been designed to haul contaminated soil. A 20-foot section was cut from one side of the box, and the deck was covered with heavy lumber (Figure 5-12). The boat was loaded either by direct dumping from the trucks or with loaders. The loaders remained on board and were used for offloading the LCU at the lagoon dump site (Figure 5-13). This method permitted the transportation of approximately 100 cubic yards of debris per trip. It was used for the first time on Enjebi. Loading/offloading by this method took approximately 2 hours for each operation.

The third bulk-haul method of transporting debris utilized a YC-type barge. This procedure was used only on Enewetak and Medren islands, which had access for naval craft to a pier from which loading could be accomplished. The barge was modified with four 3-foot-high steel walls around the outside edge to contain the debris. Barge capacity was 300 to 500 cubic yards depending on configuration of the debris Debris was

METHOD	LOAD		LAGOON TRANSPORT		OFFLOAD					
	EQUIPMENT	TIME (est)	EQUIPMENT	TIME*	EQUIPMENT	TIME (est)	QUANTITY**	TIME*	WHEN USED	REMARKS
1	20 ton dump truck and 2½ CY front loader (approx 10 CY debris)	10 15 min	LCM 8 (One 20 ton per boat) LCU (Six 20 ton per boat) LARC LX (One 20 ton per boat)	30 50 min 30 50 min 30 50 min	YC barge anchored at dump site w 2 USAE 12 ton cranes	30 30 min 90 120 min 20 30 min	10 CY 60 CY 10 CY	1 1 5 hr 2 3 hr 1 1 5 hr	Beach accessible to LCM 8 Beach accessible to LCU Beach inaccessible to naval craft	Initially approved method Very slow and demanded maximum use of assets with minimum results
2	Dump trucks and 2½ CY bucket loader loading direc ly into modified LCM 8	20 30 min	Modified LCM 8	30 50 min	YC barge anchored at dump site w/2 12½ ton cranes	10 15 min	30 CY	1 1 5 hr	Beach accessible to LCM 8	First innovation Eliminated need for 20 ton truck on board LCM 8 and increased efficiency but caused extensive damage to LCM 8
3	20 ton dump trucks and 2½ CY bucket loader loading directly into modified bulk haul LCU	45 90 min	Modified LCU	30 60 min	2 CY bucket loader	50 70 min	100 CY	2 3 5 hr	Beach accessible to LCU	Eliminated use of 20 ton dump trucks on board LCU and increased efficiency
4	US Navy YC barge with 3 foot walls installed and US Army 12½ ton crane w clamshell on board	8 10 hr	YC barge towed to dump site by US Navy warping tug LCM 8 or LCU depending on availability	30 60 min	12½ ton crane on board	8 10 hr	300 500 CY	16 21 hr	Pier available accessible to US naval craft	Debris was pushed out onto pier using dozer or bucket loader and loaded on board YC barge w 12½ ton crane w clamshell
5	US Navy BC barge with dozer on board loaded using 20 ton dump truck beds and 45 or 90 ton long boom crane	4 6 hr	BC barge towed to dump site by US Navy warping tug or LCM 8	30 60 min	Dozer on board to push debris over side of BC barge	45 60 min	500 700 CY	5 8 hr	Improved pier with 45 or 90 ton long boom crane available Accessible to US Navy warping tug or LCM 8	Most efficient use of resources but restricted to Enewetak Island

*Dependent upon island distance from authorized dump site
**Dependent upon configuration and density of debris

FIGURE 5-10. DEBRIS TRANSPORT/DUMPING METHODOLOGY

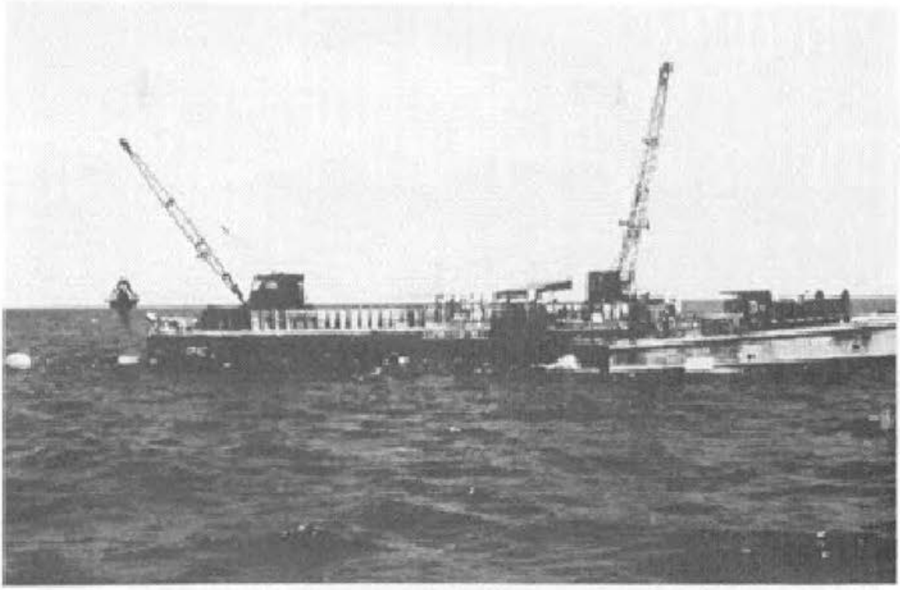


FIGURE 5-11. YELLOW/GREEN DEBRIS OFFLOAD OPERATION.

FIGURE 5-12. LCU BULK HAUL CONFIGURATION.

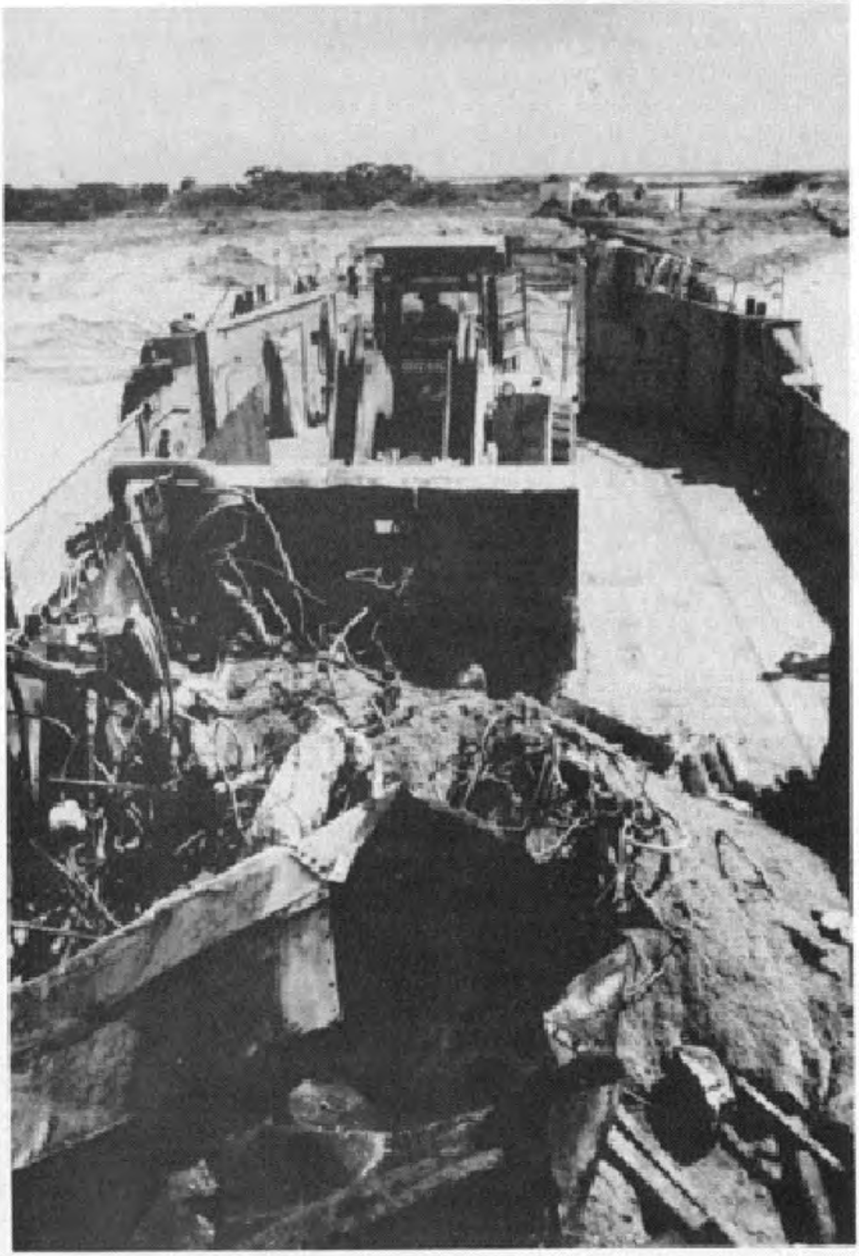


FIGURE 5-13. LCU BULK HAUL OFFLOADING OPERATION.

moved onto a pier from stockpiles using either a dozer or a loader and loaded onto the barge by a crane which was prepositioned on the barge (Figure 5-14). The barge was then towed out to the dump site, secured to the buoy marking the site, and offloaded with the crane (Figure 5-15). Normally the loading/offloading consumed 8 to 10 hours for each operation. This method was used to move most of the debris from Medren from November 1778 to May 1979.

The last and most efficient method of transporting noncontaminated debris employed a BC-type barge with a bulldozer aboard. This method was developed for use at Enewetak Island where there was a substantial cargo pier and a large volume of debris identified for lagoon disposal.

Numerous innovations were necessary to achieve maximum efficiency in the loading operation. One was the removal of dump beds from uneconomically repairable 20-ton dump trucks. These beds could easily be moved to and from stockpiles by a tractor-trailer in a loaded/unloaded configuration. Debris-loaded dump beds were emptied onto the barge at Enewetak with 45-ton or 90-ton longboom cranes (Figure 5-16). By judicious placement of loads on the barge, much higher capacities were reached. Up to 700 cubic yards were loaded on a barge, with average loads of 500 cubic yards. Loading time ranged from 4 to 6 hours. Offloading took less than an hour with the bulldozer pushing the debris off the barge at the lagoon disposal site.

FIGURE 5-14. DEBRIS LOADING ON A BARGE.

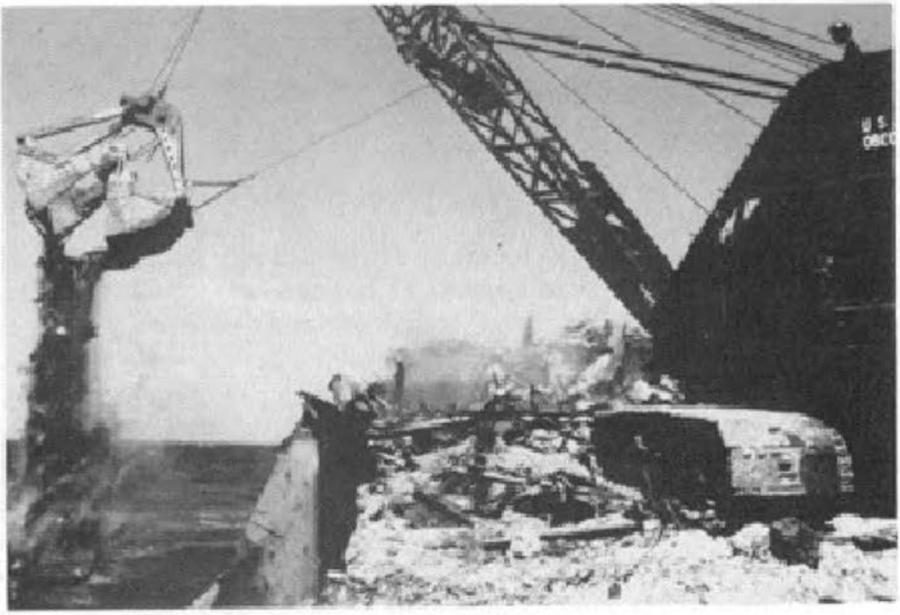


FIGURE 5-15. DEBRIS OFFLOADING AT DUMPSITE.

FIGURE 5-16. DUMP BED OFFLOADING.

DEBRIS DISPOSAL

Disposition of debris was based on the radiological condition of the item and its disposition as indicated in the Master Index. Red debris was disposed of by crater containment as described in a subsequent chapter. Green debris was left in place or otherwise disposed of as noncontaminated material. Yellow debris and some green debris were disposed of by dumping at the nearest site designated in the permit issued by Pacific Ocean Division, Corps of Engineers, for disposal of material in the lagoon.[8] There were three such sites: Site Alpha (A) off Enewetak Island, Site Bravo (B) off Runit (Yvonne) Island, and Site Charlie (C) off the coast of Enjebi as illustrated in Figure 5-17.

Disposal of hazardous ordnance (ammunition, projectiles, grenades, bombs, etc.) from World War II battles at Enewetak was carried out by trained EOD experts, as described in Chapter 4.

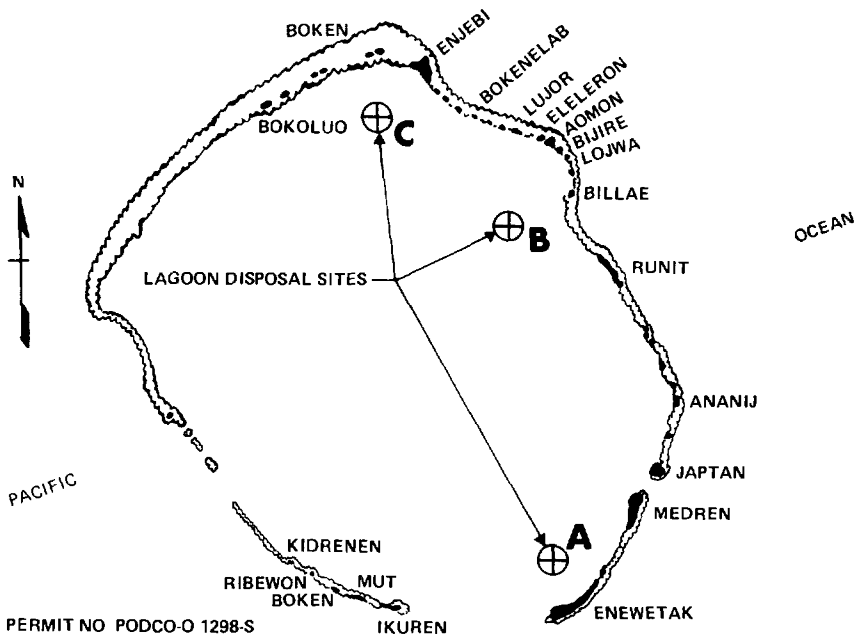


FIGURE 5-17. LAGOON DISPOSAL SITES.

NORTHERN ISLAND DEBRIS CLEANUP BEGINS

Debris cleanup for each island is described in the following sections. Cleanup of a particular island was not continuous in all cases Priorities were adjusted periodically to insure the optimum use of critical personnel and equipment resources.

When the Army and Navy Element Commanders were satisfied that debris cleanup was complete on each island, they reported this to the Commander, JTG (CJTG). He then inspected the entire island in close detail by helicopter and on foot. Only when he was satisfied as to its clean condition did he accept the debris cleanup as complete These acceptances were subsequently recorded as signed certificates for each island

Debris removal operations began on Lujor (Pearl) on 15 November 1977 and continued on some of the northern islands while soil cleanup criteria and priorities were being reviewed. By the first of December 1977, debris removal operations were underway on Lujor, Bokenelab (Mary), and Taiwel (Percy). Taiwel was the first island on which cleanup was completed

TAIWEL (PERCY) ISLAND CLEANUP

Taiwel consists of 5 acres of sandbar supported by coral shoals with very little vegetation. A small amount of scattered scrap and a portable building which had been used as an underwater cable terminal were all that remained when the island was surveyed for cleanup. No radioactive material burial sites were known to exist on the island. In planning documents, Taiwel was identified for food gathering; however, the actual use planned by the people was for occasional visitation.[9]

The debris survey in September 1977 found no contaminated debris, and the island was decontrolled on 7 October 1977 Noncontaminated debris cleanup began 25 November 1977. On 4 December 1977, the building was soaked with diesel fuel and set afire The remaining debris (2 cubic yards—noncontaminated) was removed on 5 December 1977.[10]

BOKENELAB (MARY) ISLAND CLEANUP

Bokenelab, a small island in the northeast sector, consists of 12 acres and was used as an instrumentation base during Operations Greenhouse, Ivy, and Hardtack. Vegetation was sparse to moderate. There were some concrete and wood-framed, metal-clad structures remaining. There were 24 Master Index items, including an estimated 272 cubic yards of noncontaminated debris. There were no ground zeroes on this island, and no radioactive materials were known to exist The planned use for Bokenelab was food gathering.[11,12]

The debris survey in September 1977 found no contaminated debris, and the island was decontrolled on 7 October 1977 Noncontaminated debris cleanup began on 13 December 1977 and was completed on 8 February 1978. One hundred fifty eight cubic yards of noncontaminated debris were removed.[13,14]

No debris was found on the nearby islet known as Mary's Daughter (code name Fern), and the island was decontrolled on 5 October 1977.[15]

LUJOR (PEARL) ISLAND DEBRIS CLEANUP

Lujor consists of 54 acres and was the location of the Inca event during Operation Redwing. Vegetation was moderate to heavy around the perimeter, while the interior had a grass sedge cover among the shrubs Hazardous debris included several concrete anchor blocks, steel pipe, rails, plates, miscellaneous metal scrap, and a large quantity of metal mat which had been placed during the Inca event to minimize the dust cloud. No radioactive burial sites were known, however, as a ground zero was located on Lujor, it was assumed that some actions in recovery operations or in the protection of personnel from exposure may have covered radioactive materials or areas There were 20 Master Index items, including an estimated 29 cubic yards of noncontaminated debris and 317 cubic yards of contaminated debris. The planned use for Lujor was agriculture [16]

Debris cleanup began on 15 November 1977. On 22 February 1978, debris cleanup was declared complete;[17] however, an inspection in February 1979 discovered several items of red debris in the windrows of brush which had been cleared during the initial soil survey. These were removed during soil cleanup operations. In all, 16 cubic yards of noncontaminated debris and 255 cubic yards of contaminated debris were removed.[18] Decontrol of the island depended upon soil cleanup, described in Chapter 7.

No debris was found on the nearby islet known as Pearl's Daughter (code name Gwen)

AEJ (OLIVE) ISLAND CLEANUP

Aej consists of 40 acres and was used as an instrumentation site during Operation Castle Vegetation on the lagoon side was dense, tall brush, while the ocean side was more open. No ground zeroes were placed on Aej and no radioactive burial sites were known. Hazardous debris included a concrete bunker, pieces of pipe, and other metal scrap. There were three Master Index items, including approximately 1 cubic yard of noncontaminated debris. The planned use for Aej was agriculture.[19]

Debris cleanup began on 20 February 1978 and was completed on 21 March 1978. Approximately 1 cubic yard of noncontaminated debris was removed from the island. Forms were built around the bunker opening and filled with concrete from a ready-mix truck to seal the bunker.[20] The other two Master Index items identified in the survey were removed. Aej was decontrolled on 2 March 1978.[21]

BILLAE (WILMA) ISLAND CLEANUP

Billae consists of 14 acres and was used for scientific recording stations. It had no ground zeroes, and no radioactive material burial sites were known to exist. Vegetation was moderate to dense. There remained a wind indicator pole, two submarine cable terminals, and miscellaneous wood and metal debris to be removed. There were also several concrete pads which were to be left in place. There were 21 Master Index items, including an estimated 88 cubic yards of noncontaminated debris. The planned use for Billae was food gathering.[22]

The debris survey in August 1977 found no contaminated debris, and the island was decontrolled on 7 October 1977. Debris cleanup began on 5 January 1978 and was completed on 26 February 1978. The wind indicator pole was cut down by explosive demolition on 12 January 1978. Sixty-four cubic yards of noncontaminated debris were removed.[23]

ALEMBEL (VERA) ISLAND CLEANUP

Alembel consists of 38 acres and was used as a scientific station during nuclear testing. It was densely vegetated with tall palm trees. No ground zeroes were located on Alembel. Debris included a 4-foot wide, 20-foot long concrete building which had contained laboratory animals, a concrete cable vault, and pieces of corroded pipe. There were four Master Index items, including an estimated 25 cubic yards of noncontaminated debris. The planned use for Alembel was agriculture.[24]

Debris cleanup began on 19 January 1978 and was completed on 3 March 1978. Approximately 1 cubic yard of noncontaminated debris was removed.[25]

ELLE (NANCY) ISLAND CLEANUP

Elle consists of 11 acres and was not used during nuclear testing. Vegetation included a dense stand of shrubs 8 to 12 feet tall and a dozen coconut palms. The only hazardous debris was one Master Index item, a piece of pipe projecting from the beach. The planned use for Elle was food gathering.[26]

Debris cleanup began on 6 March 1978 and was completed on 19 March 1978. The piece of pipe was removed by explosive demolition, after which there was a police up of small debris. Less than 1 cubic yard of noncontaminated debris, including the one Master Index item, was removed.[27]

BOKEN (IRENE) AND BOKAIDRIKDRIK (HELEN) ISLANDS DEBRIS CLEANUP

Boken, and Bokaidrikdrik which adjoins it on the southwest, are comprised of 45 acres and constitute the northernmost landmass of the atoll. They were used for the ground zero of the Seminole shot during Operation Redwing. This event created a crescent shaped shoreline along the western edge of Boken and a large, water-filled crater, 650 feet in diameter, where the event occurred. All that was left of Bokaidrikdrik was a 5-acre sandspit bordering the water-filled Seminole Crater. For practical purposes, there is only one island remaining. Boken also was affected by the Mike and Koa thermonuclear events but no burial sites for radioactive scrap were known to exist. However, large amounts of contaminated soil were suspected to be buried, impacting on the soil cleanup operations described in Chapter 7. Vegetation varied from medium to dense. Hazardous debris included three corrugated metal arch structures, five concrete bunkers, and miscellaneous metal scrap. There were an estimated 1,312 cubic yards of noncontaminated debris, including 24 Master Index items on Boken and 2 on Bokaidrikdrik. The planned use for Boken was food gathering.[28,29]

Debris cleanup began on 4 January 1978 and was completed on 12 July 1978. There were 1,905 cubic yards of noncontaminated debris removed.[30] Two Master Index items, bunkers from the Ivy shot, located at stations 200 and 600, were discovered to bear relatively low-level beta contamination which could not be removed without major destruction of the concrete. Based on the well-fixed nature of the contamination, requests for disposition authority other than destruction were submitted, and several attempts were made to remove the beta contamination, nondestructively. Sand blasting removed some of the contamination, but was generally ineffective. Washing with acid and detergents proved valueless.[31]

The DOE-Enewetak Radiological Support Project (DOE-ERSP) manager was asked for advice. He recommended the following:[32]

a. No bunker should be demolished solely because of surface contamination.
b. Radiological considerations were no reason to seal a bunker.
c. Mechanical removal and pickup of easily removable material was suggested for contaminated surfaces.

On 20 June 1978, the Director, DNA visited the bunker sites, examined the contamination, and went over the radiation readings in detail. Based upon the DOE-ERSP advice, he decided that the Boken bunkers did not require further decontamination and were to be left in place[33] (Figure 5-18).

FIGURE 5-18. BOKEN BUNKER.

BOKOLUO (ALICE) ISLAND CLEANUP

Bokoluo, the most westerly of the northern islands of the atoll, contains 22 acres and was used for scientific observation and measurement stations during the nuclear test period. While it did not serve as a test site, some surface contamination resulted from fallout from nearby tests. Vegetation, consisting of brush interspersed with patches of heavy grass, was denser and taller on the west side. Hazardous debris included a derelict landing craft, reinforced concrete structures, a plywood shack, and miscellaneous scrap. There were an estimated 10 cubic yards of contaminated debris and 436 cubic yards of noncontaminated debris to be removed, and 14 Master Index items, of which 9 were planned for removal. Planned use for Bokoluo was food gathering.[34]

Debris survey by the FRST was conducted from 24 January through 10 February 1978 The majority of the debris bore no significant contamination and was marked for lagoon disposal. Cleanup began on 10 February 1978.[35] Several concrete structures were removed by explosive demolition in March 1978,[36] and debris removal was completed on 14 June 1978.[37] There were 1,575 cubic yards of noncontaminated debris and nine Master Index items removed [38]

BOKOMBAKO (BELLE) ISLAND CLEANUP

Bokombako contains 31 acres and was the site of a few scientific test stations used in Operation Greenhouse. It never served as an event site. Vegetation generally was quite dense, but thinned out toward the northeast end of the island Only a small amount of debris was found, including a cased well and a grade beam from a signal terminal station There were an estimated 6 cubic yards of noncontaminated debris to be removed and nine Master Index items. No contaminated debris was found. The planned use for Bokombako was food gathering.[39]

Debris cleanup began on 5 March 1978 and was completed on 9 June 1978. Twenty-eight cubic yards of noncontaminated debris were removed.[40]

MIJIKADREK (KATE) ISLAND CLEANUP

Mijikadrek has an area of 16 acres and was used extensively during Operation Greenhouse for photographic coverage and for structural effects testing. There were no ground zeroes on the island and no known burial sites. Vegetation ranged from moderately dense in the south to dense in the central and extreme northern portions. Debris included a considerable amount of brick and concrete rubble, several concrete slabs and structures, and miscellaneous metal scrap There were an estimated 1,049 cubic yards of debris to be removed, all noncontaminated, and 28 Master Index items. The planned use for Mijikadrek was food gathering.[41]

Debris cleanup began on 5 April 1978 and was completed on 16 June 1978 There were 1,073 cubic yards of noncontaminated debris removed.[42]

KIDRINEN (LUCY) ISLAND CLEANUP

Kidrinen consists of 20 acres. It was used for biomedical studies and sampling during Operation Greenhouse and for some instrumentation during Operations Ivy and Hardtack I. No test events were detonated here. Vegetation was dense except at the southern end. Hazardous debris included concrete blocks, slabs, and shelters, as well as miscellaneous concrete, brick, wood, and metal rubble. There were an estimated 61 cubic yards of debris to be removed, all noncontaminated, and 18 Master Index items The planned use for Kidrinen was food gathering.[43]

Debris cleanup began on 5 April 1978 and ended on 16 June 1978. There were 257 cubic yards of noncontaminated debris removed.[44]

LOUJ (DAISY) ISLAND CLEANUP

Louj contains 21 acres and was not used to any great extent during the test era. Vegetation was sparse on the lagoon side, dense on the ocean side. Louj had no ground zeroes and was relatively free of debris from nuclear testing. Only a small pipe used as a station in the Ivy operation, as well as other miscellaneous pipes, remained. The planned use for Louj was food gathering.[45]

Debris cleanup began on 26 April 1978 and was completed on 15 May 1978. Five cubic yards of noncontaminated debris were removed. There was no contaminated debris.[46]

BOKINWOTME (EDNA) ISLAND CLEANUP

Bokinwotme is little more than a sandbar with an area of something less than 10 acres. It was not used during the test era for scientific purposes. Vegetation was sparse. Comparison with 1952 maps and photos showed that the island underwent great physical change but not as a direct result of a nuclear event. The changes apparently resulted from alterations created by the removal of Elugelab (Flora) by the Mike event. There were no structures, contaminated or noncontaminated scrap, or burial sites on the island. The planned use for Bokinwotme was food gathering.[47] The island was accepted as clean of debris on 15 May 1978.[48]

KIRUNU (CLARA) ISLAND CLEANUP

Kirunu has a surface area of 7 acres and was the site of one large and several lesser scientific stations used during Operation Ivy. It was not a site for any nuclear events. Vegetation was reasonably dense. Hazardous debris included one concrete bunker, a derelict crane, and a small amount of metal debris. There were an estimated 112 cubic yards of noncontaminated debris to be removed and three Master Index items. The planned use for Kirunu was food gathering.[49]

Debris cleanup began on 26 April 1978 and was completed on 9 June 1978. Five hundred and five cubic yards of noncontaminated debris were removed.[50]

ELELERON (RUBY) ISLAND CLEANUP

Eleleron's physical configuration was altered so radically by test activities as to cause conflicting identifications of the island, even within the same report. As shown in Figure 5-19, the original island was almost as large as Lojwa (Ursula). The majority of the island, its entire center, was vaporized in two nuclear tests, the George shot in Operation Greenhouse and the Mohawk shot in Operation Redwing. This left a 4-acre island which was identified by the Enewetak Radiological Survey and Volume I of the Engineering Survey as Ruby and by the JTG as Ruby's Child or Ruby's Daughter (code name Xeno). It also left two segments connected to Aomon by a narrow causeway which was bordered on the lagoon side by a marsh. The marsh was filled with soil during preparations for the Pacific Cratering Experiment (PACE) in 1972, joining the two southeast segments of Eleleron to Aomon in a peninsula which now appears to be part of Aomon. This peninsula was identified as Eleleron in Volume II of the Engineering Study, in the Master Index, and in most of the JTG reports. All of the cleanup work described in this section took place on the peninsula. No cleanup was required on the other remnant of Eleleron [51,52,53] The Enewetak Radiological Survey regarded the island as a possible burial site because of the two ground zeros; however, both sites are now underwater.

Hazardous debris included 196 cubic yards of contaminated bulkhead rails, coaxial cables, and other metal scrap. Ten Master Index items were identified on the peninsula. The planned use for the island was food gathering.[54]

Debris cleanup began on 1 June 1978 and, by 8 July 1978, generally was completed except for small amounts of yellow and green debris.[55] These were removed on 10 July 1978 and dumped in the lagoon from a LARC.[56]

Two hundred and fifty cubic yards of contaminated debris and a minor amount of noncontaminated debris were removed.[57]

AOMON (SALLY) ISLAND DEBRIS CLEANUP

Aomon is comprised of 99 acres, including a man-made peninsula which connects it to remnants of Eleleron (Figure 5-19). Vegetation consisted of dense brush ringing grassy open spaces. The island was the site of three tower events, the Yoke event of Operation Sandstone and the Yuma and Kickapoo events of Operation Redwing (Figure 5-20). Aomon did not contain a large amount of exposed debris but did have known plutonium burial sites. Hazardous debris included concrete bunkers, footings, anchor blocks, submarine cable terminals, a wooden tower, and miscellaneous debris. There were an estimated 2,106 cubic yards of contaminated debris and 1,054 cubic yards of noncontaminated debris to be removed. There were 41 Master Index items on Aomon. The planned use for Aomon was agriculture.[58]

The radiological survey of Aomon was delayed by approximately 10,000 sooty terns which were nesting on the island. On 2 November 1977, a hot line was set up on Aomon and initial survey points were established.[59] Debris survey began on 8 December 1977.[60] On 16 January 1978, the USAE began sealing bunker doors with concrete.[61] Most of the debris cleanup was completed by 29 July 1978, although the final policing and

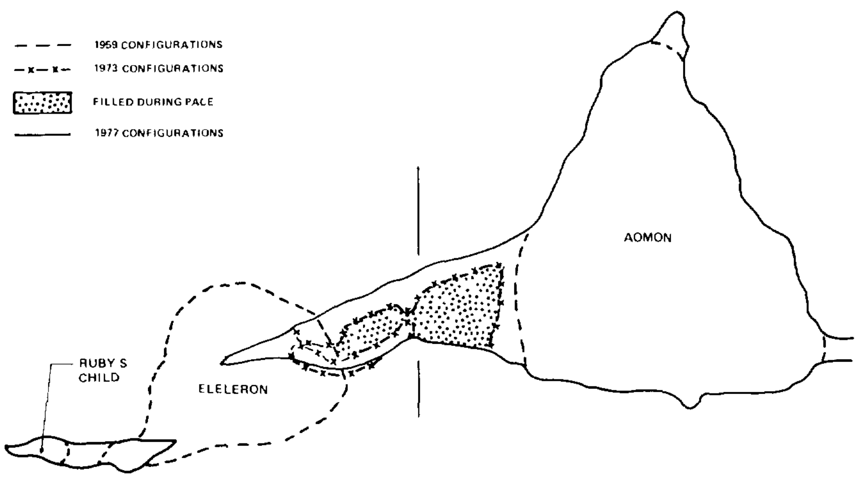


FIGURE 5-19 ELELERON - AOMON.

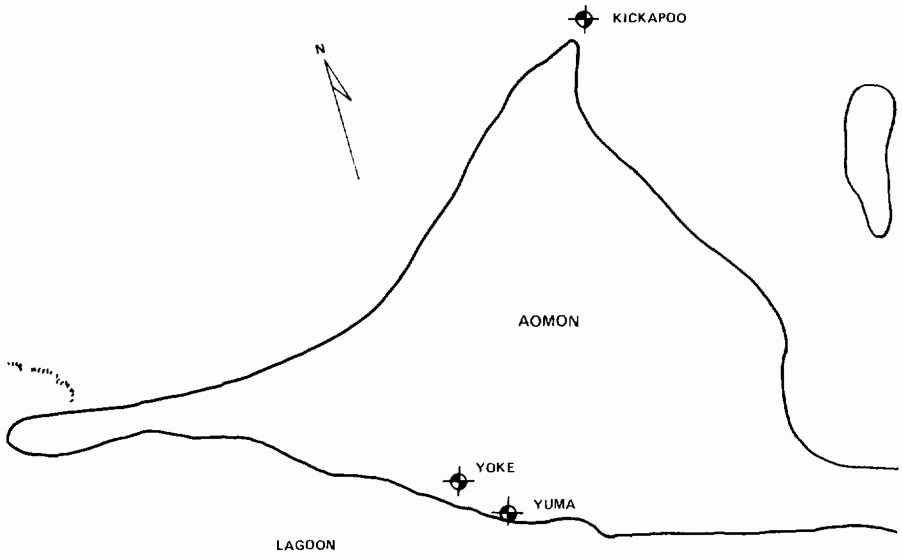


FIGURE 5-20. AOMON GROUND ZEROS

acceptance of the island was not completed until 28 September 1978.[62] Seven hundred and twenty-eight cubic yards of contaminated debris and 2,186 cubic yards of noncontaminated debris were removed.[63]

The EIS Case 3 cleanup mission required that plutonium be removed from three burial crypts on Aomon. Cleanup of the crypt on the causeway between Aomon and Bijire was primarily a soil cleanup effort and is described in Chapter 7. The other two were concrete blocks located near the Yuma and Kickapoo ground zeroes and bearing brass plaques identifying them as crypts. Research indicated that they were tower bases which had been covered with clean concrete to coat their contaminated surfaces. After intense discussion among DOE, USAE, and the JTG J-2 regarding color coding and disposition, the blocks were broken up by explosive demolition under the personal supervision of the Assistant J-2, Captain Nathan S. Mathewson, USA. They were found to have only weapon fuel plating on the previously exposed surfaces. Very little of the material was actually in yellow condition (the great majority being green). However, because it was associated with a ground zero and had been marked as a contaminated material burial site, it was coded yellow and disposed of in the lagoon.[64]

During the cleanup of the Kickapoo ground zero area, DOE personnel discovered several rock-like fragments which contained amounts of plutonium on the order of a few microcuries. They were similar to some found on Runit. This contamination was not enough to cause the area to exceed the 40 picocuries per gram of soil criterion. However, the concentration of a relatively large amount of plutonium in the small rocks caused concern. In early October 1978, personnel from J-2, DOE, and FRST visited the Kickapoo area to determine the distribution of the plutonium-contaminated fragments. Instruments sensitive to the gamma rays of americium-241 were found to be most useful for identifying the contaminated fragments. It was soon learned that plutonium was found only on fragments of a rusty color. The fragments were found mainly along the shore, probably washed there as a result of tidal action and storms. DOE personnel surmised that the fragments probably were condensed from molten fragments of the tower which originally supported the nuclear device and had been plated with plutonium. About 50 pounds of fragments were collected at this time and designated for disposal in the Cactus Crater. Since they were easy to identify, there did not appear to be very many of them, and they might become controversial in the future, it was decided that a team of FRST personnel supervised by JTG J-2 would collect all they could find. This search collected 100 pounds of the fragments, which were also placed in the Cactus Crater.[65] As a result of storms, some fragments continued to be found in the Kickapoo area well into the demobilization phase.[66]

Noncontaminated debris discovered on the nearby islet known as Sally's child (code name Zoe) during the FRST survey in April 1978 was removed by the survey team.[67] Restoration of the PACE test bed and the cleanup of the third Aomon Crypt are covered in Chapter 7.

BIJIRE (TILDA) ISLAND CLEANUP

Bijire consists of 52 acres and was used for photographic, instrumentation, and scientific stations during nuclear testing. It did not serve as a ground zero for any events and, although it accumulated some fallout from events on neighboring islands, it had no contaminated scrap. A 1,300-foot-long runway extended down the center of the island. Vegetation included Scaevola and Messerschmidia shrubs 10 to 15 feet tall with grassy clearings in the interior. Hazardous debris included several concrete bunkers and slabs, plus miscellaneous wood and metal scrap. There were an estimated 200 cubic yards of noncontaminated debris and 26 Master Index items. The planned use for Bijire was agriculture.[68] The debris survey by the FRST, completed on 31 October 1977, confirmed that there was no contaminated debris on the island.[69] It was decontrolled and used as an adjunct to the Lojwa Base Camp, primarily as the location for a burnable refuse dump.

Debris cleanup began on 8 June 1978 using an Army LARC to remove debris from the island for lagoon disposal.[70] Debris removal, completed on 23 July 1978, included 720 cubic yards of noncontaminated material.[71] The most significant efforts were the removal of the exterior hazards and sealing the openings of a large reinforced concrete photographic bunker (Greenhouse Station 100) which bore some beta contamination on the roof and wingwalls.[72] The bunker, 28 feet wide, 33 feet long, and 33 feet high, remains the tallest structure in the northern islands (Figure 5-21). Final cleanup of Bijire, including the burnable trash dump, was accomplished during cleanup of the Lojwa Base Camp.

ENJEBI (JANET) ISLAND DEBRIS CLEANUP

Enjebi consists of 291 acres, making it the second largest island in the atoll. Vegetation included dense growths of Messerschmidia up to 12 feet tall on the lagoon side and much sparser shrubs, including clumps of Scaevola, on other parts of the island. On the north end, the openings were filled with hummocks of dry grass. In other openings, morning glory vines crisscrossed the landscape.

Three nuclear tests were conducted on the surface of Enjebi, and it collected fallout from a total of 26 events. The island also served as the site of many scientific stations for other series of tests. Hazardous debris included reinforced concrete test structures and bunkers, concrete anchor blocks and slabs, wooden towers, a contaminated runway parking area,

FIGURE 5-21. GREENHOUSE STATION 100.

wells, and miscellaneous scrap Only the base camp islands exceeded Enjebi in the amount of noncontaminated debris There were an estimated 19,884 cubic yards of noncontaminated and 568 cubic yards of contaminated debris to be removed There were 166 Master Index items, plus the largest amount of unexploded World War II munitions to be found on any island on the atoll [73]

The debris survey began in July 1977 and continued, with occasional interruptions, well into the next year Based on the Master Index, 3,300 cubic yards of debris were classified for crater and lagoon disposal and scheduled to be physically removed from Enjebi Resurvey of the concrete items in early 1978 identified an additional 7,700 cubic yards to be removed from the island, including concrete pads, bunkers, and anchor blocks comprising 3,200 cubic yards of material and the multistory building at Greenhouse Station 3.11, nicknamed the "Enjebi Hilton " The structure was coded in the Master Index for on-island disposal; however, the resurvey found beta contamination on the roof This contamination and the immense volume of other material contained in the building made on-island disposal impractical The resurvey identified over 75 percent of the structure, some 4,500 cubic yards, for lagoon disposal

These changes required more time and resources for Enjebi debris cleanup than originally planned The principal impact was on the Army Element and the Navy Boat Transportation Team.[74]

Debris cleanup began at Enjebi on 26 January 1978. The first major project was to raze the Enjebi Hilton, a multilevel building 52 feet wide, 196 feet long, and 36 feet high It had been constructed in three sections to test the effects of nuclear blast on various types of materials and construction techniques commonly used in commercial buildings in the United States. Though still standing, the building had been severely damaged in the tests (Figure 5-22). After the FRST discovered that the roof contained extensive beta contamination, the contaminated portions were chipped loose and transported to Runit for containment The roof-chipping operation was completed on 4 March 1978 and, on 13 March 1978, USAE began demolishing the remaining structure with a wrecking ball The technique was effective but slow After extensive study and planning, it was decided to use explosives and demolish one section at a time. After a test blast on 21 March 1978, the first section was dropped on 29 March 1978 with 2,000 pounds of explosive charges.[75] The remaining sections were demolished the following week with two similar explosions, leaving only the concrete base (Figures 5-23 and 5-24). Several months were required to remove the rubble

The base of the Enjebi Hilton posed a difficult problem It was 7 feet thick with 1- and 2-inch diameter steel reinforcing rods. There was soil-cement, as well as a lean mixture of concrete, under all footings. Grouting

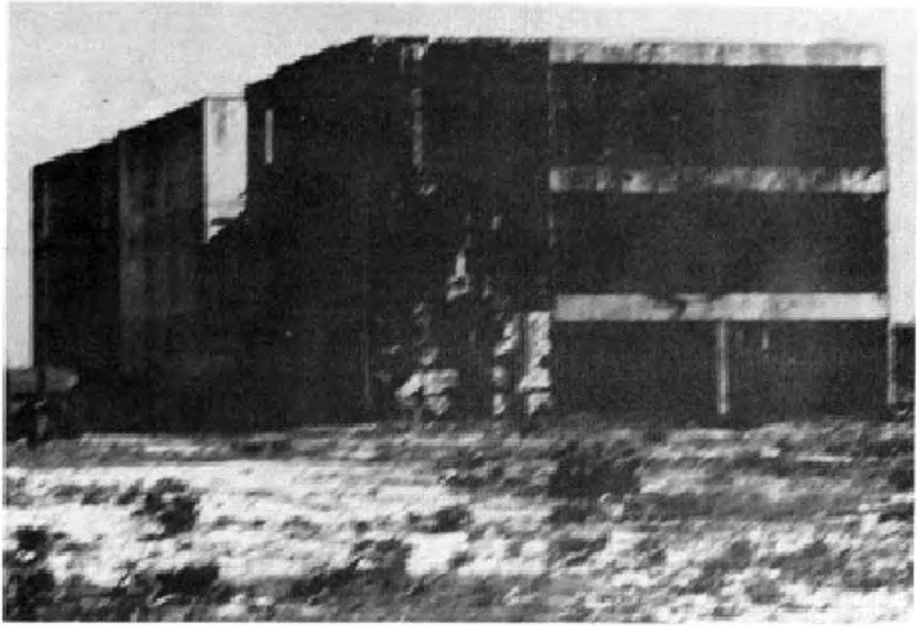


FIGURE 5-22. ENJEBI HILTON BEFORE DEMOLITION.

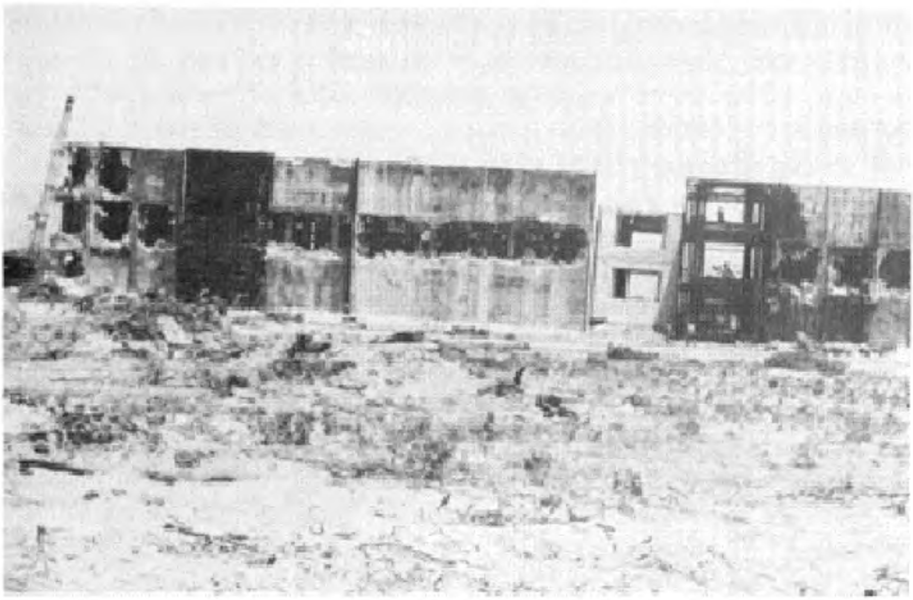


FIGURE 5-23. ENJEBI HILTON DURING DEMOLITION.

FIGURE 5-24. ENJEBI HILTON AFTER DEMOLITION.

operations had created a continuous slab 10 to 12 feet thick at points of heavy loading.[76] Extensive radiological investigation of the base revealed only beta contamination, which was limited to the surface of the concrete. Approximately 150 square meters of the surface was contaminated. This was removed by chipping with air hammers. The surface was resurveyed, after which the entire base was buried under 2 feet of soil contoured to grade so that all traces of the former landmark were eliminated.[77,78]

The Enjebi Hilton was only one of four unusually difficult Master Index items on Enjebi. The second was a very large bunker on the east side of the island. Portions of the face of this bunker were also contaminated. While the bunker was to remain in place after hazards were removed, the contamination had to be removed by sand blasting (Figure 5-25). Once the hazards were removed, the bunker would be usable as a storm shelter or covered storage area.

The third item requiring major effort was another large bunker on the northwestern tip of the island. This bunker was to remain in place, but hazards were to be removed. While there was no contamination found on the bunker, the inside was heavily laced with pipes, electrical circuitry, motors and other equipment. The removal of all the internal hazards would have required extensive effort and probably would have led to the removal of the entire structure. With the concurrence of the Enewetak Planning Council, all entrances were sealed with concrete to prevent access. (See Figures 5-26 and 5-27.)

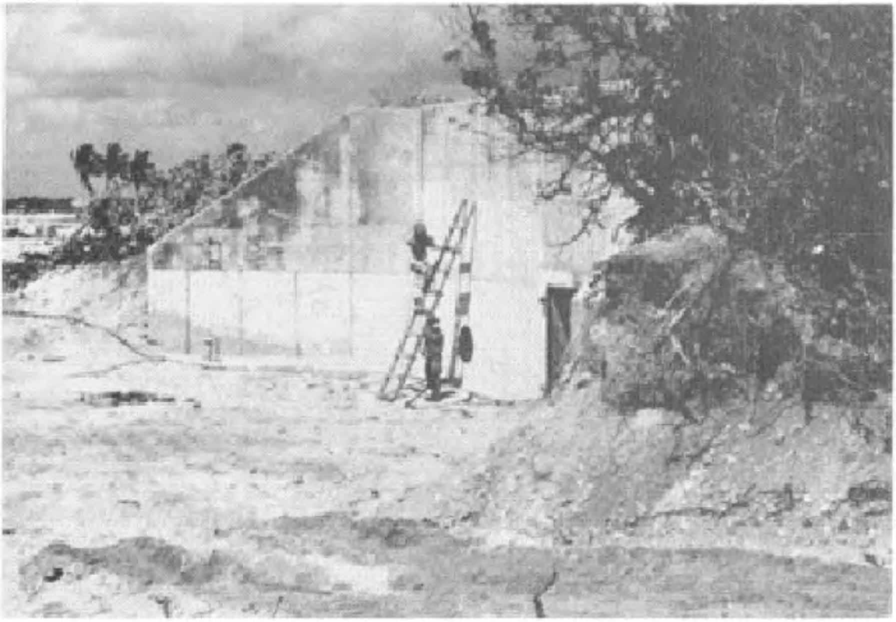


FIGURE 5-25. BUNKER SAND-BLASTING OPERATION.

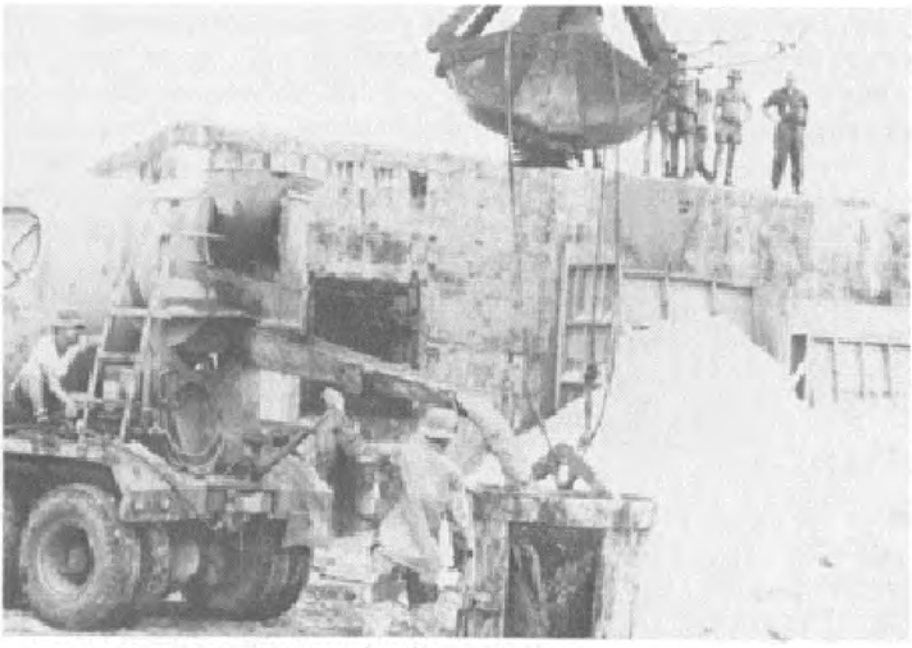


FIGURE 5-26. BUNKER SEALING OPERATION.

FIGURE 5-27. SEALED BUNKER.

The fourth troublesome Master Index item on Enjebi was a small, heavily reinforced, concrete instrument vault. The aggregate used in the concrete was primarily scrap metal, including nuts, bolts, and other hardware. A small portion of the vault's surface contained beta contamination. Chipping removed this contamination, but exposed even more rusty, jagged metal. Attempting to remove this physical hazard by explosive demolition did not appear safe or effective. The vault finally was made safe by covering the entire structure with 6 inches of concrete.

Debris cleanup was completed on 15 May 1979.[79] Five hundred and thirty cubic yards of contaminated debris and 15,947 cubic yards of noncontaminated debris were removed.[80]

SOUTHERN ISLAND DEBRIS CLEANUP

With the completion of Lojwa Camp construction, Company C of the USAE was reconfigured as a cleanup organization. The company returned to Enewetak Camp in two increments on 14 and 17 February 1978 to accomplish the tasks assigned to Team A in the OPLAN—noncontaminated cleanup in the southern islands. They began work on Medren on 15 February 1978 and on Enewetak Island on 13 March 1978, concentrating on those areas where the DOI/TTPI rehabilitation contractor was due to begin preparing sites for construction. In addition, Company C worked to repair damage from Typhoon Mary and Tropical Storm Nadine at Enewetak Camp, including the runway piers.[81]

Northern island debris cleanup had been expected to keep Companies A and B of the USAE occupied until late August 1978. However, by 3 June 1978, they had completed most of the northern island debris cleanup except for the islands where soil cleanup also was required. The following week, part of Company B was redeployed to Enewetak Camp and assigned the task of assisting Company C in cleanup of the southern islands. Debris cleanup on the islands of Boko (Sam), Munjor (Tom), Inedral (Uriah), Jinedrol (Alvin), Jinimi (Clyde), and 60 percent of Ananij (Bruce) was completed before the end of June 1978 when Company B was reassigned to augment Company A for two-shift operations on Runit.[82,83] Company C continued the cleanup of the southwest islands, completing the last one, Bokandretok (Walt), on 9 October 1979. The Army LARCs were invaluable, in that they could negotiate wide expanses of shallow reef on the lagoon side of the southwest islands to remove debris. Cleanup of the southern islands is described, in approximate chronological order, in the remaining sections of this chapter.

BOKO (SAM) ISLAND CLEANUP

Boko has an area of less than 1 acre and was not used as a scientific site during the test era. Vegetation was sparse and the island was free of debris. The planned use for Boko was food gathering.[84] Boko was accepted as free of debris on 23 June 1978.[85]

MUNJOR (TOM) ISLAND CLEANUP

Munjor contains 2 acres and was not used for scientific purposes during the test era. Vegetation covered most of the island in thick clumps and there was no debris. The planned use for Munjor was food gathering.[86] Munjor was accepted as free of debris on 23 June 1978.[87]

INEDRAL (URIAH)) ISLAND CLEANUP

Inedral has a surface area of 4 acres and was not used as a scientific site during the test program. Vegetation was dense except for a few small cleared areas. Debris consisted of two structures, the remains of a navigational beacon and a submarine cable terminal box. Both were Master Index items scheduled for removal. It was estimated that 6 cubic yards of debris would be removed. The planned use for Inedral was food gathering.[88] The island was accepted for debris cleanup on 23 June 1978.[89]

VAN ISLAND (NO MARSHALLESE NAME) CLEANUP

Van has an area of 7 acres and was not used as a scientific station during the test era Vegetation was dense and completely covered the island. An estimated 50 cubic yards of noncontaminated debris were to be removed including one Master Index item, a large steel bouy in deteriorated condition. The planned use for Van was food gathering.[90] Debris cleanup began on 22 June 1978 and ended the following day. Ten cubic yards of debris were removed.[91]

JINEDROL (ALVIN) ISLAND CLEANUP

Jinedrol has an area of about 2 acres and was not used as a scientific site during the test era. There was no debris, and vegetation was dense over most of the land area. The planned use for Jinedrol was food gathering.[92] The island was accepted for debris removal on 6 June 1978.[93]

ANANIJ (BRUCE) ISLAND CLEANUP

Ananij is comprised of 25 acres and was used as a scientific station during Operations Redwing and Hardtack I. Vegetation was dense. Debris included a collapsed wooden tower, the remains of a helicopter landing pad, a submarine cable terminal vault, copper-covered wooden platforms, and other wood, concrete, and metal debris. It was estimated that 184 cubic yards of debris, all noncontaminated, would have to be removed. There were 28 Master Index items identified The planned use for Ananij was agriculture.[94]

Debris cleanup began 29 June 1978 and ended on 14 August 1978. The amount of noncontaminated debris actually removed was 95 cubic yards.[95]

JINIMI (CLYDE) ISLAND CLEANUP

Jinimi has an area of about 3 acres and was not used for scientific purposes during the test era. Vegetation was sparse, and there was no debris. The planned use for Jinimi was food gathering.[96] Jinimi was accepted for debris removal on 6 June 1978.[97]

JAPTAN (DAVID) ISLAND CLEANUP

Japtan is comprised of 79 acres and was used for recreation and to house animals for use in nuclear effects tests. Later, during Operation Redwing, it became the radio receiver site for the atoll with a permanent 20-man camp. Vegetation was extremely dense, especially in the eastern part of the island. Debris remaining from the test era included numerous concrete slabs, buildings, poles, posts, pipes, masts, cables, and the bow of a wrecked ship. It was estimated there were 6,331 cubic yards of debris, all noncontaminated, including 61 Master Index items. The ship's bow, which was blown on its side by the salvage contractor but not removed, accounted for 3,900 cubic yards of the debris (Figure 5-28). The planned use for Japtan was residence.[98]

Debris cleanup began on 8 June 1978 and ended on 13 October 1978. There were 1,290 cubic yards of debris removed, of which 500 cubic yards were removed by scrap contractor.[99] Photographs of Japtan before and after cleanup and rehabilitation are at Figures 5-29 and 5-30.

FIGURE 5-28. DERELICT SHIP OFF JAPTAN.

FIGURE 5-29. JAPTAN BEFORE CLEANUP.

FIGURE 5-30. JAPTAN AFTER CLEANUP.

JEDROL (REX) ISLAND CLEANUP

Jedrol has a surface area of 5 acres and was used as an explosives storage facility. Vegetation ranged from heavy in the central portion of the island to moderate at either end. Hazardous debris included a quantity of dynamite in an igloo at the northern end of the island, numerous structures, and 10 to 15 tons of cables and chain. The amount of debris to be removed was estimated to be 125 cubic yards, all noncontaminated. Seven Master Index items were identified. The planned use for Jedrol was food gathering.[100]

Debris cleanup began on 5 July 1978 and was completed on 29 September 1978. The volume of debris actually removed was 28 cubic yards.[101]

BIKEN (LEROY) ISLAND CLEANUP

Biken has an area of 14 acres and was used during three of the test operations for various scientific purposes including fallout collection. Debris included concrete and wood rubble, a helicopter landing pad, and the wreckage of a small boat. There were an estimated 119 cubic yards of debris, all noncontaminated, to be removed, and eight Master Index items were identified. The planned use for Biken was food gathering.[102]

Debris cleanup began on 19 July 1978 and was completed on 14 August 1979. The amount of debris actually removed was 197 cubic yards.[103] In late 1979 and early 1980, final island surveys by the Navy EOD Team revealed considerable quantities of unexploded ordnance on the reef in the vicinity of Biken. These munitions, which were disposed of by the EOD team, included several 500-pound bombs, indicating that Biken could have been a jettison site for unexploded ordnance during World War II.

KIDRENEN (KEITH) ISLAND CLEANUP

Kidrenen is comprised of 24 acres and was the site of a temperature and humidity recording station during the Hardtack I Operation. Vegetation was dense. Debris included a derelict landing craft, a deteriorated steel pier, and a moderate quantity of wood and steel debris It was estimated that 208 cubic yards of debris, all noncontaminated, required removal; there were 10 Master Index items identified. The planned use for Kidrenen was food gathering.[104]

Debris cleanup began on 19 July 1978 and was completed on 18 August 1978. One hundred and forty cubic yards of debris were removed.[105]

BOKEN (IRWIN) ISLAND CLEANUP

Boken contains 29 acres and was used for measurements of temperature, humidity, and changes in water level during Operation Hardtack I. Vegetation was dense. Debris included derelict marine craft and miscellaneous metal debris There were an estimated 161 cubic yards of noncontaminated debris, and five Master Index items were identified. The planned use for Boken was food gathering [106]

Debris cleanup began on 19 July 1978 and was completed on 1 September 1978. The volume of debris actually removed was 270 cubic yards.[107]

RIBEWON (JAMES) ISLAND CLEANUP

Ribewon has an area of 19 acres and was used for wave, temperature, humidity, and water level recordings during Operation Hardtack I. The Wahoo event of Operation Hardtack I was detonated 500 feet underwater, 1.4 miles south of Ribewon. Vegetation was dense. Debris included the remains of three marine craft and a large pile of debris There were estimated to be 156 cubic yards of debris, none of it contaminated, including four Master Index items. The planned use for Ribewon was food gathering.[108]

Debris cleanup began on 26 July 1978 and was completed on 25 August 1978. A total of 254 cubic yards of debris was removed [109]

MUT (HENRY) ISLAND CLEANUP

Mut has an area of 40 acres and was used as a rocket station for air blast measurements as well as a camera station. Other scientific instrumentation was located on or near the island. Vegetation was dense. Debris included derelict marine craft plus a moderate amount of miscellaneous wood, metal, and concrete rubble. It was estimated that 199 cubic yards of debris, all noncontaminated, required removal. Sixteen Master Index items were identified. The planned use for Mut was food gathering [110]

Debris cleanup began on 8 August 1978 and was completed on 8 September 1978. Two hundred and fifteen cubic yards of debris were removed.[111]

IKUREN (GLENN) ISLAND CLEANUP

Ikuren contains 41 acres and was the site of a photo station and other scientific instrumentation during the test era. The Umbrella event of Operation Hardtack I was detonated 150 feet under water 1.4 miles north of the western tip of the island. Vegetation was dense. There were some derelict marine craft on the lagoon side as well as a large quantity of miscellaneous wood, metal, and concrete debris scattered over the island. An estimated 975 cubic yards of debris required removal, all noncontaminated; 23 Master Index items were identified. The planned use for Ikuren was food gathering [112]

Debris cleanup began on 30 August 1978 and ended on 22 September 1978. A total of 908 cubic yards of debris was removed.[113]

BOKANDRETOK (WALT) ISLAND CLEANUP

Bokandretok has an area of less than 1 acre and contained a navigational beacon, generator, transmitter, and two-man accommodations from which debris remained. Vegetation was dense, particularly on the ocean side. There were estimated to be 34 cubic yards of debris, all noncontaminated, including seven Master Index items. The planned use for Bokandretok was food gathering.[114] Ten cubic yards of debris were actually removed on 9 October 1978.[115]

MEDREN (ELMER) ISLAND CLEANUP

Medren contains 220 acres and was used during the test era as the headquarters of the scientific community which, at its peak, numbered about 3,000 people (Figure 5-31). Vegetation was abundant, although not as dense as on some of the other islands. It was from the support facilities that most of the debris and scrap had accumulated. Hazardous debris included large numbers of concrete blocks, buildings and slabs, towers and posts, pier and dock facilities, and much miscellaneous wood, metal, and concrete debris. None of this debris was contaminated. It was estimated that 58,206 cubic yards of debris required disposition, including 312 Master Index items. Of all the noncontaminated concrete rubble and metal debris found on the entire atoll, nearly half was found on Medren alone. The planned use for Medren was residence.[116]

Debris cleanup by the JTG began on 15 February 1978 and was completed 2 years later in February 1980. To make room for the DOI/ TTPI rehabilitation effort, the center portion of the island was cleared on a

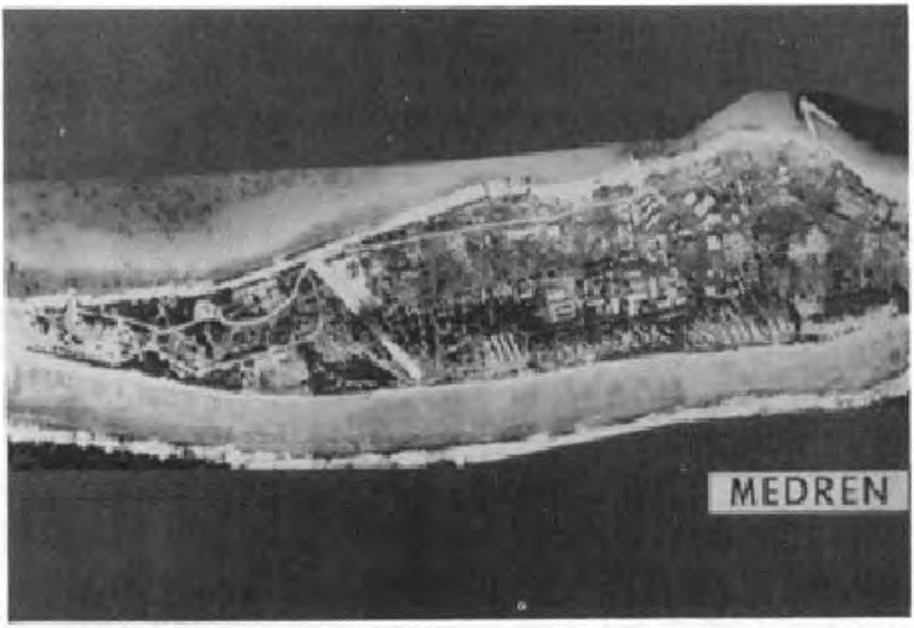


FIGURE 5-31. MEDREN SCIENTIFIC COMMUNITY.

priority basis and turned over to TTPI. The majority of debris was removed by October 1979. During this entire period, rehabilitation efforts were unimpeded. Most of the concrete rubble (27,000 cubic yards) generated by the destruction of buildings and structures was used to extend the north point of Medren. This was deemed necessary to protect the future use of the new deep-water pier constructed under the TTPI Rehabilitation Program. Removal of huge piles of scrap metal and hazardous debris from the northern tip of the island had altered the water flow, and sand was being deposited in close proximity to the pier's docking areas. The north point extension was designed to redirect the flow to preclude the buildup of sand (Figure 5-32). The north point buildup was highly successful for this purpose, and countless man-hours and equipment hours were saved by not transporting this rubble to lagoon dump site A. A total of 14,028 cubic yards of other debris (including 160 Master Index items) from Medren was dumped in the lagoon. There were 73,528 cubic yards of debris removed, including 32,500 cubic yards removed by the scrap contractor and 27,000 cubic yards used as shore protection.[117] Medren after cleanup is shown in Figure 5-33.

FIGURE 5-32. NORTH POINT EXTENSION, MEDREN.

FIGURE 5-33. MEDREN AFTER CLEANUP.

COMPLETION OF DEBRIS CLEANUP

Debris surveys of all islands continued through March 1980 using helicopter overflights Debris located during these surveys was monitored and disposed of accordingly The Engineering Study in 1973 estimated that there were approximately 133,000 cubic yards of contaminated and noncontaminated debris to be removed.[118] By the time cleanup was completed, 253,650 cubic yards of debris had been removed, including 5,883 cubic yards of contaminated debris, 55,000 cubic yards of scrap removed by a salvage contractor, and 77,153 cubic yards of concrete rubble placed as shore protection. A recapitulation of debris removal operations is at Figure 5-34 All Master Index item requirements were accomplished in accordance with disposition instructions.

Runit debris and soil cleanup is described in Chapter 8. Cleanup of Lojwa and Enewetak Islands—the sites of the two major camps—is described in Chapter 9 (Demobilization)

Island (Site)	Notes	Contam Debris Est	Contam Debris Actual	Uncontam Debris Est	Uncontam Debris Actual	Total Debris Removed	Master Index Items: No of Items	Leave	Remove Cont	Remove Uncont
Bokoluo (Alice)		10	0	436	1,575	1,575	14	5	1	8
Bokambako (Belle)		0	0	6	28	28	9	2	0	7
Kirunu (Clara)		0	0	112	505	505	3	1	0	2
Louj (Daisy)		0	0	0	5	5	3	0	0	3
Bokinwotme (Edna)		0	0	0	0	0	0	0	0	0
Bokaidrikdrik (Helen)	a	0	0	15	15	15	2	0	0	2
Boken (Irene)	b	0	0	1 297	1,890	1,890	24	6	2	16
Enjebi (Janet)		568	530	19 884	15,947	16,477	166	18	29	119
Mijikadrek (Kate)		0	0	1 049	1,073	1 073	28	20	0	8
Kidrinen (Lucy)		0	0	61	257	257	18	9	0	9
Taiwel (Percy)		0	0	5	2	2	1	1	0	0
Bokenelab (Mary)		0	0	272	158	158	24	14	0	10
Elle (Nancy)		0	0	0	1	1	1	0	0	1
Aej (Olive)		0	0	1	1	1	3	1	0	2
Lujor (Pearl)		317	255	29	16	271	20	4	11	5
Eleleron (Ruby)		196	250	0	< 1	251	10	1	8	1
Aomon (Sally)	c, d	2,106	728	1,054	2 186	2,914	41	24	10	7
Bijire (Tilda)		0	0	200	720	720	26	17	0	9
Lojwa (Ursula)	e	0	0	170	2,115	2,115	90	25	0	65
Alembel (Vera)		0	0	25	<1	<1	4	0	0	4
Billae (Wilma)		0	0	88	64	64	21	12	0	9
Runit (Yvonne)		4,064	4,120	6 155	11 482	15 602	128	79	18	31
Jinedrol (Alvin)		0	0	0	0	0	0	0	0	0
Ananij (Bruce)		0	0	184	95	95	28	13	0	15
Jinimi (Clyde)		0	0	0	0	0	0	0	0	0
Japtan (David)	f	0	0	6,331	1 290	1,290	61	28	0	33
Jedrol (Rex)		0	0	125	28	28	7	5	0	2
Medren (Elmer)	g	0	0	58 206	73,528	73,528	312	152	0	160
Enewetak (Fred)	h	0	0	27,513	132 780	132,780	310	181	0	129
Ikuren (Glenn)		0	0	975	908	908	23	10	0	13
Mut (Henry)		0	0	199	215	215	16	7	0	9
Boken (Irwin)		0	0	161	270	270	5	2	0	3
Ribewon (James)		0	0	156	254	254	4	0	0	4
Kidrenen (Keith)		0	0	208	140	140	10	3	0	7
Biken (Leroy)		0	0	119	197	197	8	5	0	3
Unibor (Mack)	i	0	0	0	0	0	0	0	0	0
Drekatimon (Oscar)	j	0	0	0	0	0	1	1	0	0
Reef North of ML	k	0	0	0	0	0	2	2	0	0
Boko (Sam)		0	0	0	0	0	0	0	0	0
Munjor (Tom)		0	0	0	0	0	0	0	0	0
Inedral (Uriah)		0	0	6	0	0	2	0	0	2
Van		0	0	50	10	10	1	1	0	0
Bokandretok (Walt)		0	0	34	10	10	7	7	0	0
TOTALS		7 261	5 883	125,126	247,767	253,650	1 433	656	79	698

NOTES

a Fifteen cubic yards of uncontaminated debris is per Master Index
b Master Index includes Boken (Irene) debris data with Bokaidrikdrik (Helen) breakout between two islands is based on map study
c Master Index lists debris on Aomon (Sally) with Eleleron (Ruby), breakout between two islands is based on map study
d Includes 505 cubic yards of debris removed from the Aomon Crypt
e Includes 813 cubic yards of concrete rubble placed as shore protection
f Includes 500 cubic yards of debris removed by scrap contractor
g Includes 32,500 cubic yards of debris removed by scrap contractor and an additional 27,000 cubic yards used as shore protection
h Includes 22,000 cubic yards of debris removed by scrap contractor and an additional 49,340 cubic yards used as shore protection
i No trace of the photo tower and generator platform remain on this coral head
j Concrete triangulation platform on coral head
k Although located on reef north of Biken (Leroy), the Master Index identified these two items as MW, which is Bokandretok (Walt)

FIGURE 5-34. DEBRIS AND MASTER INDEX CLEANUP SUMMARY.

CHAPTER 6

SOIL CLEANUP PLANNING

INITIAL STRATEGY

The cleanup of contaminated soil involved many more management and technical problems than did the cleanup of contaminated debris. The initial strategy was to develop and test soil survey and removal techniques during the Mobilization Phase so that there would be no delay in beginning the actual cleanup phase on 15 November 1972. The basic guidance had been set forth in Field Command Operations Plan (OPLAN) 600-77 and, in May and June, Field Command began developing priorities and schedules for the island-by-island cleanup operations.[1] Basically, the planners in the Field Command's Hawaii office and their counterparts in the 84th Engineer Battalion of the U.S. Army Support Command Hawaii (USASCH), working on atoll with the Environmental Research and Development Agency (ERDA)-Enewetak Radiological Support Project (ERSP) managers, developed and refined procedures for inclusion in the USASCH cleanup phase operations order. These procedures would employ a strategy of testing soil survey and removal techniques on Enjebi (Janet) and then continuing cleanup work there to reduce plutonium concentrations to levels below 40 pico curies per gram (pCi/g), thereby qualifying the island for residential/agricultural use once fission products decayed to safe levels.[2,3] Concurrent debris and soil surveys and cleanup then would proceed to the next island, Boken (Irene), then Lujor (Pearl), then Aomon (Sally), leaving Runit (Yvonne) until last. Unknowns (of which there were to be many) would be dealt with on a pragmatic basis as they were encountered. By conducting debris and soil cleanup concurrently whenever possible, channel clearance, logistics, and transportation problems would be minimized.[4,5,6] It was envisioned that all contaminated debris, including that from Runit, could be collected on Runit before tremie operations began so that it could be encased in the slurry. Concurrently, contaminated soil from the other islands would be stockpiled on Runit. When the stockpile was sufficiently large to sustain operations, the tremie operation would begin. As the placement of contaminated soil and debris and slurry reached the water line, an attempt would be made to determine the amount of contaminated material remaining to be contained so that a determination of the final size and shape of the dome might be possible.[7,8] It was assumed that, if this strategy were followed, some resources would remain in the closing months of the cleanup to tackle Runit surface contamination. The Defense

Nuclear Agency (DNA) would do its best, as the Director had indicated to Congress, to clean up Runit using the remaining available resources.[9] However it was apparent to the planners that, under this approach, the possibility existed that cleanup of Runit soil might not be possible within the constraints of the Military Construction (MILCON) funds and time. Then it would be necessary either for the Department of Defense (DOD) to go back to Congress to seek additional funds or to leave the island quarantined.[10,11]

Plans for implementing this strategy were developed on the atoll, incorporated into the USASCH Cleanup Phase Operation Order, and presented to the new Commander, Field Command, Brigadier General Grayson D. Tate, and his staff in a briefing at Field Command headquarters on 12 August 1977.[12] Meanwhile, the basic concepts of soil cleanup were being challenged again.

A CHALLENGE TO SOIL CLEANUP CONCEPTS

The week of 27 June 1977, the ERDA-Nevada Operations Office (ERDA-NV) began providing soil sampling support at the atoll through its ERSP Rad Lab. That same week, the ERSP Project Manager and two deputies were in Livermore, California, for a workshop review of all ERDA programs in the Marshall Islands, including ERSP. They returned to ERDA-NV with an unsigned draft position paper which raised, once again, the same doubts and objections regarding soil cleanup and disposal which they and some ERDA headquarters personnel had raised unsuccessfully more than 3 years earlier.[13,14,15]

The position paper questioned whether the Atomic Energy Commission (AEC) guidelines for soil removal were supportable and objected to the removal of topsoil from Enjebi and other islands. It also indicated that the amount of plutonium to be removed from the islands was insignificant compared to the total amount in the lagoon and commented that it might leak from the crater into the lagoon. These same objections had been considered and rejected by the top-level ERDA, Environmental Protection Agency (EPA), and DNA leadership in February 1975.[16] Those former DNA leaders had now been replaced by a new Director, a new Commander, Field Command, and new key staff members, who would hear the old objections for the first time.

The position paper was forwarded to ERDA's Assistant Administrator for Environment and Safety, although none of the Marshall Islands Workshop attendees had signed the draft.[17] The ERDA-NV letter of transmittal indicated that the ERSP professional staff was being placed in the position of advising upon and participating in a soil cleanup activity which they considered technically unsupportable, economically unsound, and environmentally counterproductive. It recommended that the soil cleanup plans, which had been developed over the past 5 years and were even then being implemented, be reviewed again.[18]

THE BAIR COMMITTEE

As a result of the unsigned position paper, ERDA convened a panel of scientists at ERDA-NV on 15-17 August 1977 to review·

a. AEC recommendations for cleanup and rehabilitation of Enewetak and, specifically, the criteria for plutonium (Pu-239) in soil.
b. Environmental and health implications and long-term monitoring requirements for crater disposal of contaminated soil and debris on Runit.

The panel was chaired by Dr. W. J. Bair of Battelle-Pacific Northwest Laboratory and subsequently became known as the Bair Committee. It included scientists from several disciplines. Two of the members had attended the Marshall Island Workshop. Observers and guests included most of the ERSP management; DNA's Deputy Director for Operations, Major General William E. Shedd; BG Tate; and Colonel Charles J. Treat, USA, Field Command's Special Assistant for Enewetak Operations.[19]

Briefings were presented by ERDA representatives on that agency's participation in developing the soil cleanup guidelines and the policy decisions to which the unsigned position paper objected. DNA also presented briefings on the implementation of the AEC guidelines in the Environmental Impact Statement (EIS)[20] During the course of these briefings, several critical issues surfaced.

THE CRITERIA ISSUE

The AEC Task Group had recommended 400 pCi/g as a cleanup criterion because it had been shown, conservatively, to be equivalent to the maximum permissible concentration (MPC) in air for radiologically unrestricted areas.[21] Accordingly, a nonoccupationally exposed individual could remain continuously in such concentrations and not exceed the permissible radiation dose rate limits: 1.5 rem/yr to lung or 3 rem/yr to bone. As is frequently done, the AEC Task Group introduced a factor of ten safety margin and recommended 40 pCi/g as a criterion below which no cleanup was required. The Task Group recommended a factor of two only (safety margin) and dose limits for whole body[22] The corresponding dose at 40 pCi/g thus would be 10 percent of that permitted for an individual member of the public. The Task Group recommended that whether or not cleanup should strive for the added factor of ten safety margin be determined on a case-by-case basis.

The AEC Task Group guidelines had seemed clear enough when they were adopted in DNA's EIS in 1975 and in Field Command, DNA's Concept Plan (CONPLAN) 1-76 in 1976, i.e.:

a. Plutonium concentrations below 40 pCi/g required no action.
b. Plutonium concentrations over 400 pCi/g would be excised.
c. Plutonium concentrations between 40 and 400 pCi/g would be treated on a case-by-case basis considering potential use and other factors.
d. Once cleanup action was initiated, the plutonium concentrations would be reduced to the lowest practicable level, not to some prescribed numerical level.

In implementing the last guideline, DNA had stated in its EIS that, where initiated, soil cleanup would be to well below 40 pCi/g. This criteria had been modified by ERDA-NV's input to the OPLAN which permitted cleanup to levels below 400 pCi/g (Condition A) and to levels below 100 pCi/g (Condition B) depending on potential use by the people and other factors. This change was challenged by the DNA planners who had developed the EIS on the basis that the change violated the EIS requirement to clean to well below 40 pCi/g. ERDA-NV representatives argued that cleanup to below 40 pCi/g would require removal of unnecessarily large amounts of soil, causing irreparable damage to some islands. They maintained that DNA had misinterpreted the AEC guidelines in developing the EIS. They were aware that the original guidelines were vague and had attempted to provide better criteria in the OPLAN.

Mr. Roger Ray, ERDA-NV, explained that the soil cleanup criteria developed for the OPLAN were intended to associate a plutonium level with an island use. In Mr. Ray's explanation, "Condition A" was specifically related to "food-gathering" use: an island could be used for food gathering if the surface plutonium concentration at any location (assay area) did not exceed 400 pCi/g; "Condition B" related to "agricultural use," i.e., an island could be used for agriculture if the surface plutonium concentration in any half-hectare did not exceed 100 pCi/g; "Condition C" related to residential use, i.e., an island could be used for residence if the surface plutonium concentration in any quarter-hectare did not exceed 40 pCi/g; and "Condition D," an additional restraint, related to all three uses, i.e., an island could be used for food gathering, agriculture, or residence provided it met the appropriate surface criterion and provided the subsurface plutonium concentration at any location did not exceed 400 pCi/g. These changes raised fundamental questions on the compatibility of this guidance with that in the EIS The association of criteria levels with island use was a surprising development to Field Command planners who had followed development of the criteria as a sampling technique to be used with the in situ system. The association between 100 pCi/g and agricultural use appeared to have no technical basis since the AEC Task Group Report treated islands to be used for food-gathering and agriculture the same with respect to plutonium.

Dr. Bruce Wachholz, ERDA Headquarters, briefed the panel on unofficial EPA views related to the conformance of the soil cleanup criteria to its forthcoming guidance, then under development, on dose limits for transuranic elements in the general environment EPA's verbal assessment was that the "less than 40 pCi/g" level would not be a problem and the "40-400 pCi/g" range most likely would not be a problem. During the guidance development, a very preliminary EPA document, "Draft Proposal, Federal Guidance for Plutonium in Soils, 19 August 1976," attracted particular DNA interest [23,24,25] as it indicated a cleanup action level about a factor of three lower than the 40 pCi/g level recommended by the AEC as a very conservative guideline for the Enewetak Cleanup.[26] Guidance of this nature, if followed, would significantly affect quantities of soil for removal; however, informal opinions from EPA and DNA indicated that no guidance for the United States should apply to Enewetak Atoll. MG Shedd stated DNA's view that the cleanup should proceed as planned. Mobilization was too far advanced to allow the project to be delayed for more studies, reviews, and EIS actions to consider undefined alternatives of uncertain value.

The Bair Committee generally rejected the unsigned position paper's objections and endorsed the OPLAN 600-77 soil cleanup criteria, removal, and disposal methods. There was unanimous agreement that the criteria for contaminated soil cleanup were reasonable and that the planned emplacement of plutonium-contaminated soil and debris in concrete in Cactus Crater did not impose unacceptable environmental and health risks. The panel recommended that more specific guidance for application of the criteria to plutonium levels between 40 and 400 pCi/g be developed for the Commander Joint Task Group (CJTG).[27] Although the unsigned position paper had been thoroughly addressed and answered, its resolution set in motion events which consumed a significant amount of the project's most critical resource—time—and substantially delayed soil cleanup operations. These events are described in subsequent sections.

THE PRIORITY ISSUE

In its report on the August 1977 conference, the Bair Committee expressed concern that the cleanup project could be terminated before completion if funds and other resources appropriated for the effort proved insufficient due to underestimates of the amount of soil that had to be removed.[28] This concern was shared by BG Tate and COL Treat, who made their first visit to the atoll shortly after the conference adjourned.

The EIS identified four islands requiring cleanup of plutonium concentrations over 400 pCi/g: Boken, Lujor, Aomon, and Runit. Eight others in the 40 to 400 pCi/g range were listed for consideration on a case-by-case basis: Bokoluo (Alice), Bokombako (Belle), Kirunu (Clara), Louj (Daisy), Mijikadrek (Kate), Kidrinen (Lucy), Aej (Olive), and Eleleron (Ruby). To these, the CONPLAN and OPLAN added Enjebi for consideration on a case-by-case basis When BG Tate arrived, work was beginning on Enjebi in accordance with the initial strategy, with a view toward continuing its cleanup to qualify it for eventual residential use. Since Enjebi was not identified for cleanup under Case 3 of the EIS and it could require 6 months or longer to accomplish the cleanup, there was considerable opposition to going ahead with this effort. CONPLAN 1-76 estimates indicated that over 27,750 man-hours would be required to remove debris from the island and over 24,000 man-hours would be required to remove the plutonium-contaminated soil concentrations to levels below 40 pCi/g[29]. BG Tate was unwilling to devote so many man-hours to Enjebi without more assurance that resources would be available to complete the items specifically required in the EIS. He was particularly concerned about Runit, where 58 percent of the radiological cleanup work identified in Case 3 of the EIS would be required. Therefore, during his visit, BG Tate and Mr. Ray, the ERSP Manager, agreed to move out on identifying the work to remove plutonium from the burial crypts on Aomon, identifying the Lujor soil removal requirement, and characterizing the nature and scope of work to clean Runit to required levels.[30]

After BG Tate's visit, Mr. Ray, in a letter to Field Command, expressed surprise that the cleanup of Runit was considered so important. He asked what level of confidence Field Command expected in the Runit characterization the ERSP was being tasked to carry out and what priority it should receive. He indicated that ERDA-NV could identify the work required to clean Runit or could assist in preparing a reclama to leave Runit uncleaned and quarantined. He hinted that additional funding from DNA might be required for detailed Runit soil characterization.[31] BG Tate replied that he did not consider the reclama proposal to be a viable option and that the radiological survey of Runit should meet the same standards and priority as the Lujor and Boken surveys.[32] In retrospect, in raising serious questions about the cleanup of Runit, Mr. Ray reinforced the position of Army engineers and Field Command staff planners regarding Runit soil cleanup, i.e., it should be accomplished last so that the limited resources available could be used to assure completion of cleanup on the other islands specified in the EIS which would be of most value to the dri-Enewetak. His support, combined with other considerations discussed later in this chapter, eventually proved decisive in convincing the DNA leaders at Headquarters and Field Command, who were relatively new to the project, not to devote precious resources to an attempt to clean Runit before the other islands were complete. Such an attempt could have proven futile, resulted in recontaminating Runit in subsequent crater containment operations, and used all available resources without leaving the people any other currently contaminated islands in a usable condition.

On 12 September 1977, BG Tate and COL Treat traveled to Washington to discuss the cleanup project with DNA leadership and participate in discussions at ERDA headquarters the following day The proposed characterization of Runit was discussed with VADM Monroe, who stressed that it was ERDA's routine responsibility to identify contaminated soil for removal and that characterization of Runit must not be permitted to evolve into an extraordinary program requiring additional DNA funding. The Director also observed that an addendum to the EIS might be needed if there were major differences between the OPLAN criteria and the EIS criteria for soil cleanup.[33]

Other issues in the soil cleanup criteria were brought to DNA's attention in the discussions at ERDA headquarters on 13 September 1977. DNA previously had received oral assurance from EPA that the proposed new EPA guidelines for all transuranic contamination—currently under review in draft form by various organizations of the Government—would not apply to Enewetak, then or in the future. On 13 September 1977, ERDA advised DNA that it would ask EPA for written assurance that EPA guidelines would not apply.

ERDA also advised DNA—for the first time—that the AEC guidelines were intended to apply to all transuranics and not just the Pu-239/240 identified in the AEC Task Group Report. The AEC had concluded that potential dose to people at Enewetak via inhalation was low for all living patterns investiaged,[34] and the only significant contributors to the low inhalation dose were Pu-239 and Pu-240.[35] Other transuranic isotopes; e.g., Pu-238 and americium (Am-240), were considered insignificant based on concentrations which had been measured in Enewetak soil during the AEC Radiological Survey in 1972 and comparisons with maximum permissible concentrations in air in use in the United States [36] The dri-Enewetak, however, had expressed concern over Am-241 and Pu-

238 in their comments on the EIS[37] by noting that the uptake of Am-241 in the food chain, which would double due to radiodecay of Pu-241, may be the critical pathway. There appeared to be higher tumor risks for Pu-238 than for Pu-239.[38] DNA pointed out that the AEC Task Group Report cleanup criteria clearly stated that cleanup of Pu-239/240 negated any contribution by Pu-238 or Pu-241 and that the report did not even mention other transuranics. The impact of this issue became more apparent when, following some radiation counting experiments with Enewetak soil by Field Command, it became evident that Pu-238 concentrations were significant. This caused concern since cleanup estimates had been based on volumes of soil containing Pu-239/240 only, and the AEC guidelines on cleanup were not clear with respect to inclusion of other plutonium isotopes.

Dr. Wachholz also advised DNA that if transuranic contamination were cleaned to below 40 pCi/g on residential islands, the Enewetak cleanup probably would meet the new EPA guidelines; but if transuranic contamination of over 40 pCi/g were left on residential islands, the cleanup probably would not meet the new guidelines.

Linking the previous two items, ERDA informed DNA that the AEC/ERDA guidelines for residential islands had always been intended to include total transuranics, even though they named only plutonium.[39] DNA pointed out that, in fact, AEC/ERDA's numerical guideline of 40 pCi/g for soil cleanup actions had not been related to residential use, or any other particular use, in either the AEC Task Group Report or the criteria ERDA recommended for the OPLAN. DNA also pointed out that there was no requirement in the AEC Task Group Report, the EIS, or the OPLAN for plutonium cleanup of any residential island. This reopened the issue of using Enjebi for residence.

ERDA then advised DNA that the ERDA staff had always intended to place top cleanup priority on reducing levels of contamination on Enjebi to less than 40 pCi/g. This came as a surprise to DNA, because the AEC Task Group specifically recommended no soil removal for Enjebi, but simply the conduct of tests to determine when exposures would be within acceptable criteria.[40] The AEC Task Group's guidance for case-by-case decisions on soil levels between 40 and 400 pCi/g indicated that soil removal was better justified on larger islands such as Aomon or Enjebi, where residences might someday be located, but its Report gave no numerical criteria for residential use.[41] Nevertheless, ERDA now stated that unless Enjebi was cleaned to less than 40 pCi/g of transuranics, the concept that Enjebi could be used as a residence after some 30 years could not possibly be realized, since that concept was based strictly on fission product decay ERDA especially objected to placing the priority for Runit cleanup ahead of Enjebi cleanup, saying that it was their intent to give first priority to cleanup of potential residential islands; i.e., Enjebi.

DNA responded that these intentions were not apparent in the AEC Task Group Report, which (1) did not mention transuranics other than plutonium, (2) specifically recommended against Enjebi soil removal, and (3) specifically recommended that plutonium-contaminated soil on Runit be removed.[42] DNA reminded ERDA that the EIS, on which ERDA had coordinated, and the OPLAN, which ERDA had helped develop, specifically identified excision of plutonium concentrations on Aomon, Lujor, Boken, and Runit as required cleanup tasks.[43] The only mention of Enjebi soil cleanup in those documents was that it would be harmful.

It became apparent at the 13 September 1977 meeting that the existing policy, plans, and schedules for soil cleanup were based on AEC-ERDA data and guidelines which were no longer reliable. It was obvious that ERDA was revising its guidelines for plutonium cleanup to better correspond to EPA's proposed guidelines for all transuranic contamination, despite EPA's assurances that its guidelines would never apply to Enewetak. This not only cast doubt on the original AEC guidelines but rendered invalid the existing soil volume estimates and, consequently, the existing soil cleanup plans, priorities, and schedules which were based on those guidelines. As a result of the 13 September 1977 meeting, the Director, DNA decided to suspend soil cleanup preparations until firm guidelines and estimates of all transuranic soil contamination could be developed.

On 1 October 1977, ERDA was reorganized. Those components involved in the Enewetak project were assigned to the newly established Department of Energy (DOE) with little change except in name and office symbol; e.g., ERDA-NV became DOE-NV.

RUNIT CHARACTERIZATION

On 4 October 1977, experts from DOE-NV, the Armed Forces Radiobiology Research Institute (AFRRI), Field Command, and several DOE contractors met at Las Vegas, Nevada, to examine means of meeting requirements for a more definitive, quantitative characterization of the scope of work involved in the radiological cleanup of Runit Island. The conference was chaired by Field Command's COL Treat who briefly reviewed the cleanup background, requirements, and the specific problem of assuring that the plutonium concentrations on Runit could be removed within the resources available and with consideration for the impact of Runit cleanup on the cleanup of other islands. ERDA headquarters representatives questioned DNA's interpretation of the AEC Task Group Report as requiring priority be given to concentrations over 400 pCi/g.

Changing their position from the 13 September 1977 meeting, DOE now said that it had always been the intent of the AEC Task Group to place equal priority on cleaning those concentrations between 40 and 400 pCi/g and those over 400 pCi/g.[44] In rebuttal, Field Command cited the AEC Task Group Report as follows:[45]

a. Under 400 pCi/g of soil - corrective action not required
b. 40 to 400 pCi/g of soil - corrective action determined on a case-by-case basis considering all radiological conditions.
c. Over 400 pCi/g of soil - corrective action required.

COL Treat reiterated that resources were constrained, which limited the total amount of work that could be done. This required that priority be given to the actions specified in planning documents and that consideration be given to reducing the scope of work on Runit. Runit contamination data available from earlier surveys were reviewed and found inadequate for accurate definition of the soil cleanup work It was concluded that additional soil profile and in situ survey data were required to define the location and volume of soil to be removed.

The remainder of that day and the next were devoted to extensive discussions of procedures for survey and characterization of Runit soil contamination. The costs in time and other resources required for the characterization were discussed; and, while it was generally agreed that they could not be accurately estimated, it was felt that they would not be excessive. It was believed that these efforts would contribute to the eventual cleanup and/or certification of Runit; therefore, the additional resources required for characterization would be minimal [46]

It was agreed that Runit characterization should receive the same priority as soil cleanup of Lujor and Boken. It was hoped that available assets would permit simultaneous work on cleanup and characterization.

Two options for reducing the volume of soil cleanup and disposal were discussed: plowing, and use of low-level soil from other islands for fill on Runit. It was generally agreed that plowing should not be used to meet cleanup criteria but that it might be used to reduce concentrations after other cleanup actions were complete. It was generally agreed that low-level soil should not be spread on Runit, but that it could be left in a stockpile or used to backfill evactuations.[47]

The conference ended on 5 October 1977. However, due to differences in opinion on what was said and what it accomplished, almost 2 months were required to complete the conference report. Meanwhile, on 14 October 1977, COL Treat was formally designated as Special Assistant for Enewetak Operations, reporting directly to the Commander, Field Command, and having a small staff detailed from other directorates. The Special Assistant was to formulate policy and guidance for the conduct and support of the cleanup project and coordinate interagency actions.[48] The other Field Command directorates continued to provide staff management for the project in their functional areas of responsibility, while the Special Assistant's primary concerns were radiological studies and the characterization of Runit.

Although the minutes of the Runit Cleanup Conference were far from being completed, Field Command instructed the CJTG on 21 October 1977 to begin the soil characterization of Runit as soon as possible. The instructions were untimely, because they arrived just as the Field Radiation Support Team (FRST) members—who would have to survey and mark the 50-meter grid, then search out and remove plutonium-contaminated metal fragments[49] — were completing their 179-day temporary duty (TDY) assignment The original team was trying to complete several other island surveys before they departed, and the new team was just beginning initial training at Hickam AFB, Hawaii The initial survey of Runit could not begin until the second week in November 1977 [50,51]

The JTG Radiation Control Division (J-2) developed a schedule to coordinate FRST, ERSP, and United States Army Element (USAE) efforts for the characterization of Runit (Figure 6-1). Machetes, chain saws, and other hand tools were used by the FRST and USAE to clear brush around original survey markers and in the Fig-Quince area, while the USAE used bulldozers to debrush larger areas. A 50-meter grid was surveyed and marked on the island north of the hot line. The grid was intensified to 25 meters in the Fig-Quince area. Extraordinary radiological protection measures were employed during this and all subsequent operations on north Runit.

Once the grid was established, the FRST conducted a search for the milligram-size and larger fragments of plutonium-contaminated metal which had precipitated the earlier quarantine of Runit. The search was made with Field Instrument for the Detection of Low-Energy Radiation (FIDLER) probes. Hot spots were excised with a shovel and placed in plastic bags, which were held for future burial in the crater. This operation was intended to minimize the contribution of the hot fragments to in situ readings and minimize the volume of soil to be excised. In practice, the procedure was slow and the value of its results was questionable, considering the cost in time and manpower diverted from cleanup operations.

Soil profile samples were taken using earth augers operated by the USAE and probes operated by the FRST. Backhoes were used to cut 12 pits in various areas and to cut 4 trenches across the berms in the north central area of Runit. Soil samples were taken at intervals in the walls of the pits and trenches.

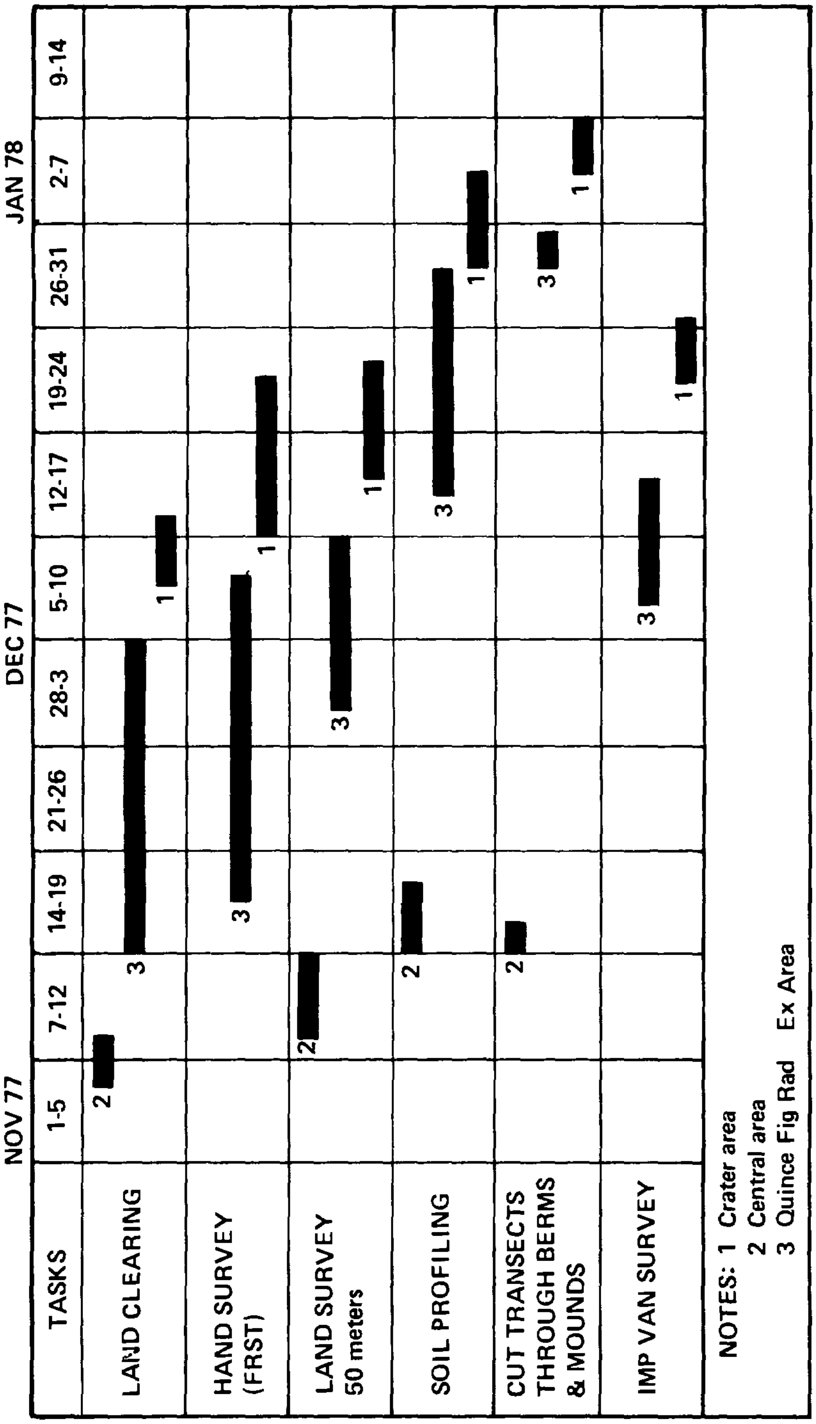


FIGURE 6-1. RUNIT CHARACTERIZATION SCHEDULE

By mid-December 1977, a month after cleanup was scheduled to begin, it was obvious that Runit soil characterization would take far more effort, time, and other resources than originally estimated. Field Command set a deadline of 15 January 1978 for completion of the effort.[52] The hot fragment search and soil profiling were completed before the deadline despite two severe storms and other setbacks. However, little effort was made on the in situ survey until February 1978, and no results were available until April 1978. In February 1978, COL Treat was forced to lower the priority of the Runit characterization effort to release ERSP resources to complete surveys of other islands.[53] Meanwhile, the uncertainty over the cleanup guidelines and the lack of results from another radiological survey stalled the DNA planning. Without these elements, DNA did not have sufficient data upon which to base decisions on what soil was to be removed and how the available resources could best be used.

JANUARY 1978 CONFERENCES

It had been planned that soil cleanup; i.e., the excision and encapsulation in Cactus Crater of contaminated soil, would begin on 15 November 1977, the date of commencement of the cleanup phase. However, the uncertainty over the cleanup guidelines and the lack of results from a detailed, island-by-island soil characterization stalled the soil cleanup operation.

Director, DNA and Commander, Field Command realized clearly that soil cleanup resources were limited and, if they were to be used in the long-range best interest of the dri-Enewetak, they must not be committed to projects that could not be completed, projects that were unnecessary, projects that were of low priority, etc Until some reasonably detailed approximation of the overall soil contamination problem could be developed (i.e., how many cubic yards of contaminated soil, of what transuranic concentration, was present on each island of the atoll), any start at actual soil excision could prove to be a false start and could provide results which would be of less benefit to the dri-Enewetak than envisioned during the planning.

As the delays which resulted from the need to accommodate the changes brought about by the inclusion of all transuranics in the cleanup, the linkage of criteria to island use, the change in priority after BG Tate's visit, and the desire to have more detailed island radiological characterizations stretched into December 1977, the Director, DNA initiated Washington-level action to expedite resolution of the issues. A major DOE-DNA conference was scheduled to alert top DOE Headquarters officials to the serious implications of the delay in characterization and to the need to resolve the remaining unknowns in fine-grain criteria for cleanup.

On 6 January 1978, DOE and DNA officials met in Washington, DC, to discuss these matters further. They agreed on the following actions:

a Soil cleanup criteria would include all transuranic elements, as did the EPA's proposed new guidelines, and not just one or two plutonium isotopes, as had AEC's guidelines.

b. DNA and DOE would put priority on completing the radiological survey and characterization of all the northern islands, excluding Runit.

c. DOE would make dose assessments for a range of contamination levels and island uses.

d DOE would provide estimates of soil volumes to be moved to achieve various degrees of soil cleanup.

e After all the data and estimates were received, DOE and DNA jointly would consider the cost-benefits of soil cleanup of the various islands, including Enjebi. DOE stated that cleanup of Enjebi to below 40 pCi/g would meet EPA's proposed transuranic guidelines for residential use and permit full-time residence on Enjebi after the fission products decayed to harmless levels.

f. DOE would develop dose estimates based on cleanup and use patterns of the islands to provide guidance for cleanup of islands in the 40-400 pCi/g range for agricultural or visitation use.

g DOE would consider the acceptability of plowing as a method of meeting certain use criteria; however, there was doubt that plowing would satisfy EPA requirements.

A new strategy to deal with Runit had been evolving and was proposed at this conference. The AEC Task Group Report and EIS required that plutonium concentrations over 400 pCi/g be excised from Runit and encapsulated in the crater whereupon the quarantine could be removed. Subsequently, Mr. Theodore Mitchell, the Enewetak people's attorney, agreed that, after the contaminated soil was encapsulated on Runit, the people could retain the quarantine of the island as an additional safety precaution.[54] Some of the conferees now proposed that, if Runit were going to be quarantined because of the material in recoverable storage, little or no effort need be made to excise and encapsulate the contaminated soil.[55] While the proposal had considerable appeal to some, it was not adopted.

The conference failed to provide the Director, DNA with anything substantive which could be used to answer the concerns of the service element commanders during his visit to the atoll later that month. The earth-moving equipment, operators, and boats had been ready to remove soil for over 2 months, and the commanders were waiting for decisions on what to remove and where to begin

INSPECTION AND REVIEW

The Director, DNA was accompanied on this trip by the High Commissioner of the Trust Territory of the Pacific Islands (TTPI), Adrian Winkel, BG Tate, and the three men the Director came to rely on as his principal agency advisors for the project: Mr. Roger Ray, of DOE-NV; Mr. Theodore Mitchell, of Micronesian Legal Services Corporation (MLSC); and Mr Earl Gilmore, of Holmes & Narver, Inc. While en route to the atoll, they discussed the soil cleanup alternatives at length. It was generally agreed that Runit would not be cleaned until other islands had been cleaned to some yet-to-be-determined level. It was agreed that the eventual resettlement of the dri-Enjebi on Enjebi Island was a desirable objective but that it might not be possible if a large amount of soil removal were required. Other alternatives for northern island residence on Aomon, Bijire, and/or Lojwa also were discussed. Any use of the northern islands for residence would have severe impacts on the rehabilitation construction contract which had recently been awarded. Also, any significant changes in the cleanup and rehabilitation plans could require an amendment or supplement to the EIS.[56] It was agreed that these and other soil cleanup matters must be resolved at a top-level policy conference scheduled for April 1978 at Headquarters DNA.

VADM Monroe arrived at Enewetak on 17 January 1978 for his second inspection and review of cleanup project progress. Detailed briefings were held, inspection trips were made to all key islands, and back-to-back meetings were held until past midnight on virtually every subject pertinent to the operation. The JTG and Service Element Commanders had most problems well identified and were working out solutions to those which had not already been resolved.

The most significant problems remaining were soil cleanup criteria and priorities. The new in situ survey requested by BG Tate had been expanded to cover all northern islands and was taking longer than had been anticipated. Thus, the DNA leadership still could not be certain how much soil had to be removed from which islands to achieve optimum results for the dri-Enewetak VADM Monroe still was determined not to start removing and encapsulating soil indiscriminately, unnecessarily using up volume in the Cactus Crater structure and possibly wasting manpower and money, but rather to keep pressure on DOE for soil characterization data so that a coherent overall plan could be made that would best serve the interests of the dri-Enewetak. In addition, there were ongoing discussions on the inclusion of all transuranics in the cleanup and on the actual criteria for soil cleanup considering the new EPA guidelines and the Bair Committee deliberations, all of which prolonged the delay in the start of the soil cleanup. Among the on-atoll forces—the CJTG and his staff, the Service Element Commanders—there was impatience to begin soil operations. Understandably, these individuals were concerned because the soil removal equipment, operators, and other resources, which they had worked so hard to have in place for the start of Cleanup Phase on 15 November 1977, had not yet begun soil cleanup—and it was mid-January 1978. They wanted to begin soil cleanup at once.

After many hours of discussions, VADM Monroe directed the following actions.

a Begin a pilot soil removal project to ascertain the effectiveness of the planned soil excision technique in reducing transuranic concentrations and to consolidate the planning factors of time, men, trucks, boats, quantities, etc., on which firm planning would later depend. The choice of island for the pilot soil removal project was to be agreed between the ERSP and Field Command and recommended to the Director, DNA for decision

b. Expedite compilation of all island soil characterization data by DOE and finalize soil cleanup criteria including consideration of the new EPA guidelines

c. Expedite review by Field Command, DOE-NV, and TTPI of island use plans and island cleanup priorities.

d Intensify characterization efforts at the Aomon crypt, including interviews with any people still available who were involved in its construction, and solicit ideas from all concerned on how to survey and excise the crypt.

e Concentrate Army and Navy Element efforts on northern island debris cleanup, both contaminated and uncontaminated, until soil cleanup decisions could be made.[57,58]

Thus, VADM Monroe's plan was to compensate for the late start in soil cleanup by getting ahead of schedule in the cleanup of debris. As will be shown later, the characterization and reviews continued well into the spring of 1978. Meanwhile, a small, but important, soil cleanup operation was conducted shortly after the Director's visit

MEDREN (ELMER) ISLAND SOIL CLEANUP

The 1973 Enewetak Radiological Survey indicated two areas on Medren with elevated gamma levels One area was found to contain a cobalt (Co-60) source in a dosimeter calibration shed This source was removed and gamma levels returned to normal background. The other area was not identified at that time It was essential that the JTG locate and remove the contamination before the Defense Property Disposal Service contractor began scrap removal operations on Medren.

The contamination was located by Radiation Control Division personnel during a survey of old laboratory facilities in November 1977. It was found in two locations, approximately 150 feet apart, 300 yards south of the old runway. The first two soil samples contained relatively low levels of Co-60 (less than 70 pCi/g).

A team consisting of one member from the JTG J-2, one from the FRST, and several USAE equipment operators was formed to identify and remove the contaminated soil. The operation began on 7 February 1978 and was completed on 10 February 1978. Personnel protection consisted of Anti-C suits with boots, hoods, gloves, and dust masks for truck drivers and survey personnel. The bucket loader operator wore a full-face respirator. During transport of soil by LCU, crew members wore dust masks when outside the quarters, and all hatches were battened to prevent possible contamination of interior spaces.

The larger area, designated Crate, was excavated first. The area was approximately 40 feet long, 30 feet wide, and 3 feet deep. Evidence was found that two trenches had been dug in the area, each 12 to 15 feet long and 3 feet wide. The highest Co-60 concentrations, 2,000 pCi/g, were found in these trenches. Outside of them, gamma levels dropped significantly.

Before excavation began, the area was wet down with sea water using a 1,200-gallon tank truck. Contaminated soil was excavated with a backhoe and loaded directly into a dump truck. When the truck bed was full, the load was wet down and covered with a tarpaulin to prevent the spreading of contamination. Trucks were driven to the boat ramp along a predesignated route which was monitored to assure it did not become contaminated. The trucks were transported by LCU to Runit where soil was offloaded at a stockpile inside the hot line. The trucks and well deck of the LCU were hosed down and monitored before returning to Medren.

The smaller area, designated Blue Star, was approximately 10 feet long, 9 feet wide, and 2 feet deep. Analysis of soil samples from this area showed Co-60 concentrations of 20 to 75 pCi/g.

After all hot spots had been excised, the entire area was backbladed and resurveyed. Surface activity levels averaged 7.2 micro-Roentgens per hour. Some 110 cubic yards of soil had been excised and removed to Runit. The operation was accomplished by Army, Navy and Air Force personnel under the supervision of an noncommissioned officer from the JTG J-2 and it served as a model for future soil removal operations.[59]

FEBRUARY 1978 CONFERENCE

On 9-10 February 1978, action officers from the military services, DOE-NV, and TTPI met in Albuquerque to review project status and to coordinate actions for continued support of the project. There was considerable concern that boat resources would not satisfy intra-atoll transportation requirements as cleanup and rehabilitation efforts accelerated. Navy representatives agreed to increase both crews and boats, including two or three more personnel transport craft. Billeting, recreation, and other personnel matters were discussed and resolved. The conferees also were asked to begin developing input for detailed demobilization plans.

The delay in starting soil cleanup caused a number of problems. The first increment of USAE soil-removal platoons was due to be replaced in April, and it appeared that their tour on the atoll would be spent without moving any significant amount of soil. Crater tremie operations had been planned to start in April 1978 with a contaminated soil stockpile sufficiently large to sustain tremie operations, but there was little contaminated soil on hand. Cement and attapulgite were being delivered and stockpiled for the tremie operation and would cause a storage problem on Runit if that operation were delayed any length of time. The Army and Navy action officers expressed the concern of their respective commands that the equipment and manpower they had provided for soil cleanup had been employed in makeshift tasks for the first several months because DNA had not given the word to start soil cleanup. BG Tate assured them that Field Command and DNA Headquarters were sensitive to their problems and that the project would not be prolonged because of these schedule changes.[60]

The conference provided an opportunity for the JTG Engineering Officer, LTC Joseph Briggs, USA, to discuss other cleanup procedures with the Field Command staff. They discussed procedures for excising the Aomon burial crypt using a sheet pile cofferdam and discussed the pilot soil removal project.

PILOT SOIL REMOVAL PROJECT

Enjebi had been scheduled for use in developing and testing radiological survey and cleanup procedures, including contaminated soil removal. Most of the tests, other than soil removal, were conducted on Enjebi before the end of August 1977, when the plan to begin soil cleanup on Enjebi was questioned. The pilot soil removal project, planned for accomplishment during the mobilization phase, was put aside until 17

January 1978 when the Director, DNA, during his visit to the atoll, decided that a pilot soil removal project should be conducted as quickly as possible. The basic purpose was to verify that soil cleanup actually could be accomplished; that is, that surface contamination could be measured, that an area for excision could be delineated, that a layer could be scraped up and removed, and that the resulting surface contamination would be significantly reduced. Important subsidiary purposes were to determine optimum equipment and procedures and to develop planning factors of time and manpower for each step of the process. On 3 February 1978, the CJTG recommended Boken as the site for conducting the project. It was one of the four islands specified in the EIS for soil cleanup Runit still was being surveyed, and the in situ survey of Lujor had shown no concentrations above 160 pCi/g, well below the 400 pCi/g guideline for mandatory cleanup. The other island considered by the CJTG, Aomon, did not require any mandatory soil cleanup according to the latest survey data.[61]

Despite these considerations, Field Command disapproved the selection of Boken because of its distance from Lojwa (Ursula) and Runit. After discussions with LTC Briggs, Field Command selected Aomon to be the site for the project in order to reduce the boat transport time between the worksite, the Runit soil stockpile, and the Lojwa Base Camp, and because the work site could be reached by truck from Lojwa. Director, DNA approved Field Command's choice. COL Treat identified some 2 dozen soil cleanup activities for time-motion documentation to be used in planning how best to accomplish contaminated soil removal.[62] It took about 3 weeks to develop and coordinate a plan which satisfied all of these requirements.[63] Work on the project began on March 1978, the day after the plan was published.

The pilot soil removal project used soil cleanup procedures which had been started on Enjebi in July 1977. The basic steps, after completion of the DOE-ERSP surveys described in Chapter 4, were:

a. Identify the site and scope of work.
b. Implement radiation safety and control procedures.
c. Survey and stake the boundaries of the excision areas.
d. Remove excess brush.
e. Excise the area and windrow excised soil.
f. Resurvey excised area using the in situ van (IMP) and/or soil samples.
g. Repeat steps e and f until contamination has been reduced to desired level.
h. Transport soil from windrows to beach stockpiles.
i. Transport soil from beach stockpiles to stockpiles on Runit.

These steps are described in some detail in the following sections.

WORK SITE IDENTIFICATION

Upon determination that an island required soil excision to reduce surface or subsurface contamination, the on-site DOE-ERSP manager determined which areas exceeded required standards. This recommendation was received by the JTG in the form of a technical note, with an overlay of the area clearly marked with all pertinent data including grid reference points and soil removal estimates. After the technical note was received, an operations meeting was held among representatives of JTG staff, the Service Elements, and DOE-ERSP. During this meeting all salient information was discussed and an operations plan was developed.

Two areas on Aomon were identified for the pilot soil removal project. The Kickapoo ground zero (GZ) was to be cleaned first (Figure 6-2), followed by the Yuma GZ.

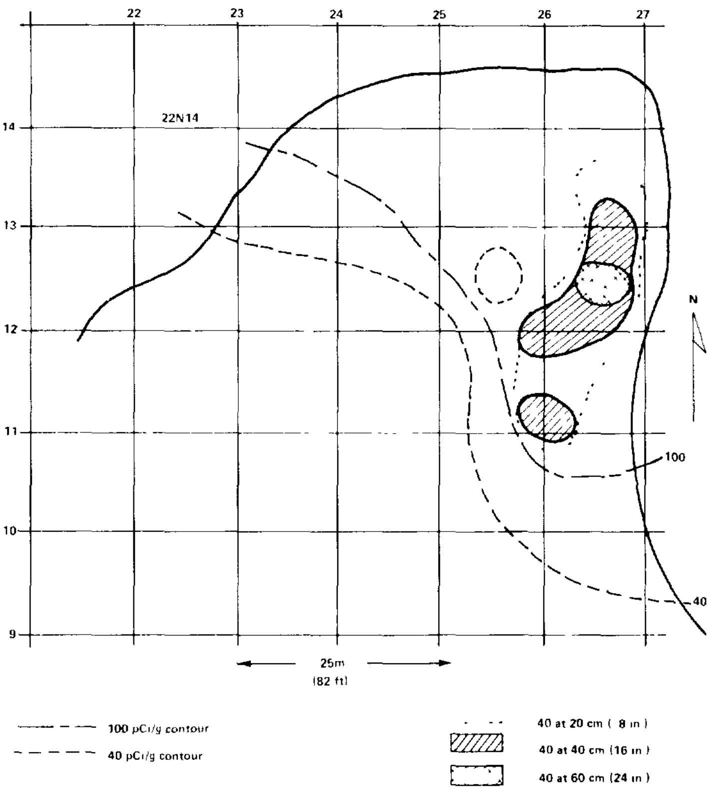


FIGURE 6-2 AOMON ISLAND KICKAPOO AREA.

RADIATION SAFETY AND CONTROL PROCEDURES

Radiation safety and control procedures were implemented prior to initiation of all soil cleanup operations. Implementation of these procedures was the responsibility of the FRST under the staff supervision of the J-2, HQ JTG. Radiation control personnel were the first persons on an island, and they determined the radiation safety measures required. When all radiation safety and control procedures were established, the FRST controlled all entry and exit from the island. Before commencing any operation which was likely to raise dust, such as brush removal, a prefabricated sprinkler system was assembled and used to spray water pumped from the lagoon over the work site as a dust pallative. This system was used in all phases of soil movement from excision to stockpiling to loading and offloading boats. While absolutely necessary, this technique slowed operations because it required at least an hour to wet down the soil adequately.

WORK SITE SURVEY

The first party of workers normally were USAE surveyors (Figure 6-3). Surveyors used the overlay with grid reference points to lay out the soil

FIGURE 6-3. USAE SURVEYOR.

excision areas. The layout was verified by the Officer in Charge of the USAE unit scheduled to accomplish the excision. The initial survey, which had to be completed before the DOE IMP survey operation could be carried out, consisted of establishing a 25- or 50-meter north-south orthogonal grid system which was tied into the island's survey reference points. Each island had several reference points which had been tied into the worldwide coordinate system. A three- to four-man survey team, with a FRST member as radiological escort, was required. When a soil lift area was identified, surveyors prepared a sketch of the area, brought elevation and position reference stakes to nearby locations, and established elevations over the excision area, generally using a 12-1/2- or 6-1/4-meter grid. The sketches of the area became the maps for soil excision.

For the pilot soil removal project, the area around the Kickapoo test GZ was surveyed and staked by USAE surveyors to mark the perimeter of contamination which exceeded 40 pCi/g, as determined by the in situ system.

BRUSH REMOVAL

At the Kickapoo GZ area, another brush removal experiment was conducted using the equipment previously tested at Enjebi. The front loader and grader again proved unsatisfactory. Roots were left in place, and wheel churning caused an unacceptable amount of soil disturbance. The D8K dozer proved the most satisfactory equipment for soil removal at the Kickapoo area (Figure 6-4). Ground surveyors estimated that less than 30 cubic yards of soil were moved with the roots to the windrows of brush using the dozer.

Later, at the Yuma GZ area, improved procedures were developed for removing brush with the front loader (Figure 6-5). For small bushes or brush, the loader with four-in-one bucket was used in a push mode. By closing the bucket and pushing forward, keeping it about 6 inches above ground, small bushes and brush could be cleared rapidly with minimal soil disturbance and little soil remaining in the vegetation pile. For larger bushes, the four-in-one bucket was lowered over the bush and firmly closed without cutting the bush. The bush was then lifted out of the soil. With the sandy soil conditions present, virtually all the soil fell from the root system. Thereafter, the front loader was used for most brush removal operations.

The uprooted vegetation was windrowed just outside the excision area. When it was reasonably dry, normally after the main work force had departed, it was doused with diesel fuel and burned in place. The ashes were screened by the IMP and, if found to be contaminated, were transported to Runit for entombment. If the ashes were not contaminated, they were left in place for soil enrichment.

FIGURE 6-4. SOIL REMOVAL USING D8K DOZER.

FIGURE 6-5. BRUSH REMOVAL USING FRONT LOADER.

SOIL EXCISION AND WINDROWING

After removal of brush from the Kickapoo site, the clearing was divided into three equal areas for soil removal experiments using the front loader, the grader, and the dozer. The experiments were recorded on video tape and still photographs. Where possible, excisions were made from the upwind portion of the lift area to minimize radiological hazards to the operators. Excisions were made from two sides toward the center, resulting in elongated windrows Each machine was tested by excising a 6-inch layer over as much of its area as possible in 2-1/2 hours, placing the soil in windrows as it was removed. Operators were aided by spotters on the ground.

In soil removal, the front loader was employed in two modes. With the bucket down, closed and pushing forward, the loader operated at a rate of 50-60 cubic yards per hour. It completed only 20 percent of its assigned area. Loader operations with the bucket open and scraping backwards achieved only half of that rate and proved to be generally inefficient.

The grader completed its assigned area but stockpiled only 10 percent of the soil. In attempting to push even moderate quantities of soil to a stockpile, the grader only spun its wheels and churned ruts, mixing the underlying soil.

The dozer excised and stockpiled nearly 80 percent of its area with moderate soil disturbance, which was easily corrected by backblading the area (Figure 6-6). It made acceptable cuts when operated in the lowest gear and not required to push farther than 50 feet. With each successive lateral cut, only 10 to 20 percent of the blade was used to make the new cut, and the remaining part of the blade carried the last furrow and accumulated soil with it. For this 6-inch cut, it worked at a rate of 700-800 square meters per hour and accumulated a windrow of dirt at the rate of 180-220 cubic yards per hour.

With the experience gained from these tests, it was easily recognizable that motorized scrapers would provide greater precision and efficiency in soil excision. However, they were not available on the atoll. The dozer was easily the most efficient item of equipment on the atoll for excising soil and placing it in windrows (Figure 6-7). It was employed to complete the pilot soil removal project.[64] For uninitiated dozer operators, a ground guide was used to give hand signals to direct the height of the dozer blade. After the operators acquired experience, they were generally able to obtain the desired cuts without the use of a ground guide.

FIGURE 6-6. BACKBLADING OPERATION.

FIGURE 6-7. SOIL WINDROWING.

AREA RESURVEY

After each 6-inch cut, additional soil samples were taken and analyzed, and the area was resurveyed by in situ van (Figure 6-8). If the results exceeded the desired limit, additional cuts were made until the limit was achieved. The initial goal on Aomon was to remove concentrations to below 40 pCi/g. For most of the Aomon areas excised, one cut was sufficient to lower the contamination to acceptable limits.

Subsurface contamination in the Kickapoo area was found to be far more extensive than the preliminary ERSP survey had predicted. It was impossible to determine whether it had been there previously or had been mixed in from the surface by the soil removal equipment. Extensive subsurface samples were taken before the second lift to see which was the case.[65] Analysis of the samples indicated significant subsurface contamination throughout the area except where the first lift had removed the surface contamination. Therefore, the initial subsurface characterization had to have been inaccurate, probably because it was based on too few samples. The solution was to take more subsurface samples.[66]

Once a determination was made that areas were within acceptable limits, the IMP surveyed all routes to the beach stockpile. Upon removal from the

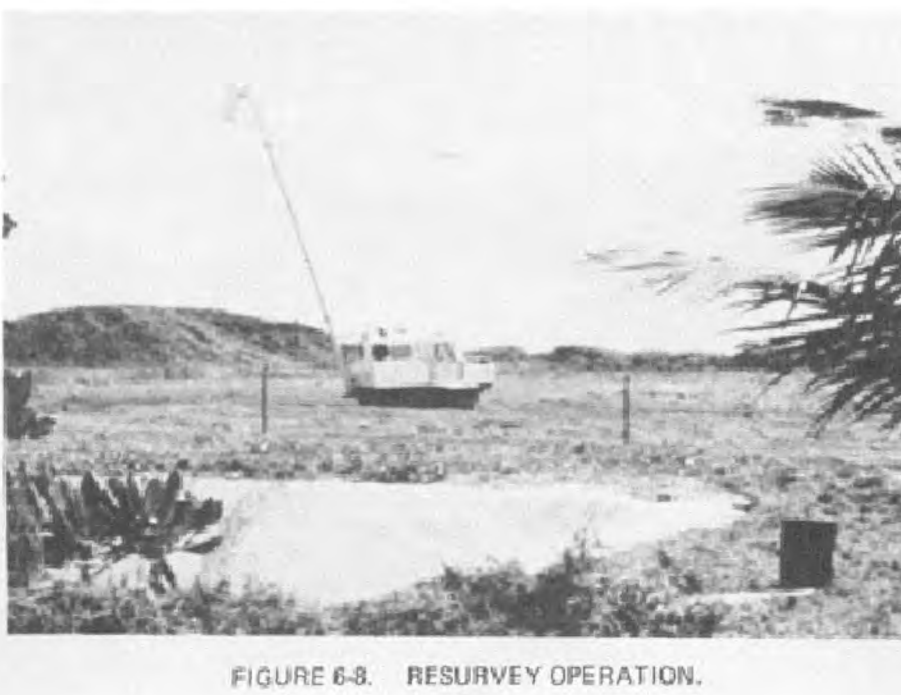


FIGURE 6-8. RESURVEY OPERATION.

island of all soil, the entire beach stockpile area, or "footprint," also was surveyed by the IMP.

One problem, which appeared early in the pilot project, was the delay in obtaining results of soil sampling and soil surveys. Priority was being given to analysis of samples from other survey sites for the characterization of the northern islands, rather than the support of the pilot project.[67] As the characterization effort neared completion, more timely support for the soil removal operation became possible. During most soil removal operations, fulltime, dedicated support by an in situ van was necessary to minimize the amount of soil excised in removing transuranic concentrations.

TRANSPORT TO BEACH STOCKPILES

Contaminated soil was moved from soil windrows to the beach stockpiles using either 5-ton or 20-ton dump trucks. A 2-1/2-cubic-yard bucket loader was used to load the trucks (Figure 6-9). After the trucks were offloaded at the beach stockpiles, the pile was consolidated using either a 2-1/2-cubic-yard bucket loader or a dozer. Beach stockpiles were located as close as possible to the loading areas for boat transportation but above the high-tide line.

FIGURE 6-9. CONTAMINATED SOIL MOVEMENT.

ACCOUNTING FOR CURIES

One additional goal of the pilot project was to develop methods for measuring the amount of radioactivity in the excised soil and for sorting the soil into two stockpiles on Runit One stockpile would consist of soil with contamination levels greater than that to which Runit would be cleaned (assumed to be 400 pCi/g), and the other of soil with lower levels. The first stockpile would have to be placed in the crater, while the second could be left on Runit if resources were not sufficient to encapsulate it. The procedure also would provide an accounting for the total curies of radioactive material removed. Two methods of measurement were tested.

A dirt ramp was prepared to the top of an old Japanese bunker on Aomon. The in situ van was driven to the top of the bunker where its detector could be placed over the loaded dump truck beds to measure radiation intensity. Results varied with the configuration of the load and the positioning of the truck. As an alternative, one scoop of soil was removed from each front loader bucket before the soil was dumped into the truck. Individual scoop samples were composited to produce one sample per truck. The bucket loader sample and the truck top sample were each shaken vigorously, then one petri dish of soil was removed for scanning On-site scanning of the first 18 truckloads indicated that both of these sampling methods tended to give much higher readings than in situ surveys of the area before, during, and after soil removal operations. The truck sampling techniques were not pursued further.

The method finally adopted for calculating radioactivity removed from an area and taken to Runit was to employ the in situ data from before, during, and after soil excision, plus the subsurface profiling data.[68,69] Results were sufficiently accurate to account for total curies and to sort the highly active (hot spot) soil from the low-level soil.

TRANSPORT TO RUNIT

Several methods of transporting contaminated soil from beach stockpiles to stockpiles on Runit were tested during the pilot soil removal project. The U.S. Navy Element (USNE) was tasked to support the project with one LCU, two LCM-8s, and a warping tug with two causeway sections assembled as a ferry or floating platform. The USAE was tasked to test the LARC-LX for soil transport. Intensive reconnaissance efforts were conducted to identify alternative channel approaches and to quantify tidal restrictions to all approaches. Channel improvement techniques were included in the overall plan. Variations and modifications were authorized with HQ JTG approval.

The first tests consisted of carrying loaded dump trucks on various types of watercraft. The trucks were loaded at the beach stockpiles using 2-1/2-cubic-yard front loaders. Typical loading time averaged 10 minutes per truck. The 20-ton truck tended to lose traction in dry sand while the 5- and 10-ton trucks could traverse most dry surfaces. All vehicles required an improved surface or ramp on the beaches. A loaded 20-ton dump truck was originally estimated as carrying 10 cubic yards of contaminated soil. In February 1979, after careful study, a more precise estimate of 8 cubic yards was established. A 5-ton truck, which used almost as much deck space on the landing craft as a 20-ton truck, was estimated to have a usable volume of only 4 cubic yards. This made the 5-ton trucks impractical for deliveries of soil to Runit and required use of dedicated 20-ton trucks for each watercraft. As time passed, corrosion and maintenance problems impaired the availability of 20-ton trucks, and the water transport operation became heavily constrained. In addition to the normal adverse effect of the climate on the 20-ton trucks, the exposure to salt spray during the over-water movement compounded their degradation by rapidly damaging electrical and brake systems.

The load capacity of the LCM-8 and the LARC-LX were identical in that each could carry only one 20-ton truck. However, the LCM-8 made the round trip from the loading point on Bijire (Tilda) to Runit in 82 minutes, while the LARC-LX took 101 minutes. The LCU took 103 minutes for the round trip, but could deliver six 20-ton trucks per trip (Figure 6-10).

The causeway sections were used with two sections side by side or end to end with the warping tug as the propulsion unit. In this configuration, known as the Warping Tug Causeway Ferry, four 20-ton trucks could be moved; but this method was the slowest in transit time, 143 minutes per round trip[70] (Figure 6-11). A modification to this procedure incorporated three causeway sections in combination. Two of the sections were end to end with the third section side by side to the trailing section. This configuration accommodated eight 20-ton trucks, but the transit time was increased due to the additional drag of the third section. Again, the warping tug was the means of propulsion. This means of transportation caused the most salt water spray damage to the 20-ton trucks

During the pilot project, it became obvious to the CJTG that the limiting factor in soil cleanup operations was boat transport of soil to Runit (Figure 6-12). The USAE suggested use of the bulk-haul method, by which soil had been moved to the Enjebi tree farm and aggregate had been moved from Enjebi to Lojwa. The CJTG concurred in a test and, on 6 and 7 April 1978, an LCM-8 was modified by welding quarter-inch-thick steel plates around the welldeck sides and steel strips on the deck to protect the cleats during offloading. On 8 April 1978, the LCM-8 was loaded with 40 cubic yards of soil and taken to Runit. Transit time was unaffected. Loading time

FIGURE 6-10. LOADED LCU.

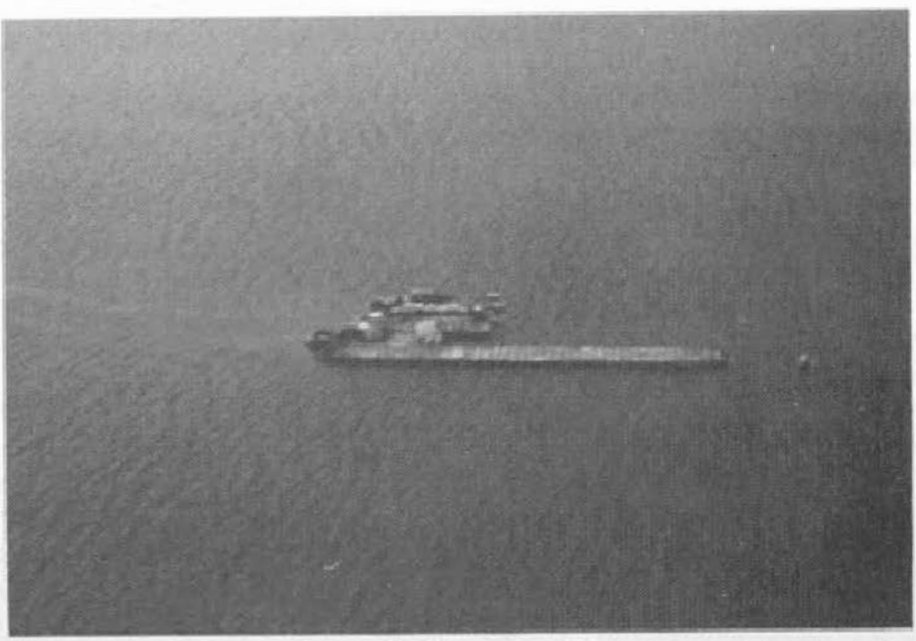


FIGURE 6-11. WARPING TUG CAUSEWAY FERRY.

METHOD	LOAD DEVICE	LOAD[3] CY	AVG LOAD TIME	OVER-WATER TRANSPORT	TRANSPORT[1] TIME (AVG)	AVG OFF-LOAD TIME	TOTAL TIME PER TRIP
Truck	20-T Truck/1	8	10 min	LARC LX	50 min	20 min	130 min
	20-T Truck/1	8	15 min	LCM-8	40 min	20 min	115 min
	20-T Truck/6	48	30 min	LCU	50 min	40 min	170 min
	20-T Truck/4	32	40 min	2 Causeways w/ warping tug	75 min	50 min	240 min
	20-T Truck/8	64	60 min	3 Causeways w/ warping tug	80 min	80 min	300 min
Bulk Haul	5/20-T Truck	95-110	40 min	Modified LCU	50 min	45 min[2]	185 min
	5-T Truck	28	20 min	Modified LCM-8	40 min	20 min[2]	120 min
	20-T Truck	32	20 min	Modified LCM-8	40 min	20 min[2]	120 min
	5 CY Bucket Loader	52-56	20 min	Modified LCM-8	40 min	30 min[2]	130 min

1. Transportation times normalized to trip from Aomon to Runit.
2. Offloaded by 5 cubic yard bucket loader at Runit.
3. Loads changed based on study conducted in February 1979 (20-T truck capacity changed from 10 cubic yards to 8 cubic yards).
4. Includes transit time back to Aomon which is same as travel time to Runit.

FIGURE 6-12. SOIL TRANSPORT TIMES.

was 25 minutes, while offloading took 52 minutes on the test run. These times were expected to improve with practice Also, it was expected that the average load would be only 30 cubic yards. Air samplers were operated during loading and offloading and the crew of the LCM-8 wore full-face respirators Monitoring revealed no contamination of the crew or air filters Boat decontamination using sea water took four men approximately 2 hours. The modification had no effect on the craft's capability to haul trucks, supplies, or debris. The JTG was enthusiastic about the results of the test and began planning to modify other craft should the proposal be approved at higher echelons [71,72] No further bulk-haul deliveries of soil were made until the modification was approved by the Director, DNA for radiological and service tests

The contaminated soil transportation capability increased in successive stages as additional equipment was modified or became available A summary of these increases is at Figure 6-13.

The pilot soil removal project met all of its objectives and provided Director, DNA and Commander, Field Command with data that were critically needed for all of the major cleanup decisions, once adequate soil characterization information was developed. Most important was the positive knowledge that inexperienced troops in the field could learn and accomplish "surgical" excision of contaminated top soil and that, generally, one or two cuts would result in a radiologically acceptable area.

Also of importance were the detailed planning factors of time, manpower, and equipment required per unit of soil moved. With this information developed by the JTG and Field Command, all that was required before all of the major soil-cleanup decisions could be made was the DOE soil characterization data from which estimates could be made of the amount of soil needed to be excised from each island to achieve alternative levels of cleanup results (e.g , to make the island acceptable for residential, agricultural, or food gathering purposes)

The pilot soil removal project evolved into a cleanup of contaminated soil on Aomon to qualify it for either agricultural or residential use depending on DOE's forthcoming data

APRIL 1978 CONFERENCES

On 11 April 1978, COL Treat briefed the Director, DNA on some overall rough planning factors, using the results of the pilot soil removal project and the time and motion study based on data obtained during the project. The study did not take into account the improved capability that experience and maximum use of bulk haul would bring; thus, its predictions were not optimistic Because 5 months already had been lost

STAGE DATES	CRAFT	NO	AVG AVAIL/ DAY	AVG CU.YDS./ CRAFT	NO TRIP/ DAY	AVG CU YDS/ DAY
I	WTCF w/5 Trks	1	8	40	1	32
1 Jun–2 Jul 78	LCM-8 (B)	1	8	35	2	56
						88
II	WTCF w/5 Trks	1	8	40	1	32
3 Jul–9 Jul 78	LCM-8 (B)	1	8	35	2	56
	LCU (B)	1	8	100	1	80
						168
III	WTCF w/8 Trks	1	8	64	1	48
10 Jul–18 Jul 78	LCM-8 (B)	1	8	35	2	56
	LCU (B)	1	8	100	1	80
						184
IV	WTCF w/8 Trks	1	8	64	1	48
19 Jul–20 Aug 78	LCM-8 (B)	2	1 5	35	2	84
	LCU (B)	1	8	100	1	80
						212
V	WTCF w/8 Trks	1	8	64	1	48
21 Aug 78–1 Apr 79	LCM-8 (B)	3	2 0	35	2	112
	LCU (B)	1	8	100	2	160
						320
VI	LCM-8 (B)	3	2 0	35	2	140
2 Apr–23 Apr 79	LCU (B)	2	1 7	100	2	340
						480
VII	LCM-8 (B)	4	3 0	35	2	230
24 Apr–10 May 79	LCU (B)	2	1.7	100	2	340
						570
VIII	LCM-8 (B)	6	4 0	35	2	280
10 May–30 May 79	LCU (B)	2	1.7	100	2	340
						620
IX	LCM-8 (B)	6	4 0	52	2	416
30 May–Complete	LCU (B)	2	1.7	100	2	340
						756

Note (B) = Bulk Haul Converted

FIGURE 6-13. RELATIVE DAILY SOIL TRANSPORT CAPABILITY.

from the time scheduled in the OPLAN for soil cleanup, COL Treat estimated that, unless the project were extended beyond its scheduled 15 April 1980 completion date, only 12 months would be available to excise and transport soil from the northern islands, leaving another 2-1/2 months to complete Runit soil cleanup and 1 month to finish closing the concrete cap. His study predicted that only 60,000 to 67,500 cubic yards of soil could be moved by boat in that 12 months.

The Director, DNA was determined to complete the project on time, unless it proved manifestly impossible to do so He believed his two overriding commitments were: (1) to achieve satisfactory radiological cleanup results for the dri-Enewetak; and (2) to complete the project on time and within the funds appropriated from the taxpayers by the Congress. While the first was paramount, VADM Monroe felt the second also was of critical importance, and he still believed both could be achieved. On-time completion was of great importance because of the significant drain on the Services' manpower, funds, equipment, and other resources. VADM Monroe remained confident that COL Treat's initial time and quantity factors would improve with experience, and that other efficiencies could be found.

Boat transportation was the principal constraining resource. There was enough engineer manpower and equipment to excise and contain the 150,000 to 180,000 cubic yards of soil COL Treat estimated it would take to reduce all islands, including Runit, to below 40 pCi/g. The elongated configuration of the Cactus Crater container design would provide sufficient volume and the MILCON funds for crater containment appeared to be adequate to contain the currently estimated amounts of contaminated soil.

The crux of the boat transportation problem was Enjebi. Field Command estimated that 57,900 cubic yards would have to be removed from Enjebi to bring it below 40 pCi/g. This would use almost all of the transport capability for a year. Alternatively, in the same year, 63,700 cubic yards of soil could be removed from seven other northern islands (excluding Enjebi and Runit) to bring all seven to below 40 pCi/g. Runit could be cleaned in either case since no boat assets were required.

According to COL Treat's initial rough estimates, two obvious alternatives were: (1) clean Enjebi to residential levels and clean Runit; or (2) clean the other seven islands and Runit.[73] However, two old Runit issues, which COL Treat had been studying and reviewing with the ERSP manager, were reopened in the briefing.[74,75]

The ERSP characterization of Runit, requested in October 1977, had not, for a number of reasons (previously discussed), been completed at the time of the 11 April 1978 meeting with Director, DNA. During the conference, it was proposed again that, since Runit might have to be quarantined indefinitely because of subsurface contamination, there was little reason to clean surface contamination. Some discussions revolved around proposals to store contaminated soil from other islands on the surface of Runit, not clean Runit, and require that Runit be quarantined indefinitely. The DNA General Counsel supported the proposals on the basis that the dri-Enewetak already had appeared to accept the loss of Runit. Most of the Field Command staff opposed the proposals since they did not conform to the EIS requirements and a substantial investment and effort already had been directed toward crater containment. The Director, DNA decided that: (1) soil contaminated to levels greater than 400 pCi/g from islands other than Runit and all contaminated debris would be removed and contained in the crater; (2) lower level contaminated soil from islands other than Runit would be encapsulated within available resources and optimum crater design; and (3) Runit would be cleaned as much as possible with priority to highest level "hot spots," dependent on availability of resources, time and crater capacity remaining.

Other matters discussed at the conference included the need for soil cleanup criteria, the possibility of cleaning Aomon, Bijire, and Lojwa to residential levels as an alternative to Enjebi, and whether amendments to the EIS might be required if significant deviations were made from its provisions.[76] While these discussions served to focus future analysis and planning, all of the DNA leadership realized that more work would still have to be done to allow the key questions of "which islands," "in which priority," and "to what level" to be answered.

The 11 April conference served to confirm for the Director, DNA the need to bring all organizations with an interest in Enewetak together to learn of the results to date, hear all of the information available, consider the alternatives, and have the opportunity to make recommendations on cleanup decisions. Furthermore, DOE had advised that its data would be available to Field Command in time to support such a major policy conference in early May 1978.

Several other actions pertinent to the May conference took place in April 1978. On 21 April 1978, Mr. Theodore Mitchell, of MLSC, the Enewetak people's attorney, advised Field Command of the results of his 2-day conference with the dri-Enewetak council at Ujelang. Their response to the idea of living on Enjebi was rather low key. They would only consider it if they could live there safely. The possibility of residence on the Aomon-Bijire-Lojwa complex was complicated by ownership disputes between the dri-Enjebi and the dri-Enewetak. They were quite safisfied with the current plan of mixed residence of dri-Enewetak and dri-Enjebi on the three southern islands.[77]

On 26 April 1978, DOE advised of a related complication. The Bikinians were going to be removed from their atoll because of disturbingly high intakes of strontium and cesium, both of which were known to exist on Enjebi.[78]

BAIR COMMITTEE RECOMMENDATIONS

At the 6 January 1978 conference, Mr Tommy McCraw, DOE, had indicated that Lawrence Livermore Laboratory (LLL) was being tasked to make an Enewetak dose assessment study which could serve as a basis for associating island use with concentration of plutonium and other transuranic elements[79] On 3 April 1978, DNA was briefed on the key finding of the study. Based on an assumption that the dri-Enewetak would apportion their time on residence, agricultural, and food-gathering islands according to 60, 20, and 5 percent, respectively, compliance with the EPA guideline would be achieved if residence, agriculture, and food-gathering islands were cleaned to at least 10, 20, 40 pCi/g, respectively[80,81] (The remaining 15 percent of the time was considered to be spent on the water, traveling or fishing, or away from the atoll, i e , Ujelang, Majuro.) This finding caused concern at DNA since the stringent criteria might prohibit some islands from qualifying for their planned use as detailed in the EIS, and the required cleanup effort would be greatly expanded.

On 4 April 1978, DOE requested that the Bair Committee provide advice on the soil cleanup questions raised at the 6 January 1978 conference and on other radiological support matters.[82] The Committee, also referred to as the Enewetak Advisory Group, met with DOE and DNA representatives at DOE-NV on 13-14 April 1978 and was briefed on the status of the cleanup and its current problems. A key topic of discussion was the recent LLL draft dose estimate study. The principal technical point of the study related to the unexpected large dose predictions to bone resulting from inhalation of all transuranics, compared to those from plutonium alone The study indicated that inhalation dose to bone might exceed the dose to lung by a factor of three or more (the ratio of dose limits for lung and bone). The large dose was due to the less abundant Am-241 which Dr William Robison of LLL explained was the result of his using a high Am-241 "gut transfer coefficient " The high coefficient was challenged by some Committee members, but Dr. Robison stated that he felt obligated to use the high coefficient since it had been noted recently by several experimenters. This draft dose estimate study caused Am-241 to be considered an important contributor to dose and an important ingredient in cleanup evaluations.

The Bair Committee met again on 26-27 April 1978 in Denver, Colorado, to consider the following questions

a. Is it possible to develop dose-related cleanup guidance that would assure that doses to future residents of Enewetak Atoll would not significantly exceed proposed EPA guidelines for transuranics?

b What advice can be given to DNA at its early May conference to facilitate planning for cleanup of transuranics on Enewetak?

c. What additional information can be obtained which could improve the confidence of the dose estimates and cleanup criteria for transuranics?

d. Can plowing be used as an effective cleanup measure for transuranics in soils?

The Committee reviewed information and data provided by DOE-Division of Occupational and Environmental Safety, LLL, DOE-NV, and DNA. The draft LLL dose assessment study was the basic document from which the Committee was to formulate answers to the questions raised and to provide advice. The Committee offered the following response to the questions as they pertained to transuranic elements only (not fission products, which they understood might delay the resettlement of some islands for a number of years):

a. The Bair Committee did not find it possible to develop reasonable cleanup guidance which would assure that radiation doses from transuranics to future residents would not exceed proposed EPA guidelines to the extent to be of concern. Obviously, the more stringent the cleanup criteria, the greater the degree of assurance, but uncertainties inherent in our present understanding of the problem precluded absolute assurance. One could not predict with certainty the contamination levels that would exist in the islands after cleanup, this would be determined at a future time. One could not predict the lifestyle and dietary habits of every individual who returns to the islands. Perhaps most important, many of the factors that are involved in movement of transuranics in the environment and the depositions and retention of transuranics in human beings are not well established.

However, the Committee was of the opinion that its recommended cleanup criteria would result in average transuranic radiation doses to subsequently exposed populations that would be commensurate with proposed EPA guidelines. The EPA considered its guidance levels to be equivalent to a lifetime risk of about 14 premature cancer deaths per 100,000 persons exposed and to perhaps an equal number of genetic effects, although these estimates are based on many uncertain assumptions and generally are considered to be quite conservative. An estimate of 14 cancers per 100,000 people would correspond to a 3 percent chance of one cancer appearing in a population of 200 people exposed to EPA guidance levels for their lifetime; or expressed differently, to a probability of one cancer in every 2,100 years (assuming a constant population size).

b. Considering the physical and ecological limitations to removal of transuranics from the Enewetak Atoll, the Bair Committee recommended the following cleanup criteria:

(1) All one-quarter or one-half hectare areas on residential islands should be cleaned unless the average concentration in surface (0-3 cm) soil does not exceed 40 pCi/g (with 70 percent confidence). That is, each one-quarter or one-half hectare area should be cleaned if the average concentration plus one-half standard deviation (for the unit area) exceeds 40 pCi/g. From the information then available and being used for dose assessment, the Committee believed this procedure would provide a reasonable expectation that dose in the bone and lung would be commensurate with the EPA guidance. In terms of radiation dose-sparing benefit to future inhabitants, the Committee pointed out that cleanup of a standard area on a residential island was worth about four times as much as cleanup to a given level on an agricultural island and 12 times as much as cleanup of the same area to the same level on an island designated for food gathering. In the light of existing contamination levels and available cleanup resources, it would appear that cleanup of all one-quarter or one-half hectare areas on residential islands according to the above criteria should receive first priority.

(2) Because the other islands may have increased use over that currently assumed, a second priority should be the cleanup of agricultural island half-hectare areas unless the average concentration for the unit does not exceed 80 pCi/g (with 70 percent confidence).

(3) A third priority should be the cleanup of food-gathering island half-hectare areas unless the average concentration for the unit does not exceed 160 pCi/g (with 70 percent confidence). If resources were exhausted, some islands might not be cleaned up, and final dose assessment might indicate that these islands would have to be quarantined.

The Committee noted that the soil profile on Lujor was anomalous, since the concentration of transuranics appeared to be uniform with depth. They believed that the possibility of effective cleanup for use as a residential or agriculture island was remote However, the possibility of covering Lujor with the less contaminated soil from the residential islands, and perhaps from the agricultural islands, should be considered for lowering the average surface contamination levels and reducing the logistics problems of transporting the soil from the other islands to Runit.

The Committee listed several ongoing and proposed actions to provide additional information which could improve the confidence of the dose estimates and cleanup criteria for transuranics. They also indicated that plowing might reduce surface soil concentrations and hence reduce the potential inhalation problem, but that it was unlikely to reduce plant uptake.[83]

DOE SOIL CHARACTERIZATION

The DOE-ERSP characterization data for the northern islands was forwarded to Field Command on 27 April 1978. It covered all transuranics, while the EIS covered plutonium only, and it included estimates of soil volumes to be excised under various conditions. Some of these estimates were used in updating the Field Command time and motion study for the briefing to be given at the 3-4 May 1978 conference, while others were disregarded due to significant variances with data on hand

The DOE characterization had taken 9 months to complete. In general, it confirmed what had been indicated in the 1972 radiological survey, AEC Task Group recommendations, EIS, CONPLAN, and OPLAN. Five islands required removal of plutonium concentrations to permit their use as planned by the dri-Enewetak Aomon, Boken, Enjebi, Lujor, and Runit. None of the eight case-by-case islands required any soil cleanup. Nine other northern islands, not previously identified for soil cleanup, also had been characterized and found with no contamination above 40 pCi/g.

DOE-ERSP's estimates of the volumes of soil to be removed from the four islands named in the EIS to permit the planned use was approximately 72,000 cubic yards. The EIS estimate for those islands was 79,000 cubic yards. The DOE-ERSP estimate for the fifth island, Enjebi, was 44,835 cubic yards to qualify it for residential use.[84] These estimates were reassuring to the planners since they indicated that volumes of soil previously estimated to be moved would not be materially affected by the inclusion of all transuranics, which had not been previously considered

Regarding the time utilized for the soil characterization, it should be noted that the advanced techniques developed by DOE-NV for this complex task and the new equipment fabricated from research and development components were truly remarkable. To field this effort in the distant, harsh Enewetak environment—and to put it on a paying basis relatively quickly—was quite an achievement. The soil cleanup project had been delayed, but this had been compensated for by a speedup in contaminated debris cleanup. Since DNA had avoided making decisions involving major resource commitments which might have proven to be ill-advised, no serious harm had been done to the overall project by the delay

In April 1978, the first soil removal platoons completed their TDY tour and were replaced in the second "Operation Switch." They had just begun developing techniques and skills for contaminated soil removal by excising the Medren hot spots and by beginning the pilot soil removal project.

3-4 MAY 1978 CONFERENCE

On 3-4 May 1978, representatives from all involved Departments, Services, and other agencies met at Headquarters, DNA, Washington, DC The dri-Enewetak were represented by their counsel, Mr. Theodore Mitchell, of MLSC, and their interests also were represented by Mr. Oscar DeBrum, District Administrator of the Marshall District of the TTPI. The purpose of the conference was to review progress to date and to develop recommendations on a wide range of radiological cleanup decisions. The most important decisions concerned contaminated soil cleanup criteria and island cleanup priorities Decisions on these issues would allow soil cleanup operations—now 6 months behind schedule—to commence. The conference was given added urgency by repeated queries from the Services regarding the growing delay in undertaking the most difficult work of the project and how much more manpower, equipment, and/or time DNA expected them to provide to overcome the delay.[85] A full day of prebriefings, critiques, and working group meetings on critical agenda items on 3 May provided extensive preparation for the decision meetings on 4 May.

VADM Monroe, who chaired the conference, opened it with a review of soil cleanup developments, including the following points:

a. All previous planning documents, including the EIS and OPLAN, contained only general guidance on soil removal, based on the 1972 radiological survey It was widely recognized that more specific data would be required for actual removal of contamination from the islands. It had been planned that soil surveys would be conducted by DOE during the mobilization phase and that sufficient data would be provided to begin soil cleanup operations on 15 November 1977 However, it took much longer than planned to obtain the detailed data on all of the northern islands and to characterize the total scope of soil cleanup work, as DNA had requested, for use in deciding the priority order in which the islands would be cleaned and the levels to which they would be cleaned

b. Prior planning, including that in the OPLAN, had assumed that these decisions would be made in the field, island by island, based on the people's planned use and AEC/DOE guidelines It had since become apparent that these were key decisions which would shape the pattern of future use and habitation and would determine radiological exposure levels at the atoll for years to come Thus, the Director had determined that the decisions were his to make, based on review and consultation with all parties concerned with Enewetak cleanup and rehabilitation. Although all the data on all the islands were not yet available, the point had been reached where decisions had to be made so that soil cleanup operations could commence.

c. Two major changes which affected soil removal had occurred since the project began. First, based on Field Command's studies, experience factors, and radiological considerations, estimates of the volumes of soil to be removed had increased significantly. Second, new guidelines for transuranic contamination limits had been proposed by the EPA which had been interpreted by the Bair Committee to require soil cleanup criteria to be lowered significantly, i.e., from 400 pCi/g to 160 pCi/g for food-gathering islands and from 100 pCi/g to 80 pCi/g for agriculture islands.

d The factors which had not changed were the charter from the Joint Chiefs of Staff (JCS) to do the job with the same amount of Service resources, and in the same amount of time. The planned completion date was still 15 April 1980.

e. The Director, as DOD Project Manager, would balance resources against requirements, exercising responsible stewardship of Service resources assigned to the project and realizing that cleanup of radiological contamination could become an endless task. The decisions that were made must go beyond immediate results and stand the test of time—30 years in the future—when the impact of poor decisions would be felt by a people who had already suffered greatly. Any such decisions would certainly reflect adversely upon the United States.

f. In making these decisions, the Director, DNA needed the participation and advice of all conferees, as well as their understanding that all the decisions would not, in every case, please everyone. Many factors had to be balanced: the people's benefit, the funds, the time available, the lack of some data, and most of all the fact that soil cleanup must begin as soon as possible.[86]

BG Tate reemphasized that the primary goal of the conference was to determine where to begin soil cleanup and to what levels it should be carried out so that the JTG could start moving soil on 1 June 1978. He described the constraints as follows:

a. Optimize benefit to the dri-Enewetak/dri-Enjebi.
b. Stay within $20 million MILCON funding appropriated by Congress.
c. Ensure that soil cleanup decisions did not delay the planned 15 April 1980 completion date.
d. Minimize changes in Service/DOE-allocated manpower and equipment resources.

e. Minimize deviations from the EIS which might require amendments and delays.
f. Maximize compatibility with the TTPI Rehabilitation/ Resettlement Program.
g. Assuming that the new proposed EPA guidelines on transuranics and dose criteria for the continental United States were adopted (and were to be applicable to Enewetak), minimize deviations from these criteria in order to avoid problems encountered at Bikini (lawsuits, delays, recleanup, exposure).[87]

PROJECT STATUS BRIEFINGS

Field Command next presented a series of briefings on the status of the project. Debris cleanup had begun on schedule and was now well ahead of schedule because resources which would have been used on soil removal were instead accomplishing debris cleanup. The forces were running out of debris work in the north and some were being assigned lower priority work in the southern islands to keep them occupied. The only major lag was soil cleanup (Figure 6-14).[88]

Details on the status of manpower, equipment and funds were presented. The data showed clearly that the resources were on hand to accomplish soil removal and containment in Cactus Crater. The Army and DNA already had invested over $3 million for crater containment equipment and construction on Runit. Funds were available to contain at least 145,000 cubic yards of contaminated soil.[89]

A detailed briefing was presented on the crater containment design by the Corps of Engineers Pacific Ocean Division (POD). POD had developed a flexible design, based on using one crater, which would accommodate 200,000 cubic yards in the Cactus Crater.[90] A circular configuration provided for containment of from 29,000 cubic yards up to 116,000 cubic yards. Once the optimum height had been achieved, elongating the structure would permit the additional containment up to 200,000 cubic yards. The POD design provided for completion of the tremie operation and, based on an estimate of remaining soil to be encapsulated, an attempt would be made to define the height to which the structure must be constructed and whether or not elongation would be necessary. In terms of economy of time and funds, and considering that the tremie fill of the crater would follow the crater contours, the options favored using the circular configuration if at all possible.[91]

The evolution of soil cleanup criteria was reviewed from the AEC Task Group Report through the latest Bair Committee report, showing how the AEC/DOE guidelines had become more stringent and better defined. What originally was a requirement to remove all concentrations over 400

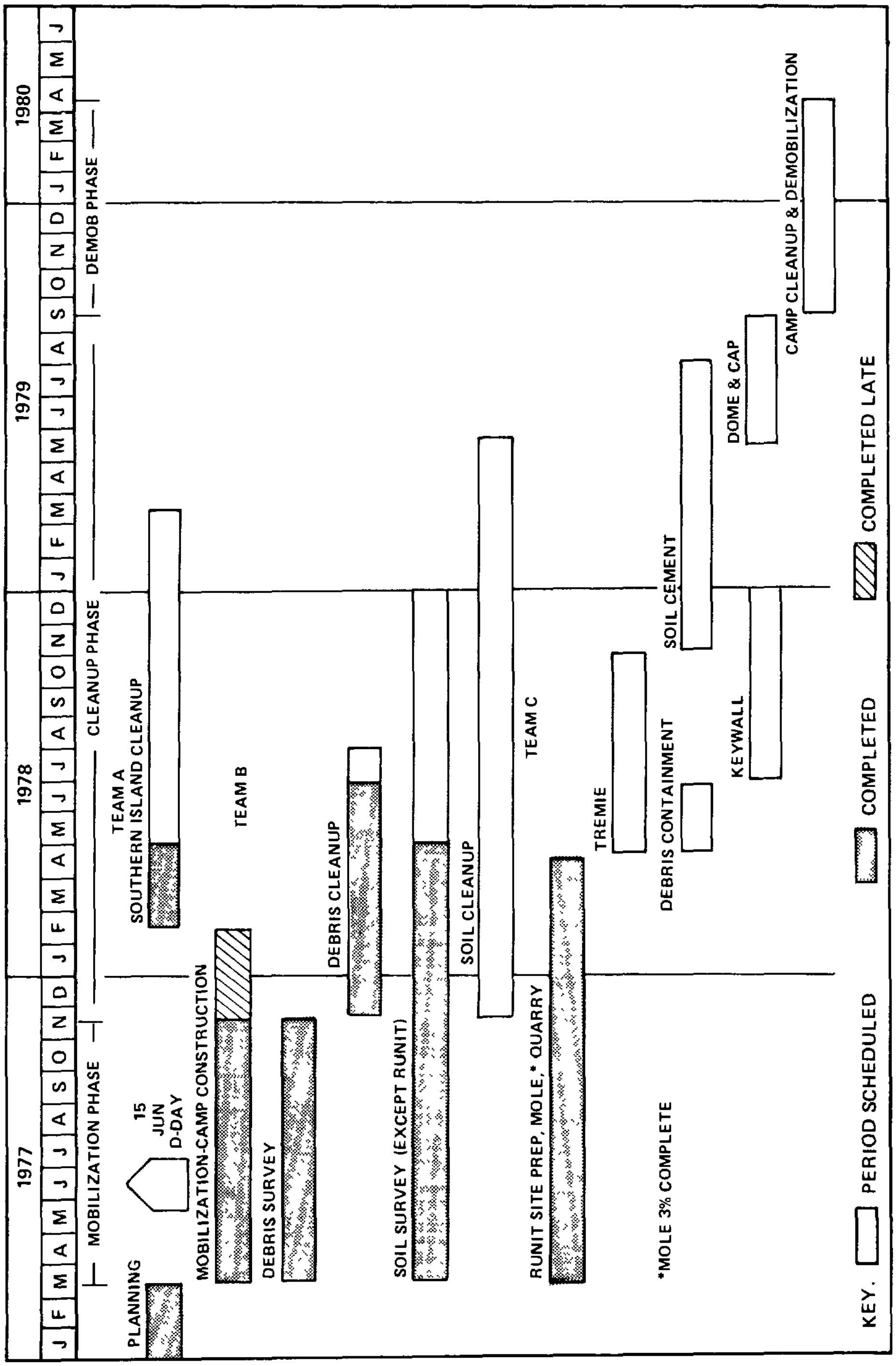


FIGURE 6-14. ENEWETAK CLEANUP PROJECT STATUS, 4 MAY 1978.

pCi/g had evolved into requirements to remove concentrations over 160 pCi/g from visitation/food-gathering islands, over 80 pCi/g from agriculture islands, and over 40 pCi/g from residential islands.[92]

The evolution of island use plans also was reviewed, including the differences between the desires originally expressed by the people in 1973 and the EIS or AEC Task Group Report:

a. The people desired to collect coconut crabs on all islands while the EIS and Task Group Report limited such activity to the southern islands.
b. The people desired to use Runit as an agriculture island while the EIS and Task Group Report only prescribed that Runit would be cleaned and the quarantine removed, without specifying eventual use.
c. The people desired to use Enjebi for residence while the EIS and Task Group Report did not specify such cleanup but merely indicated it might eventually be used for that purpose. The briefer indicated that this was a highly desirable goal, unaware that the people had recently communicated a lack of enthusiasm for such residence.

The pilot soil removal project and its results were described in detail. One principal result was the identification of more subsurface contamination in the soil than anticipated. This discovery, together with the inclusion of all transuranics, the more stringent soil cleanup criteria, and the time already lost, resulted in greater demands on cleanup capabilities to satisfy the people's desires and opened the possibility that some islands might have to be permanently quarantined.[93]

SOIL CRITERIA BRIEFING

DOE then presented a briefing on soil cleanup criteria. Following the 1972 radiological survey of Enewetak, which was probably the most extensive done in any environment, the agency had a dose assessment study conducted by their contractor, LLL. The assessment considered all of the pathways by which radionuclides enter humans, soil being only one component. This dose assessment was the basis for the original soil cleanup criteria. After the cleanup phase had begun, DOE began working with EPA on their development of federal guidelines for transuranic elements in soil. DOE then recognized the need to review the Enewetak dose calculations to determine just how their values compared with those they had helped EPA develop. After some rough comparisons, DOE tasked LLL to redo the Enewetak dose calculations with additional data collected in the past 5 years, including some of the in situ survey results from Enewetak. The new dose assessment included other transuranics as well as plutonium. (Initial LLL estimates had indicated that Am-241 was an important contributor to dose; however, the calculations contained an arithmetic error and the concern was unfounded) The new LLL dose assessment was reviewed by the Bair Committee and was the basis for their recommendations of revised levels for agricultural and visitation/food-gathering islands.[94] The arithmetic error was not discovered until after the new guidelines were issued. The new guidelines were based on estimated doses from time spent in various activities, such as food gathering or residence, on various islands with different levels of contamination (Figure 6-15).

The model for the LLL dose assessment and Bair Committee recommendations assumed that the people spent 60 percent of their time on residential islands, 20 percent on agriculture islands, and 5 percent on food-gathering islands. It also assumed that 65 percent of the coconuts and all of the other food consumed would be grown on residence islands. An estimated 25 percent of the coconuts consumed would come from agriculture islands and 10 percent from food-gathering islands.

The cleanup guidelines proposed removal of concentrations exceeding 40, 80, or 160 pCi/g as appropriate. The resultant island averages, however, would be lower. Dose calculations based on these guidelines were estimated at 10.3 millirad per year from inhalation and 2.7 millirad per year from terrestrial sources for a total of 13 millirad per year to the bone. This exceeded the proposed EPA guideline of 3 millirad per year; however, it was well within the International Commission on Radiological Protection dose limit to bone which was equivalent to 30 millirad per year.

COMMITTEE RECOMMENDATIONS*
TRANSURANIUM ELEMENTS IN SOIL

PRIORITY**	ISLAND TYPE	SOIL CONCENTRATION***	AREA
I	VILLAGE ISLANDS	$\leq$ 40 pCi/g	1/4 HECTARE
II	AGRICULTURAL ISLANDS	$\leq$ 80 pCi/g	1/2 HECTARE
III	PICNIC ISLANDS	$\leq$ 160 pCi/g	1/2 HECTARE

* HEAVILY QUALIFIED DUE TO UNCERTAINTIES. NO ABSOLUTE ASSURANCE CAN BE GIVEN—IN THE OPINION OF THE ADVISORY GROUP, CLEANUP TO THESE LEVELS WILL RESULT IN AVERAGE TRANSURANIC DOSES COMMENSURATE WITH PROPOSED EPA GUIDELINES

** IF RESOURCES ARE EXHAUSTED, SOME ISLANDS MAY NOT BE CLEANED UP, FINAL DOSE ASSESSMENT MAY INDICATE THAT THESE ISLANDS WILL HAVE TO BE PERMANANTLY QUARANTINED.

*** WITH 70 PERCENT CONFIDENCE.

FIGURE 6-15. DOE DOSE.

The 13 millirad dose assumed the worst case where residence, commercial agriculture, and food gathering took place on islands with soil contaminated to 40, 80, and 160 pCi/g, respectively. If the people followed the EIS Case 3 habitation plan and lived only on the southern islands—which would measure less than 2 or 3 pCi/g—the dose to bone would be much lower.[95,96]

DOE endorsed the new guidelines as fully in keeping with the recommendations and cleanup criteria contained in the EIS. The requirement to remove all concentrations over 400 pCi/g was unchanged. Specific guidance was provided for concentrations in the 40 to 400 pCi/g range which were to be decided on a case-by-case basis. The dose estimates were done with the best models available, using the EPA criteria as a goal. DOE hoped the cleanup would come within a factor of three or four of the EPA goal, in which case it could meet the spirit and intent—if not the letter—of EPA guidance.[97]

SOIL CLEANUP BRIEFING

The final briefing covered the estimated volumes of soil to be removed, the assets available to excise and transport soil to Runit, and some of the options for accomplishing soil cleanup. It was a revised version of the briefing given to Director, DNA on 11 April 1978. Although data were presented on all 21 northern islands, only five required soil cleanup to satisfy the original dri-Enewetak desires for use: Runit and the islands from which soil would have to be transported by boat; i.e., Aomon, Boken, Enjebi, and Lujor.

The soil volume data varied somewhat from the DOE-ERSP estimates. The most significant factor in Field Command's estimates of soil to be removed and transported was the so-called "Treat Factor." This was a soil removal "experience factor" which COL Treat developed to adjust the initial estimates of soil volumes The principal aim of the "Treat Factor" was to provide decision-makers with a reasonable approximation of the amount of soil that would ultimately have to be removed from an area with high surface contamination in order to reduce it, by means of successive 6-inch cuts, to a designated level. It was based upon consideration of experience from other soil cleanup operations; e.g, Hattiesburg, Rocky Flats, etc. Application of the Treat Factor caused estimated volumes of soil which had a surface contamination of over 400 pCi/g to be multiplied by a factor of four. (This meant that it was estimated that soil removal teams would have to make four 6-inch cuts to bring the surface levels down to acceptable residual levels of radiation. In essence, it was a compensation for the fact that experience had indicated that one cut normally was not sufficient, spillage and cross contamination could be expected, and high subsurface levels would be encountered.) Surface contamination levels over 80 pCi/g were multiplied by a factor of two and those over 40 pCi/g by 1.3. Applying this factor to the initial estimates for the four most critical islands (so far as soil transport was concerned) almost doubled the estimate of soil volumes to be removed and transported.[98,99] As it happened, use of Treat Factor resulted in overestimation of the soil volume to be removed, and the actual volume removed was only about 5,000 cubic yards (6 percent) over the original, uncorrected DOE-ERSP estimate.[100,101]

Use of the factor led to pessimistic predictions at the conference. It indicated that cleaning Enjebi to residential levels (40 pCi/g) would involve removing 58,670 cubic yards—more than could be transported in the year remaining, even using bulk haul. It also indicated that 25,000 cubic yards would have to be removed from Lujor just to prevent the island from being quarantined (i.e., to clean it to less than 160 pCi/g). To qualify Lujor for agriculture (80 pCi/g) as the dri-Enewetak desired, it appeared that 49,400 cubic yards would have to be removed and transported.

The boat transportation available would have been adequate to move the predicted volumes if soil cleanup had begun on time; however, it did not appear adequate to move the predicted volumes in the time remaining. It appeared that, unless the project were extended past 15 April 1980, a maximum of 12 months would be available to excise and transport soil from the four islands, leaving another 2-1/2 months to complete Runit soil cleanup and 1 month to complete closing the concrete cap[102] (Figure 6-16). The latest estimates of boat capability were that only 48,000 cubic yards

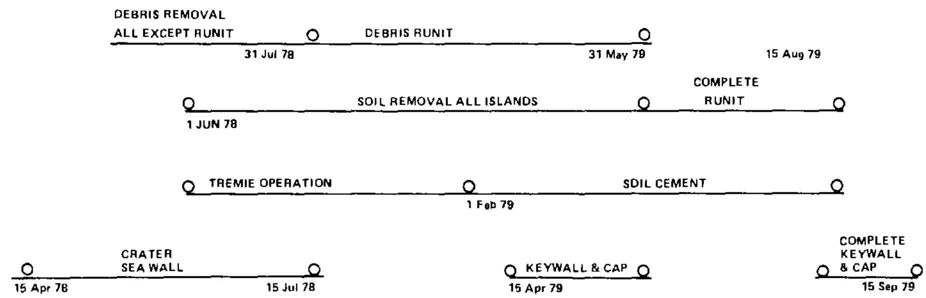


FIGURE 6-16. ENEWETAK CLEANUP PROJECT SCHEDULE, 4 MAY 1978.

could be transported by trucks loaded on the watercraft in a year's time. Use of bulk-haul technique on two of the LCUs and three LCM-8s would increase the estimated capacity to 77,000 cubic yards.

For the purposes of discussions, the soil transport estimate was rounded to 80,000 cubic yards. This transportation limit became confused by some planners with the EIS estimate of 79,000 cubic yards of soil over 40 pCi/g to be excised from Aomon, Boken, Lujor, and Runit. It also became confused with the maximum capacity of the Cactus Crater container. These misunderstandings were significant because, like the Treat factor, they led to miscalculations of the workload and apparent constraints in soil cleanup planning. The only real constraints on completing the removal and containment of all the contaminated soil were time, based on the scheduled 15 April 1980 completion date, and the capacity of boats to move soil within that time constraint

The new soil volume estimates, coupled with these constraints, posed serious problems. Attempting to clean Enjebi to residential standards would eliminate any other soil cleanup except Runit, and even then there was no assurance that Enjebi could be completed. If this were done, Aomon, Boken, and Lujor would have to be left with levels over 400 pCi/g and possibly quarantined. On the other hand, cleanup of the other islands would apparently eliminate Enjebi as a future residence island. Also, leaving Runit until last raised the possibility that it might not be cleaned to prescribed standards.

The final briefing evolved into a lengthy discussion of alternatives and combinations of options for soil cleanup. Mr. Mitchell, of MLSC, reiterated the position he and the people had taken and maintained from the beginning: every attempt should be made to make every bit of the atoll available to all of the people of Enewetak for any use that they might see fit. Mr. DeBrum, District Administrator of the Marshalls District, affirmed that the TTPI supported the people's position to have all the islands as clean as possible within the available resources.[103] The conferees then reviewed and discussed each issue on which a decision was required; and the Director, DNA, after hearing all recommendations, made the necessary decisions to advance the cleanup project. The critical decisions are outlined in the following nine sections.

CONTAMINATED SOIL CRITERIA DECISION

The first issue considered was the criteria for contaminated soil removal The criteria recommended by the Bair Committee for nonresidential islands were considerably more stringent than the AEC Task Group guidelines and the guidance furnished by ERDA for the OPLAN.

Under the Bair criteria, islands designated for food gathering (used for infrequent visits to gather food such as coconut crabs, birds, and eggs) should not exceed 160 pCi/g concentration of transuranics on the surface (0-3 centimeters) averaged over one-half hectare. On this basis, OPLAN Condition A would be lowered from 400 pCi/g to 160 pCi/g.

Agriculture islands, to be used principally for commercial crops of coconuts, pandanus, and breadfruit, should not exceed 80 pCi/g concentration of transuranics on the surface averaged over one-half hectare. On this basis, OPLAN Condition B would be lowered from 100 pCi/g to 80 pCi/g.

Residential island criteria remained unchanged; i.e., surface concentration of transuranics, averaged over one-quarter hectare, should not exceed 40 pCi/g. This coincided with OPLAN Condition C.

Since the Bair Committee criteria had been endorsed by DOE, the agency responsible for furnishing radiological advice for the cleanup project, the Director, DNA believed DOD must accept them. However, he pointed out that, while the 40-80-160 pCi/g cleanup criteria would henceforth be regarded as policy, their rigid acceptance must not preclude accomplishing the most beneficial cleanup with resources available.

DOE representatives stated that the Bair Committee had not been given the entire problem; that is, the Committee did not have access to all the soil cleanup data and the engineering soil removal and movement factors to which this conference had been exposed. Therefore, although the Committee was proposing priorities for cleanup, it was not actually trying to pin down the islands that should be selected by the DOD Project Manager for cleanup

The Director, DNA then stated that he was concerned about the dilemma faced in the cleanup if he unequivocally agreed to 160 pCi/g as the criterion for food-gathering islands, as opposed to the originally specified 400 pCi/g. Cleanup of two islands, Boken and Lujor, desired by the people as food-gathering and agricultural islands respectively, would utilize approximately half of the soil transport available, thus diverting these resources from, perhaps, a more beneficial application. He felt that if he did not do this, the two islands might have to be quarantined, and this might be unacceptable for political and humanitarian reasons.

Mr. Roger Ray, DOE-NV, stated that it was important not to get trapped into believing that an island which did not meet 160 pCi/g would automatically have to be quarantined. He expressed the opinion that the Bair Committee criteria should not be accepted in a literal interpretation and that the Committee would expect that sensible trade-offs would be made to comply with these criteria as closely as possible within available resources. After that was done, some restrictions might be required on islands where work could not be completed.

The Director, DNA requested that DOE examine the possibility of not cleaning Boken and Lujor to 160 pCi/g and identifying patterns of living that could be adopted for those islands other than quarantine. DOE representatives agreed to have this done.

Dr. W. P. Wood, of EPA's Radiation Programs and its representative at the conference, pointed out that DOE/DOD acceptance of the 40-80-160 pCi/g criteria should not imply EPA approval and that, once the plan for soil removal was established, EPA would desire to examine that plan. The Director, DNA stated that he understood that there was no EPA blessing, but he also pointed out that Enewetak really did not come under the draft EPA guidelines.

The Director, DNA decided to accept the criteria recommended by the Bair Committee and DOE as the standards for contaminated soil cleanup. This acceptance was contingent upon the Bair Committee and DOE developing more precisely the status of islands (e.g., Boken or Lujor) which might end up being cleaned to below 400 pCi/g, but not down to the 160 pCi/g criteria recommended by the Bair Committee for food-gathering islands.[104]

The criterion for subsurface contamination was not discussed at the conference. That criterion, OPLAN Condition D, was the most stringent and difficult to achieve. Subsurface concentrations of transuranics were not to exceed 160 pCi/g averaged over one-sixteenth hectare on any island to be used by the dri-Enewetak.

NORTHERN ISLAND RESIDENCE DECISION

The issue of possible residence on one or more of the northern islands was raised during the discussion on soil cleanup criteria because the new criteria were based on a dose assessment model which assumed soil contamination levels that would occur only in the northern islands. The dose assessment indicated that living on islands having surface transuranic levels which averaged 40 pCi/g, growing crops on islands which averaged 80 pCi/g, and visiting islands which averaged 160 pCi/g could result in a dose of about 13 millirads for transuranics alone, over four times the proposed new EPA guideline of 3 millirads per year for the U.S. Doses from strontium and cesium in the drinking water, coconuts, and other local food were not considered since it was assumed that no one would be permitted to live on Enjebi until after those elements decayed to acceptable levels.

By this time, everyone was aware of the Bikini cleanup and resettlement problems. Mr. McCraw, of DOE, stated that Bikini was typical of what could happen in the Marshall Islands. Bikini had suffered a drought and the people there were eating and drinking from more contaminated coconuts than DOE had calculated, resulting in ten times the predicted strontium and cesium intakes. Diet varied between individuals, and Mr. McCraw was concerned that there was no cushion in the Enewetak dose assessment for those individuals who ate more of the problem foods.

Dr. Wood noted that, in setting standards, his agency had to consider individual dose as well as population dose. EPA wanted to assure that no individual in a population became overexposed. There was a question about whether a factor of two or three deviation from a given criteria could be accepted unless it was known whether the overexposure would affect a few individuals or 90 percent of the population. The Enewetak dose assessment data did not indicate which.

In response to a DOE statement that transuranic soil cleanup decisions should be based only on a northern island (Enjebi) residence lifestyle, Field Command's health physicist, Dr. Bramlitt, pointed out that the stringent EPA draft guidelines, the transuranic dose assessments, and the Bair Committee recommendations necessarily required that soil cleanup decisions be based on southern islands residence (i.e., the EIS Case 3 lifestyle). Mr. McCraw had shown in his briefing that a 40/80/160 living pattern led to a dose to bone of 13 mrad/year, three to four times the proposed EPA guideline for transuranics. Using Mr. McCraw's data, Dr Bramlitt showed that the Case 3 cleanup (40/80/160) could produce dosages over 6 mrad/year, twice the proposed EPA guidelines. Thus, if soil cleanup decisions were not oriented first toward agricultural and food-gathering islands, the Case 3 lifestyle—the primary objective of the cleanup—could be in jeopardy. Further, dose contributions from fission products, strontium and cesium, could aggravate these calculations and could preclude utilization of the northern islands as provided for in the Case 3 lifestyle. As a result of the discussions, the Director, DNA asked Dr. Bramlitt to conduct a study which would consider all radionuclides affecting Case 3; evaluate Runit, for which no dose estimates had been made, and, serve as an independent comparison of the LLL study. Results of the study are discussed in chapter 7.

Mr. Mitchell, the people's attorney, expressed concern at the complexity and additional options shown in the dose assessment data. The dri-Enewetak would require something less complicated, something that a simple people could use to assist them in making decisions on the use of the islands without exceeding established dose limits. It was decided that the final dose assessment, to be prepared after cleanup was complete, should include several possible living patterns.[105]

There were several problems with residence on Enjebi. The strontium and cesium levels were ten times higher here than on most other islands and would remain so for many years A great amount of transuranic-contaminated soil would have to be removed to bring it to residential transuranics level, while little or no cleanup was required under the current transuranic criteria for agriculture use[106] Because of its distance from Runit, removal of the estimated 58,286 cubic yards from Enjebi would require all available boat assets, leaving none for Aomon, Boken, and Lujor. It was suggested that Enjebi might be cleaned to 50 pCi/g then plowed to dilute the contamination; however, no decision could be made on that proposal until the results and acceptability of plowing were better known.

As a possible alternative to Enjebi for northern residence, the three-island complex of Aomon-Bijire-Lowja was considered. It appeared that Aomon could be cleaned to residential levels by removing approximately 3,500 cubic yards more soil than that required to bring it to agriculture levels. That would qualify the Aomon-Bijire-Lojwa complex for residential use, assuming the dri-Enewetak could resolve the problem of ownership of those islands.

It was decided that no change could be made at present to the long-standing policy that residence would be on the southern islands only Future residence on Enjebi would depend on the results of transuranic cleanup and the plowing experiment, plus the eventual decay of strontium and cesium.[107]

BULK-HAUL DECISION

The next key issue was whether to modify some landing craft for bulk haul to increase the total capability to approximately 80,000 cubic yards per year or to accept the limited capability of hauling loaded trucks. Navy representatives expressed concern about the reconfiguration required and the possible contamination that might occur to the boats, which the Navy had on loan from the Army with the stated understanding that the boats would be returned to the Army at the end of the operation in an "as-received" condition. However, Captain David MacClary, the senior Navy representative (from the Office of the Chief of Naval Operations), pointed out that it appeared that the Army would give the boats to the Navy so the problem of boat rehabilitation might be easily resolved.

Commander Theodore Krumm, COMNAVSURFPAC representative, expressed concern about contamination hazards for the craft and the crews which would operate them. It was pointed out that, with the proposed bulk-haul configuration, craft decontamination problems would be minimized. This would, of course, be verified on scene during the weekly maintenance and decontamination of each craft.

It was suggested that additional boats and trucks might solve the soil transportation problem. Lieutenant Colonel Howard Miller, of USASCH, stated that additional trucks would be provided if necessary. The Navy representative stated that additional boats and crews could also be provided. It was pointed out that the same end could be achieved by using the existing boats and trucks for a longer period of time; i.e., by extending the project a few months.

The Director, DNA acknowledged that he might be confronted with the serious choice of whether to ask for more Service personel and equipment or to extend the project. Certainly one consideration would be the impact on the Rehabilitation Program if the cleanup project were extended 6 months. It might be that the Department of the Interior (DOI) could not complete construction on Enewetak because the JTG was still using the island as an active base camp. Mr. Gilmore, of Holmes & Narver, responded that he could not estimate the impact because the scope of rehabilitation work still was being changed by the dri-Enewetak Planning Council. He asked whether the extent of soil cleanup would be determined by the time and resources available or whether the time and resources should be determined by the amount of soil that had to be removed. The Director, DNA responded that he did not consider either approach as an absolutely immutable one. He still was not convinced that available time and resources could not produce a cleanup which met all criteria, and he would make any decisions on compromises should they be necessary.

The possibility of increased radiological safety problems from bulk haul were discussed at length. It was pointed out that contaminated soil handling had been carried out on the same islands for the last 6 months and that all detection measures utilized had failed to identify any problem. Apparently, resuspended plutonium, if it did exist, existed in such reduced quantities that it could not be detected. Colonel Darrell McIndoe, USAF, Director of AFRRI, and the senior member of the Enewetak Radiological Safety Audit and Inspection Team (RSAIT), expressed his belief that the plutonium resuspension problem would not be any greater with the bulk-haul procedure if normal engineering procedures and radiological protection measures were followed. Mr. Bruce Church, DOE-NV, pointed out that a considerable amount of 500 pCi/g soil had been excised in the pilot soil removal project. By the time it had been windrowed, loaded on trucks, offloaded at the beach, and reloaded on trucks for transport to Runit, the concentrations were only about 100 pCi/g. He also remarked that the radiological exposure for a person working on an island for 6 months or even a year was completely different than that for a person who resided there for a lifetime. He felt that the radiation protection practices in force at Enewetak were far more than adequate for the actual radiological situation.

The Navy representatives proposed that one LCU and one LCM-8 be modified and tested for 30 days after which, depending on test results, additional craft could be modified The only objection was that it would delay achievement of maximum transport capacity until the test was complete

The Director, DNA decided that the CJTG would conduct the test to determine if the bulk-haul system was practical and if the boats could be decontaminated without unreasonable difficulty.[108] He directed the independent RSAIT to monitor the test to ensure that there were no health hazards to boat crews and other personnel involved in the additional transloading operations

AOMON CRYPT DECISION

The next issue discussed was what action to take on the contaminated material burial site on the causeway between Aomon and Bijire islands, commonly known as the Aomon Crypt. Several alternatives were suggested, including leaving it as it was, or capping it in place with concrete. These options would permit other uses of the resources which would be required to excise the estimated 12,000 cubic yards of contaminated material buried in the crypt. Some conference attendees felt strongly that excision of the crypt should not be attempted.

The Director, DNA pointed out that excision of the crypt was one of the specific tasks identified in the EIS. He recognized that, if the decision were made to excise the crypt, it might become a bottomless sinkhole in which a significant portion of the available resources would have to be committed Nevertheless, he felt that it was unacceptable to create a second holding place on the atoll for such contaminated soil and debris, particularly when the crypt was located in the center of the large three-island complex with great potential value to the people He felt that to leave it without an attempt to remove it would not be a reasonable decision. If unsurmountable problems were encountered after the task was begun, it still would be possible to refill the crypt with clean rubble and soil and perhaps seal it with concrete. The Director, DNA reemphasized the need to approach the cleanup project in a positive manner and to complete as much as possible with the available resources

Mr Ray, DOE-NV, remarked that there were people who had experience in going into places that are deeper, hotter, and wetter than this particular project; e.g., the drill-back on Amchitka Island He suggested that some experts from that operation be called upon to assist the JTG in determining how to accomplish this task and in obtaining the equipment designed to do it properly. The Director, DNA agreed that expert advice should be obtained He directed that a major effort to excise the Aomon Crypt be initiated as soon as practicable.[109]

ISLAND PRIORITY DECISION

The next issue was to decide which islands would be cleaned and to what levels in order to provide the most effective use of resources to the greatest benefit of the people. As in previous discussions, the critical considerations centered on accomplishing a full Case 3 cleanup or cleaning Enjebi to residential status and leaving undone some of the original tasks such as the reduction of concentration on Lujor or Runit.[110]

During the conference deliberation of this issue, the relative merits of the AEC Task Group recommendations, the EIS mission statement, and the Bair Committee recommendations were discussed at length. One dominant position, which was supported by Field Command, was that the AEC Task Group recommendations and EIS Case 3 cleanup were intended to clean up the worst hazards first, the bits of plutonium and concentrations over 400 pCi/g on Runit, Aomon, Boken, and Lujor, to insure that people would not be exposed to them during the thousands of years after the cleanup was completed. The proponents of this position were skeptical that, should any of these islands not be cleaned to prescribed levels, the people would abide by any quarantine placed or remaining in effect indefinitely.

The dominant counterposition was that the resources should be used to clean Enjebi to provide more residential land for a growing population and to restore the traditional home island of the dri-Enjebi. Proponents of this position, which included some Field Command staff members, considered some of the EIS mission, such as the cleanup of Runit, to be peripheral and not the best use of resources. They urged that an attempt be made to clean Enjebi to as near residential level as possible on the assumption that the 40 pCi/g criteria need not be absolute or that plowing might prove effective and acceptable.[111] This position had its foundation in the fact that the Bair Committee recommendations were based on 6 years' additional information and understanding of the problems considered by the AEC Task Group and that the cleanup effort and money should be spent to permit more beneficial use of the islands by the people. With the information now known about Runit contamination levels and the subsurface "marble cake" effect there, coupled with the fact that the allowed upper level criteria had been changed by the Bair Committee, it no longer appeared to make good sense to spend a great effort on Runit with the possibility of never reaching levels which would make that island usable for any purpose.

The choice between these two principal alternatives raised the question of which would have more beneficial results: cleaning a residence island which possibly could not be used until strontium and cesium levels in its soil and water dropped; or cleaning of Lujor, Boken, and—to a degree—

Runit (which might otherwise be quarantined) for agricultural and food-gathering purposes.

A discussion of the definition of quarantine followed. Mr. Joe Deal, of DOE, indicated that Runit was quarantined until the bits of plutonium and high concentrations of contamination were removed, not because it was over 400 pCi/g or 160 pCi/g. Mr. Ray stated that he did not believe the Bair Committee meant that a Runit-style quarantine was automatic for islands over 160 pCi/g. However, as long as that possibility existed, failure to clean Boken, Lujor, or Runit below 160 pCi/g could result in their being quarantined as a consequence of the cleaning of Enjebi to residential level. Director, DNA stated that he didn't believe the term "quarantine" made any sense in the long term, since the conditions on those islands were not so bad that no one could ever set foot on them.[112]

Mr. Mitchell was asked his opinion on the approach of concentrating on Enjebi, Aomon, and the Aomon Crypt, then examining the alternatives for cleaning the other islands. He responded that under the assumption that resources were limited, he agreed; howeyer, he hoped that the resources would not be so limited as to require that approach.[113]

The Director, DNA observed that the soil volume estimates, other than Runit, had increased since the EIS. These estimates originally had been 15,000 cubic yards for the northern islands, excluding Runit and Enjebi. The latest Field Command estimate was 61,300 cubic yards, plus 44,835 cubic yards for Enjebi, or a total of 106,135 cubic yards excluding Runit. Applying the Treat Factor increased the estimate to 171,226 cubic yards, and the estimates could continue to increase.[114]

Based on the latest estimates and factors, Lujor appeared hopeless if Enjebi was to be cleaned.[115] Almost 50,000 cubic yards would have to be removed to qualify it for agricultural use. Boken was somewhat less difficult. It was estimated that 21,600 cubic yards would have to be excised to qualify it for food-gathering use.

Considering the estimates, factors, constraints, and various discussions presented in the conference, Director, DNA made the following decisions on soil cleanup priorities:[116,117,118,119]

a. Continue cleanup of Aomon for agricultural use (80 pCi/g), with the option to continue cleanup to residential levels (40 pCi/g) if this appeared possible by removal of a few thousand more cubic yards, as was currently indicated. (This action would provide a large, three-island complex in the northern islands cleaned to residential levels.)

b. Concurrently, begin soil removal at Enjebi. Start with area of highest contamination (i.e., 70 to 80 pCi/g) and clean progressively, pending further developments regarding Boken and Lujor. (VADM Monroe made this decision although it was contrary to all project direction to date, contrary to Field Command's recommendation, and contrary to the general sense of the conference because he believed that attempting to reclaim the dri-Enjebi's home island for them was an important cleanup goal. He had confidence that the forces in the field would use ingenuity and develop more efficient procedures if the task were set for them. In the event that complete success was not possible, even partial success; e.g., a 50 pCi/g cleanup, might make eventual residence possible.)

c. Consider all possible alternatives to assure Boken and Lujor are not quarantined; e.g., removing soil over 400 pCi/g from Boken, covering Lujor with low-level soil from Enjebi, plowing, etc. If no alternative is found in 6 months, cease work on Enjebi and concentrate on soil removal from Boken and Lujor, in that order, to reduce them to 160 pCi/g or less and preclude quarantine.

PLOWING DECISION

The issue of plowing to dilute contaminated soil concentrations could not be resolved until its effects could be determined by a controlled scientific experiment. In any case, plowing would supplement, not substitute for, soil removal. It would only be implemented after all practical soil removal had been completed. While it would probably reduce the resuspension hazard, the extent to which plowing would assist in reducing any plant uptake of radioisotopes was unknown and would require further analysis.

The Director, DNA decided to initiate a controlled plowing experiment as soon as practicable. Field Command, DNA and DOE-NV had located a suitable plow at the Nevada Test Site and arranged to have it delivered to Enewetak by 1 June 1978.[120]

RUNIT SOIL CLEANUP DECISION.

The issue of Runit soil cleanup was raised again for the same reasons the Aomon Crypt cleanup was questioned. There was considerable uncertainty that it could be accomplished or that available resources were adequate to complete the task, even though boat transportation was not required. Options included:

a. Clean Runit to 160 pCi/g concurrently with other island cleanup, using equipment assigned for that purpose.
b. Clean Runit to 160 pCi/g concurrently with other island cleanup using available resources (men and equipment not required or not employed in higher priority work). These resources would increase as other work was completed.

c. Do not clean Runit
d. Clean Runit within available resources following northern islands cleanup.

The arguments for cleaning Runit had been presented during the deliberations on island priorities. Option b was recommended by Field Command to assure optimum use of resources and to demonstrate an earnest effort to accomplish the EIS mission by removing the highest level contamination on the atoll. Initially, this cleanup would be accomplished with trucks and front loaders located on Runit for the cratering operation when they were not so employed. Since there was little soil stockpiled to begin the crater containment operations, an appreciable amount of high-level Runit material could be excised and used to keep the containment operation going. Eventually, after other soil cleanup was complete, all the soil removal equipment would be used to clean Runit. Option c was based on the premise that, if the island would be quarantined because of subsurface contamination, resources should not be wasted on any attempt to clean the island.

The Director, DNA decided that cleanup of hot spots on Runit would be accomplished as a mission secondary to the other activities on that island. That is, no special resources would be allocated to the cleanup but, when those resources already on the island; e.g., front loaders, trucks, etc., were not otherwise committed, they would accomplish this cleanup. The final amount of Runit cleanup would depend on the resources available after completion of other contaminated soil cleanup [121,122]

CRATER CONTAINMENT DECISION

There was a wide divergence of views on the alternatives for crater containment. The five alternatives presented were:

a. Dispose of all excised soil and radioactive debris in the crater.
b. Dispose of contaminated soil from islands other than Runit in the crater up to zero height; add debris, cover with soil, and cap. Spread remaining contaminated soil on north Runit.
c. Dispose of 160 pCi/g-contaminated soil in crater to zero height; add debris, cover with soil, and cap. Spread lower level contaminated soil on north Runit.
d. Do not use crater for contaminated soil disposal Place contaminated debris in crater and cover with soil from ejecta and other locations to above zero height. Spread excised soil on north Runit.
e. Do not use crater for disposal. Place contaminated debris on land and cover with soil from other islands. Stabilize soil surface with vegetation.

Alternatives a, b, and c were based on the premise that compliance with the EIS required some form of crater disposal. Supporting views pointed out that, with sunken costs for crater disposal preparations already at approximately $3 million, little savings would be realized by abandoning the crater disposal concept at this point in time. Alternatives d and e evolved from the premise that, since the islands would be quarantined forever, it would require less expense and effort to simply spread the contaminated material from other islands on Runit and avoid any cleanup of Runit. Supporting arguments pointed out that most of the soil to be delivered to Runit was expected to have lower concentrations of transuranics than Runit; thus, spreading this soil over Runit's surface could actually improve Runit's condition.[123] Alternatives offered at the conference suggested that, rather than basing the construction on a zero height or 10-foot height, the elongated dome design be considered to permit containment of up to 200,000 cubic yards of soil.

The Director, DNA rejected outright the proposal to cancel the crater containment operation. He decided to continue the crater operation as planned, placing the higher level soil and debris in the crater first. The exact size (capacity) and configuration of the containment structure would be determined later. If absolutely necessary in the final months, consideration would be given to leaving some of the lesser contaminated soil from the northern islands uncovered on Runit.[124]

CERTIFICATION DECISION

The next agenda item was the format for DOE certification. There was wide disagreement on the purpose, wording, and effect of the certificate, particularly with regard to declaring the islands "safe." Mr. Ray expressed the opinion that DOE had two responsibilities. When DNA was finished, DOE must describe as accurately as possible the radiological conditions existing on the islands after cleanup. Subsequently, DOE would complete a final dose assessment based on those conditions and a realistic living pattern. That dose assessment would be the basis for DOE recommendations to DOI and TTPI as to resettlement and use of the atoll by the people.

The Director, DNA did not object to either of these, but he insisted on one other element in the island certification. he believed that DOE also had the responsibility to certify the uses to which islands could be put, based upon the accepted standards at the time of certification.

After a lengthy discussion on dose assessments, island usage and living patterns, it was agreed that DNA would submit a sample certificate to DOE for approval. This sample certificate would provide that DOE's certificate to DNA contain two parts: a description of the radiological condition of each island and a statement of the uses for which it qualified.[125]

QUARANTINE AND THE EIS

The issue of quarantine was raised during the crater containment discussion. If the contaminated material was sealed in the crater, and the final in situ survey of Runit showed no half-hectare greater than 160 pCi/g, would DOE recommend that the quarantine be lifted? Mr. Ray responded that he did not believe so because the IMP survey of surface contamination would not be enough. There could be subsurface contamination such that any digging or farming could be dangerous. If the quarantine were continued, Mr. Mitchell remarked that he had no doubt that the people would educate themselves and their children, generation after generation, not to go there

Mr. Mitchell indicated that he and the people looked at the dedication of Runit to storage of contaminated debris and soil as a contribution by the people themselves to keeping the cost of the project down. He believed that this should be a significant factor if the agencies had to request more money from Congress.[126]

The conferees returned to the Runit question after discussing the format for DOE certification. The decision made earlier to put priority on cleanup of Enjebi could result in leaving concentrations higher than 400 pCi/g on Runit, Lujor, and Boken. The DNA General Counsel advised that substantial deviations from the published EIS would require the preparation of an environmental assessment and, possibly, submission of a supplement to the EIS. Mr. Mitchell concurred and stated that, if a decision were made which resulted in the quarantine of an island or dropping out an island designated for a specific use (because of costs or other reasons), then the impact would probably have to be assessed.

The Director, DNA stated that, as an internal matter, DNA would develop and circulate to DOE, DOI, and MLSC an environmental assessment covering the project modifications at the conference (adoption of the Bair Committee criteria, cleanup of Enjebi, and possible quarantines). Based on the comments received, he would decide whether to file a supplement to the EIS.[127]

Mr. Mitchell responded that he would prefer that the Director delay, within reason, any decisions that would lead to quarantining an island and rely on good luck or increased funding. He would rather the Director did not make a decision which would require an EIS supplement.[128]

FOLLOW-ON ACTIONS

The Director, DNA announced that the conference would be documented to record the issues, decisions, and rationale, and that copies would be forwarded to all concerned.[129] Follow-on actions were to include:

a. DNA would develop an Environmental Assessment covering decisions made at this conference which deviated from the published EIS, and circulate it to DOE, DOI, and MLSC for comment and advice as to the need of an EIS supplement.
b. DNA would request DOE to have the Bair Committee reexamine its criteria based upon decisions made at the conference.
c. DNA, working through DOE, would obtain assistance of special experts to examine the Aomon Crypt and determine the best methods for excising.
d. DNA, working with DOE, would devise a plan for a plowing experiment that would permit determination of engineering practicality and radiological effectiveness.
e. DNA would report these changes to the JCS, Secretary of Defense, and Congressional committees, as appropriate.[130]

The conference provided the opportunity to develop decisions relative to two questions necessary to the commencing of soil cleanup operations; i.e., in what priority would the islands be cleaned and in accordance with what cleanup criteria. Priority would be placed on the cleanup of Aomon and Enjebi, with the cleanup of contaminated soil over 160 pCi/g on Runit being accomplished concurrently as resources became available from other activities. The cleanup would be based on the new criteria recommended by the Bair Committee; i.e., 40/80/160 pCi/g for residential, agricultural, and food-gathering use. The conference also served to increase the awareness of all participants that certain unknowns still existed and some problems were still unresolved, but these would be handled while the soil cleanup operations were underway.

CHAPTER 7

SOIL CLEANUP OPERATIONS

BULK-HAUL TEST DIRECTIVE

On 15 May 1978, Field Command instructed the Joint Task Group (JTG) to initiate the following actions to implement the decisions made by VADM Monroe, Director, Defense Nuclear Agency (DNA), at the 4 May 1978 conference:[1]

a. Convert one Landing Craft, Utility (LCU) and one Landing Craft, Mechanized (LCM-8) for bulk haul, and conduct an evaluation test of the bulk-haul system including radiological control and safety.
b. Begin preparation of plans to excise contaminated material from the Aomon Crypt.
c. Proceed with removal of contaminated soil over 80 pico curies per gram (pCi/g) on Aomon (Sally) Island. Concurrently, begin soil cleanup on Enjebi (Janet) Island, commencing with the areas of highest contamination, and working toward 40 pCi/g maximum surface contamination.
d. Prepare a plan for refilling the Pacific Cratering Experiment test bed.
e. Concurrently with other operations, begin cleanup of contaminated soil over 160 pCi/g on Runit (Yvonne) Island, using equipment available at Runit for other activities when not in use on those activities.
f. Segregate contaminated soil into three stockpiles on Runit: One containing soil excised from areas contaminated to levels over 1,000 pCi/g (based on soil samples); one for soil excised from areas of less than 1,000 pCi/g (based on soil samples), or from areas with in situ van (IMP) readings greater than 160 pCi/g; and one containing soil excised from areas contaminated to lower levels.

BULK-HAUL TEST RESUMES

As directed in early June 1978, the JTG resumed testing the bulk-haul system for transporting contaminated soil. The test used the LCM-8 which had been modified in April 1978. The purpose of the test was to determine the ability of the modifications to withstand heavy equipment operations; the degree and extent of watercraft contamination; decontamination procedures and durations; and radiological safety for personnel and equipment. In implementing the test, it was imperative that boats be modified to protect their decks and bulkheads from damage by the heavy loading equipment and to minimize contamination of their well-decks. The initial LCM-8 modification provided for lining the starboard, aft, and port bulkheads with 1/2-inch steel plate, and covering the deck with 4-inch by 14-inch timber. While this modification was satisfactory from an operational point of view, the starboard and port modifications made it extremely difficult for the LCM crew to enter voids for maintenance. The aft end of the box was vertical, which made it difficult for the bucket loader to remove the last of the soil from the box. Also, the timber decking was soon chewed up by the front loaders when unloading. From the radiological safefy viewpoint, the timber decking retained unacceptable amounts of contaminated soil, and the areas between the side plates and the bulkheads were difficult to clean. To correct these deficiencies while still protecting the boat structure, 2-inch angle iron was welded along the entire length of the cargo area bulkheads. The aft bulkhead was protected by installing 8-inch by 12-inch timbers anchored in place by 1/2-inch sheet steel strips welded to the bulkhead. The deck was protected by welding two 2-inch to 3-inch wide strips of 1/2-inch-thick steel plate onto the center section of the deck (approximately one-third and two-thirds of the width). All void-cover gaskets were replaced to prevent contaminated soil from entering the voids. Angle iron sections were welded in place to prevent damage to the cleats by bucket loaders. These modifications minimized the deficiencies and afforded protection to the LCM-8, allowed the cargo area to be easily cleaned with water hoses, and made the voids easily accessible. Figure 7-1 shows these modifications.

The modification to the LCU was greatly expedited by the experience gained in converting the LCM-8. Again, the primary concern was the protection of the bulkheads and deck. The LCU well-decks had especially thin bulkheads; therefore, they were very susceptible to damage during offloading. With slight modifications, the first methods employed with the LCM-8 were appropriate for the LCU. The U.S. Navy Element (USNE) constructed a three-sided box, approximately 5 feet high, which extended two-thirds of the length of the well-deck from the aft bulkhead. The box was welded in place on the deck and supported with angle iron. Adequate space was left outside the soil box along the starboard and port bulkheads to allow passage of personnel and for ease of cleaning. Again, the deck was protected by 1/2-inch steel plate strips, as was done for the LCM-8. Figure 7-2 shows this modification.

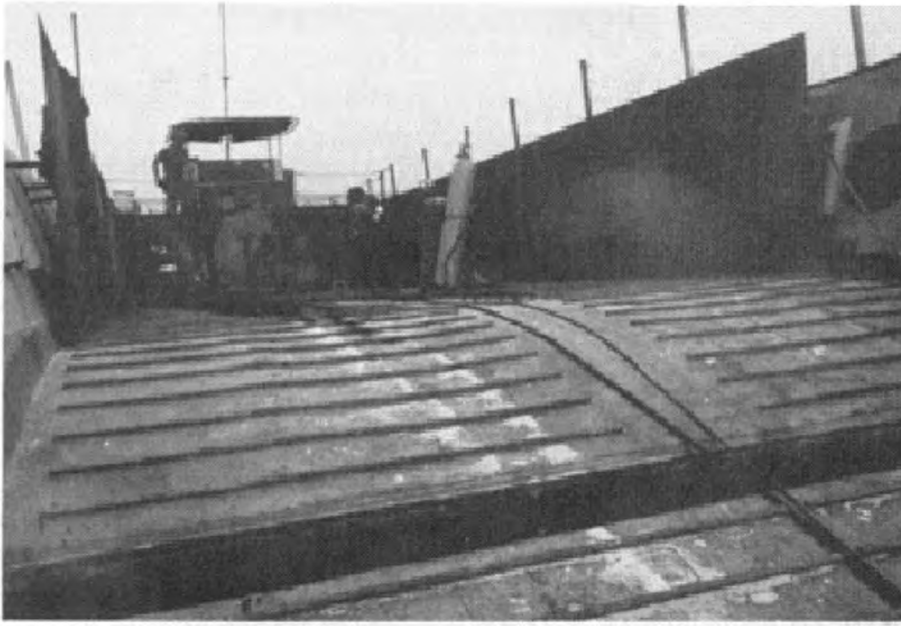


FIGURE 7-1. LCM-8 MODIFICATIONS.

FIGURE 7-2. LCU MODIFICATIONS.

BULK-HAUL PROCEDURES

Various means of loading were attempted, and all were found satisfactory. The only differences were in the final load volume and loading time. The primary means of loading the LCU was by 5- and 20-ton dump trucks (Figure 7-3). In each case, the average load was 100 to 120 cubic yards per bulk-haul boat, versus 48 to 60 cubic yards when carrying loaded 20-ton trucks. The maximum rated load capacity of the bulk-haul LCU is approximately 150 tons. However, due to the modifications required on the LCU, the soil box capacity was reduced to approximately 120 tons. Since soil weight varied from island to island because of composition and water content (0.98 to 1.2 tons per cubic yard), boat capacity also varied.

The LCM-8 was loaded using 5- and 20-ton dump trucks, and 2-1/2- and 5-cubic-yard bucket loaders (Figure 7-4). The loading equipment used on the various islands was constrained by availability of equipment and surface trafficability on the cleanup islands. The 5-ton dump truck provided the smallest soil load per LCM-8, as only seven truckloads were possible for a maximum load of 28 cubic yards. Because of their all-wheel drive capability, the 5-ton trucks were essential where fine sand, such as that on the island of Lujor (Pearl), precluded use of the 20-ton trucks. Using the 20-ton dump truck provided a maximum load of 32 cubic yards or four truckloads per LCM-8. The 2-1/2-cubic-yard bucket loader could provide a load of 32 to 35 cubic yards. However, it was not used extensively due to its limited availability. The 5-cubic-yard bucket loader provided the maximum load for the LCM-8, 52 to 56 cubic yards of soil This was accomplished because it had a higher and longer reach and could better balance the load for vessel stability. This item of equipment was not used in the loading processing until the Lujor cleanup because those available were required at Runit for the offload operation.

The average load carried by the LCM-8 using the bulk-haul configuration was 30 to 35 cubic yards versus 8 to 10 cubic yards when transporting the 20-ton dump truck. The maximum rated load capacity of the LCM-8 was approximately 60 tons. For offload, the 5-cubic-yard bucket loader was the most efficient in terms of time. The time required was increased considerably when the 2-1/2-cubic-yard bucket loader had to be used to offload (Figure 7-5)

BULK-HAUL RADIOLOGICAL PROCEDURES

All boats used for transportation of contaminated soil were considered to be radiologically controlled areas, whether used for truck-haul or bulk-haul of the soil. The radiological control procedures which had been

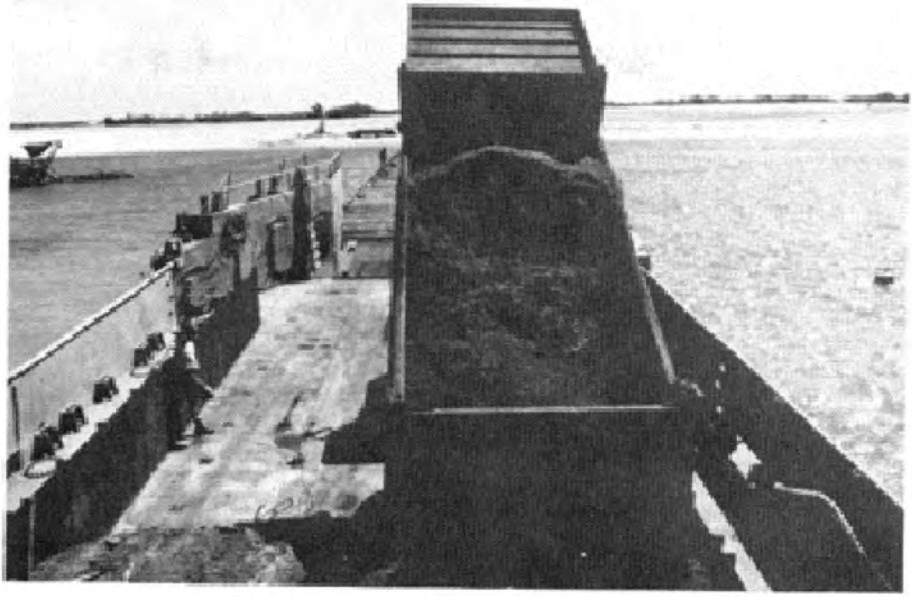


FIGURE 7-3. LCU LOADING OPERATION.

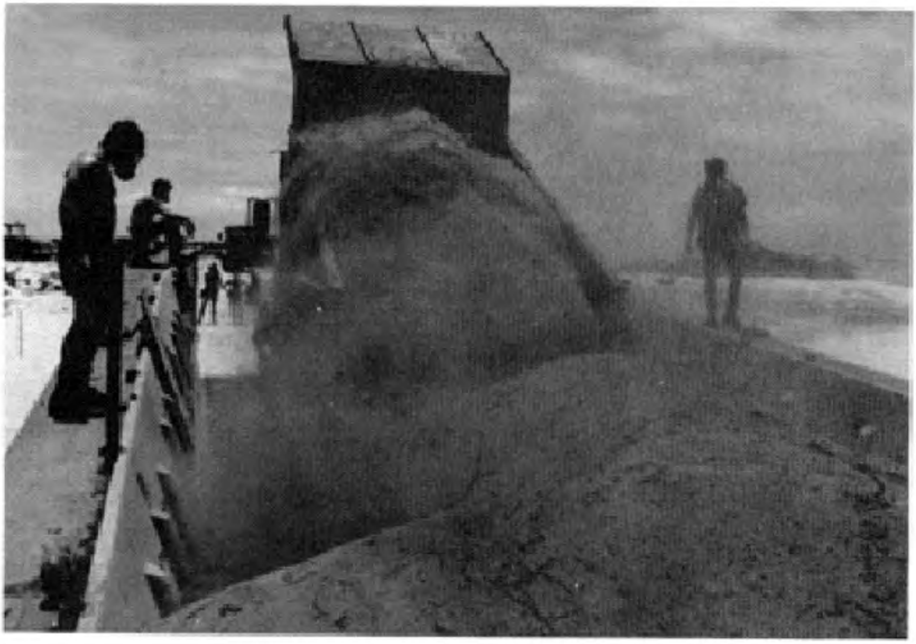


FIGURE 7-4. LCM-8 LOADING OPERATION.

FIGURE 7-5. LCM-8 OFFLOADING OPERATION.

developed for soil excision operations also were applied to these boats. During onloading or offloading of soil bulk-haul craft, respiratory protection (level IIIA—see Chapter 4—without rubber boots or gloves) was required for all personnel involved. Personnel engaged in onloading or offloading of trucks containing soil required only dust protective surgical masks (level IIB without boots) except for the drivers of the trucks who required respiratory protection (level IIIA without rubber boots or gloves). Unless otherwise indicated, protection level I was authorized while in transit between load site and Runit, as long as tarpaulins were in place over the trucks (or over the well-decks of bulk-haul craft). If there was any delay in the onloading or offloading of soil when the craft was landed downwind of a contaminated soil stockpile where the soil was not being disturbed, dust protective surgical masks (level IIB without boots) were required. If the boat was located downwind of an area where soil was being disturbed, level III, without rubber boots or gloves, was required. An area for eating, drinking, or smoking was designated on each boat in a location free of contamination and acceptable to the Field Radiation Support Team (FRST) and Radiation Protection Officer. During transport, soil was always covered with tarpaulins; trucks used to haul soil were covered prior to driving them onto the boats. The boats were cleaned at the end of each work day by using a saltwater pump and washing the small residue of soil into the lagoon en route to Lojwa Camp.

The radiological factors had a major bearing on bulk hauling and were a dominant factor in the 30-day test period. The possibility of an airborne radiological hazard during bulk-haul operation and the ability to decontaminate bulk-haul boats both needed to be assessed by the experts. Both questions were extensively researched and evaluated during the test by J-2 personnel from HQ JTG, by the FRST, and by the Radiation Safety Audit and Inspection Team (RSAIT) from HQ DNA. The findings of the RSAIT were as follows:[2]

a. Air samples consistently indicated that any airborne radioactivity level was less than one-tenth of the maximum permissible concentration (MPC). This level of activity did not require respiratory protection.
b. Crews did not experience difficulty in decontaminating the load area of the craft, although the process did require additional hours to certify decontamination.

The bulk-haul evaluation demonstrated conclusively the efficiency and radiological safety of the system. After receiving a detailed written and verbal report from the RSAIT, the Director, DNA approved the use of the bulk-haul procedure for soil transport. It continued to be improved during subsequent soil removal operations. It was one of the more important innovative techniques developed during the project,[3] and without it the cleanup would have required more time and/or resources.

AOMON (SALLY) ISLAND SOIL CLEANUP

The Department of Energy-Enewetak Radiological Support Project (DOE-ERSP) fine soil survey of Aomon began on 23 February 1978 in preparation for the pilot soil removal project. Three areas had been found to have transuranic contamination above acceptable levels. These areas, shown in Figure 7-6, were around the Kickapoo and Yuma test ground zeroes (GZ) and in a third location which the JTG designated the "Hustead" area after the then U.S. Army Element (USAE) Operations Officer (S-3). Pilot soil removal work began in the Kickapoo area on 8 March 1978. The pilot soil removal project evolved into a full-scale cleanup of contaminated soil on the island. Soil profile and in situ surveys following each 6-inch lift indicated swirls of contaminated and noncontaminated soil much like the swirls of color in a marble cake. This "marble cake" effect resulted from earth-moving actions between and following nuclear tests. Several lifts were required to meet the initial target level of 80 pCi/g.

After the three areas were IMPed in June 1978, it became evident that removal of a limited amount of additional soil would allow the island to meet residential levels (40 pCi/g). There was a narrow strip in the

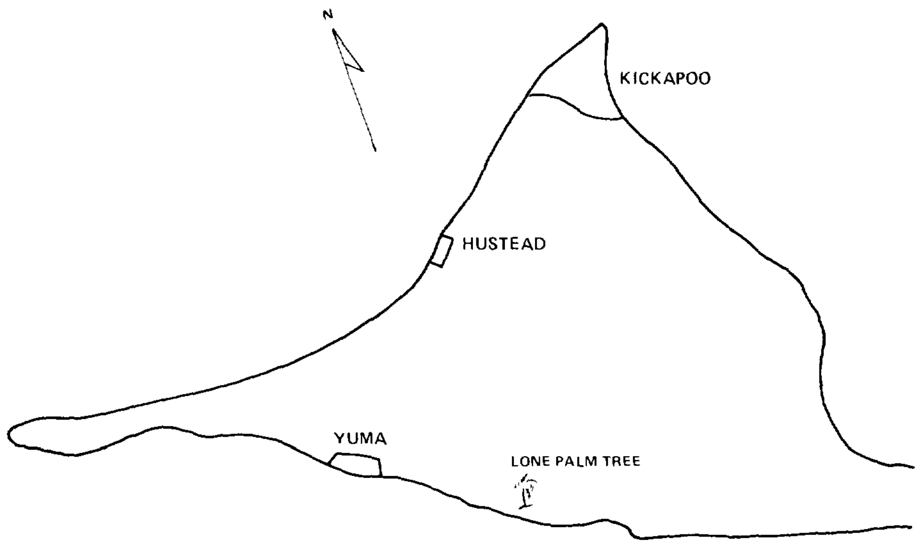


FIGURE 7-6 AOMON SOIL EXCISION AREAS.

Kickapoo GZ area which consistently showed over 40 pCi/g. The area was cleaned with hand tools and then washed repeatedly. While some low-level hot spots remained, the area met the average level for residential use.[4]

Approximately 5,503 cubic yards were removed from the Kickapoo area, 3,300 from the Yuma area, and 1,800 from the Hustead area, for a total of 10,603 cubic yards of soil removed from the island. The soil contained an estimated 1.07 curies of transuranic material.[5]

During the final cleanup of Aomon, the third fatality of the project occurred. Sergeant Donald E Moody, of Company B, USAE, was working on Aomon as Noncommissioned Officer in Charge of operations. On 14 August 1978, he and his men were attempting to jump-start one of the 20-ton dump trucks using a D8 bulldozer which had been dispatched from the Lojwa motor pool. While directing the alignment of the bulldozer, SGT Moody was hit by the dozer's blade and pinned against the truck bed. He sustained severe injuries to the chest, neck and head. Major Paul Sterner, USAF, the Lojwa doctor, arrived on the scene in a very few minutes and, after examining SGT Moody, determined that he had died almost instantly due to cardiac arrest.

ENJEBI (JANET) PLOWING EXPERIMENT

The proposal to use plowing to reduce the resuspension hazard from transuranics in the soils was made in the autumn of 1977. The Bair Committee was asked if this procedure could be used as an effective cleanup measure for transuranics in soils. Their response was that plowing might reduce the surface concentrations of transuranics and, therefore, reduce the potential inhalation problem; however, it was unlikely to reduce plant uptake. Field Command decided to pursue the matter since its latest soil volume estimates indicated that some islands could not be cleaned to the desired levels by soil removal alone. At the 4 May 1978 conference, it was decided to conduct an experiment on Enjebi to determine the engineering practicability and radiological effectiveness of plowing.

Field Command borrowed a large single blade plow with a 3-foot moldboard from DOE at Nevada Test Site and shipped it to the atoll on the May 1978 barge (Figure 7-7). On 11 May 1978, the JTG held a meeting to plan the plowing experiment. Three 50-meter by 100-meter areas on Enjebi were identified which were relatively free of debris and exhibited significant and relatively uniform surface contamination levels between 30 and 79 pCi/g. These areas are designated X-1, X-2, and X-3 in Figure 7-8.

FIGURE 7-7. DOE SINGLE BLADE PLOW.

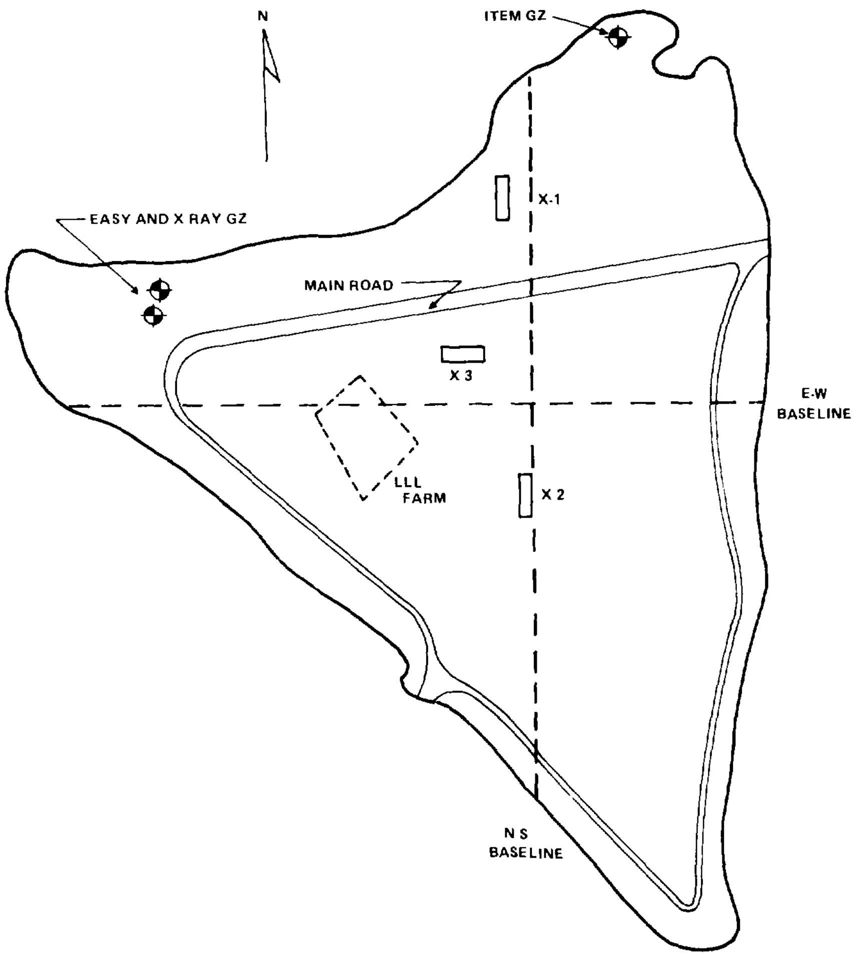


FIGURE 7-8 ENJEBI PLOW X SITES

On 13 June 1978, Dr. Chester Francis, of the Oak Ridge National Laboratory (and a member of the Bair Committee), and Dr. Rollin Jones, of the University of Hawaii, arrived at Enewetak to conduct the experiment.[6] The area identified as X-1 was selected and became known simply as the Plow-X area. Extensive radiological measurements were made to characterize the distribution of radionuclides. Each 25-by-25-meter area was measured with the in situ van while soil profiles were collected down to 50 centimeters at four locations and to ground water or bedrock at one other (Figure 7-9). IMP results showed the area to be contaminated from 49 to 109 pCi/g transuranics over the plot with an average of 71.5 pCi/g. Surface soil samples gave a range of 42 to 208 pCi/g

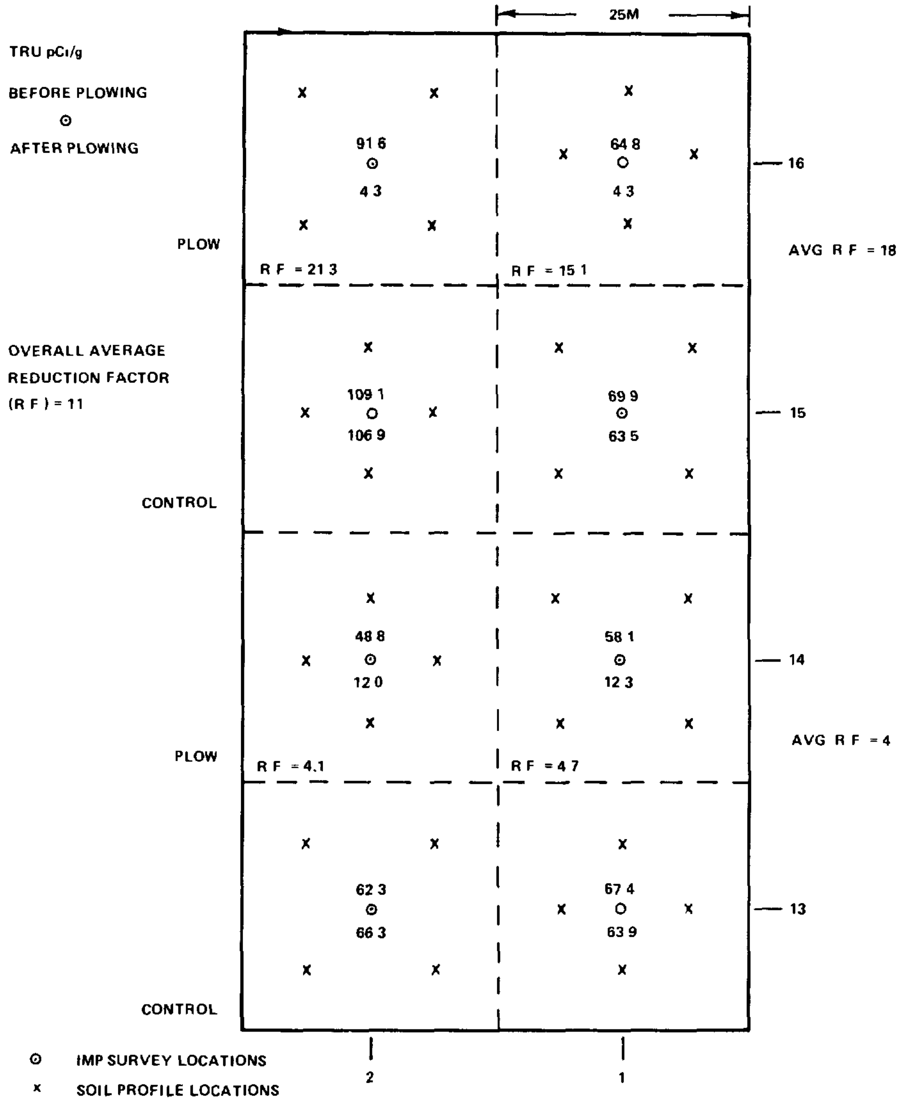


FIGURE 7-9. ENJEBI PLOW X - 1 AREA.

with an average of 97 pCi/g before plowing Soil profile readings showed a rapid drop in contamination levels, a factor of 10 in the first 10 centimeters, and no elevated subsurface readings.

Four 25-by-25-meter areas were reserved as control areas and four were selected for plowing. Most debris and vegetation was removed, and soil sampling holes in these areas were filled and smoothed. The plow was pulled by a USAE-operated D8 bulldozer, plowing to 3-foot depths with no difficulty. The plow's hydraulic system for raising and lowering the blade was inoperative, therefore a front loader was used to drive the point into the ground and lift it out Consequently, plowing was accomplished by making large turns at the ends of the furrows with the blade left in the ground. Brush, dead limbs, and old signal cables tended to foul the plow and had to be removed by bulldozer. Two of the plowed areas contained good, dark earth down to approximately 30 centimeters while cover on the other two was mostly coral and very shallow.

Plowed areas had to be backbladed with a bulldozer to provide a plane surface for IMP measurement. The IMP surveys showed considerable reduction in surface contamination on the plowed areas and no significant change in the control areas.[7]

Frequent rain stabilized the soil, facilitating subsurface soil sampling. Trenches cut with a backhoe retained their vertical structure. The soil in the trench walls appeared to be well mixed, although occasional darker patches and layers of organic origin appeared in the lighter coral regions.

The plowing experiment confirmed that, under the conditions found at Enewetak, surface contamination could be reduced substantially by plowing. A multivariate statistical analysis confirmed the expectation that the distribution of contamination would be altered considerably along the entire profile.

Contamination was generally mixed throughout the plowed profile, but some was deposited at depths with little mixing. In mixed areas, the contamination was highly diluted regardless of the original concentration. Hot spots in concentrations of 25 to 50 percent of that of the original surface contamination levels were found at all of the depths sampled, with most being observed at 30 centimeters or deeper.[8] The Plow-X area subsequently was reduced to less than 40 pCi/g by standard soil removal procedures.

The plowing experiment was eminently successful, and it showed that—without question—plowing could be used effectively to reduce surface transuranic contamination and thus reduce the likelihood of transuranic resuspension in air, with its potential inhalation hazard. However, VADM Monroe firmly regarded plowing as a "measure of last resort." He saw two significant drawbacks that would result from plowing:

First, as pointed out by the Bair Committee, plowing merely distributed the transuranics to lower levels in the soil. It in no way reduced the potential for uptake of transuranics into plants and their availability for subsequent entry into the food chain. (NOTE: The degree to which this plant uptake might occur was not known. Firm estimates on the transuranic uptake hazard were not available at this time, so the Director, DNA preferred to assume it could be significant and made decisions accordingly.) Additionally, he believed that plowing could possibly increase the potential for plants uptake by redistributing the transuranics nearer the root zones of plants.

Second, VADM Monroe was concerned that plowing would eliminate forever any possibility of removal of transuranics As it was now, these dangerous radionuclides originally had been deposited in a thin layer on the surface, and even after many years of storms, leaching, weathering, and some man-made disturbance, they were still generally in a thin surface layer. This fortuitous history made removal possible; however, once plowing was carried out, the opportunity for a more effective solution would be lost. Regardless of the drawbacks and despite the fact that plowing had proven effective in reducing surface contamination, all goals in soil excision and removal operations eventually were met without plowing.

AIR SAMPLING FOR BERYLLIUM AT ENJEBI

Rocket motors using a propellant containing beryllium had been tested on Enjebi in 1968 and 1970 as described in Chapter 2. The exhausts were directed toward the lagoon in both instances, and decontamination procedures were implemented following both tests. However, subsequent soil analysis by McClellan AFB Central Laboratory indicated that not all the beryllium contamination was removed The remaining concentrations were as high as 30 micrograms of beryllium per gram of soil. The concentrations would be removed during soil cleanup but were high enough to represent a potential resuspension problem and additional hazard during soil removal operations

Field Command determined that a reasonable MPC of beryllium in air was 0.01 microgram per cubic meter of air averaged over a 30-day period The actual concentration may be determined by calculating the resuspension of beryllium given its concentration, the type of soil, the prevailing winds, and other factors, or by direct air sampling The latter method is more effective, and it was used on Enjebi

The location of the rocket engine tests and the JTG-installed air samplers appear on the partial map of Enjebi in Figure 7-10 The air samplers were downwind of the points where soil sample results indicated the beryllium concentration in soil to be the highest. The air samplers were

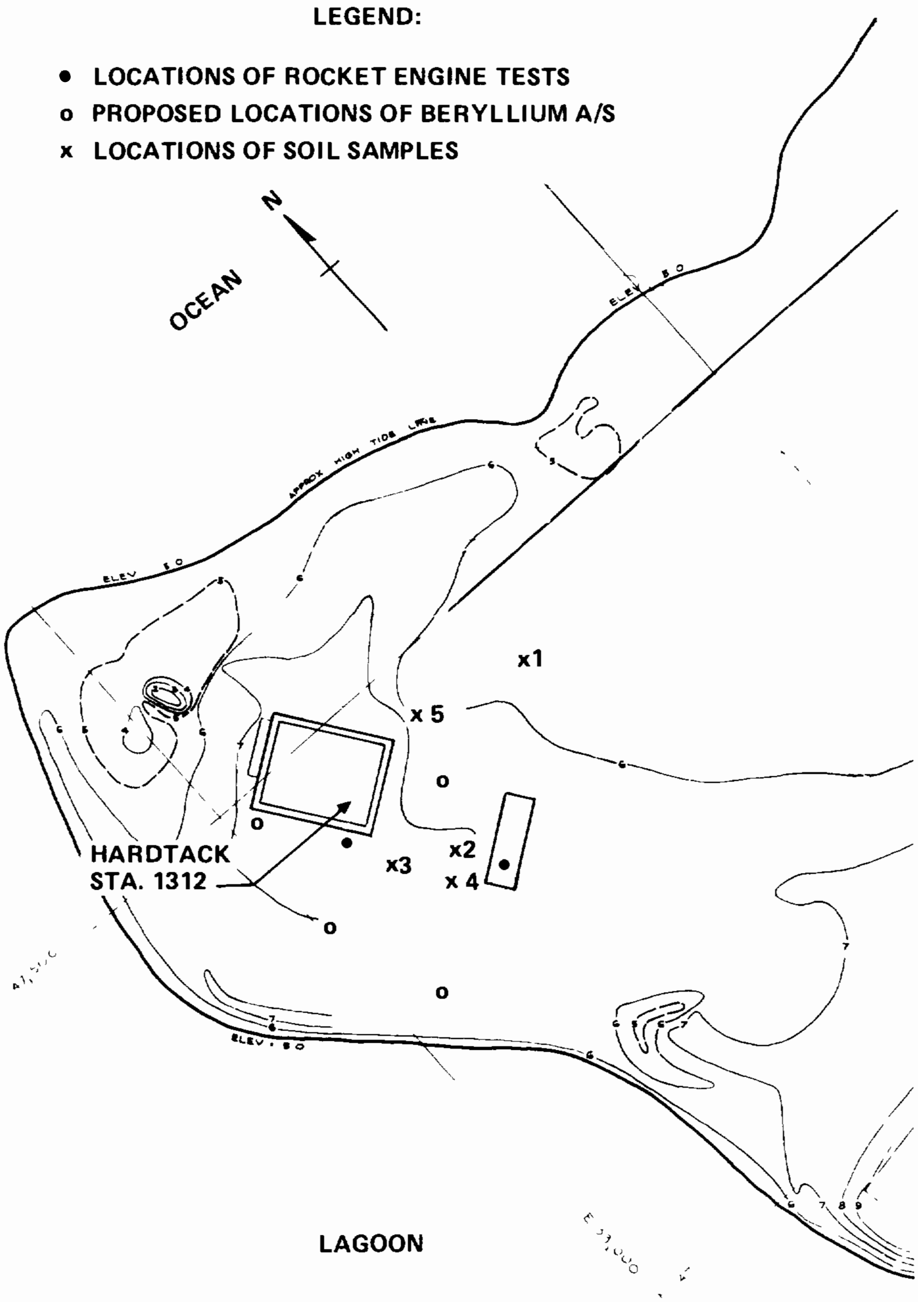


FIGURE 7-10. BERYLLIUM SAMPLE LOCATIONS.

operated for the maximum time possible for a 30-day period. The filters were changed at 1-week intervals. The main limiting factor to the air sampling program was the weather. Since rain often damaged the filters and it was desired to sample the air during the season when maximum resuspension of beryllium occurred, the beryllium air-sampling program was begun during the dry season. Approximately 24,000 cubic meters of air were sampled. One-month samples were composited and sent to the Occupational and Environmental Health Laboratory, Brooks AFB, Texas, for analysis.[9] All results were less than 0.001 micrograms of beryllium per cubic meter of air, the minimum detectable concentration, well within established limits.[10]

ENJEBI SOIL CLEANUP

Enjebi is the largest island in the northern portion of Enewetak Atoll, the political subdivision controlled by the iroij (chief) of the dri-Enjebi. With an area of 290 acres, it is the second largest island in the atoll. Cleanup of debris on Enjebi is described in Chapter 5. Soil cleanup work was complicated by a number of factors.

Enjebi was the site of the first test at Enewetak Proving Ground, the X-Ray event, on 14 April 1948. The Easy and Item tests of Operation Greenhouse also were conducted on this island. During the Hardtack I Operation in 1958, seven tests were conducted from barges in the lagoon near Enjebi. The plutonium-239 concentrations found in the 1972 radiological survey ranged from 0.08 to 170, with a mean of 8.5 pCi/g. The geographic distribution of plutonium-239 did not show any systematic pattern, and the depth distribution showed considerable variability from location to location. Most distributions displayed a rapid decrease in activity within the top few centimeters, with leveling off occurring as depth increased. Some deviations from this were noted in NVO-140. The geographical distribution of strontium-90 and cesium-137 did not show a systematic pattern either. Elevated amounts of radiation from cobalt-60 were evident in one area; however, the level was not alarming.

Records of nuclear test-related activities which affected soil cleanup were incomplete; however, soil profile samples indicated the same marble cake effect (swirls of clean and contaminated soil) which appeared on Aomon and Runit. Some standard assumptions were made; e.g., that burial of contaminated material occurred at all surface GZs. This was evidenced by the presence of mixed sand, paving material, and concrete, as well as by elevated levels of plutonium. Records indicated that some contaminated areas had simply been paved over with asphalt.

The many coaxial cable trenches across segments of Enjebi also promoted mixing and marbling. Their locations were made apparent by ridges of soil and denser vegetation than that of surrounding areas. Some cable trenches were as deep as 5 feet. Often, cables had been excavated and replaced for succeeding operations, resulting in further mixing when the cables were recovered. All these factors made Enjebi soil cleanup as complex a problem as Runit soil cleanup and, in terms of total cubic yards of soil to be removed, as vast an effort as Runit cleanup.

The DOE-ERSP fine soil survey of Enjebi began in August 1977 to define areas for soil removal Actual soil removal operations began soon after the 4 May 1978 soil cleanup conference, at which the Director, DNA decided to attempt the cleanup of Enjebi for possible future residential use. The conference decision left open the ultimate cleanup level, recognizing that resource limitations might dictate stopping at 50 pCi/g or some other value; however, 40 pCi/g was clearly the desired target. (The island met the criteria for agricultural use, 80 pCi/g, without removal of any soil.) In April 1978, DOE-ERSP estimated 44,835 cubic yards of soil would have to be excised from 20.75 hectares to achieve residential levels of transuranics. This volume estimate subsequently was revised to 54,300 cubic yards.[11,12]

Field surveys and staking of areas requiring soil removal began on Enjebi on 27 June 1978 (Figure 7-11) Actual soil removal began on 6 July 1978 in areas measuring over 60 pCi/g, from which 2,580 cubic yards of soil were removed Another 16,492 cubic yards of soil were removed from areas measuring over 50 pCi/g between 14 July and 14 August 1978. The procedure of removing the highest levels first revealed that such hot spots had a "halo" effect on soil survey data; i.e., they had given surrounding areas the appearance of containing greater levels than was actually the case. Resurvey of those areas after the hot spots were removed resulted in lower readings, fewer areas to be excised, and decreased volumes of soil to be removed. Thus, experience showed that subsurface contamination was much less of a problem than had been anticipated in the application of the "Treat Factor."

ENJEBI SUBSURFACE CONTAMINATION

In September 1977, DOE-ERSP had outlined to Commander, JTG (CJTG), a plan for subsurface exploration of the Easy, X-Ray and Item GZ sites on Enjebi. The plan was to verify NVO-140 data by backhoe soil profile sampling. Field Command had now established the priority for ERSP support to the fine survey of Boken (Irene), Lujor and the characterization of Runit As a result, the subsurface exploration plan was not implemented until January 1978.

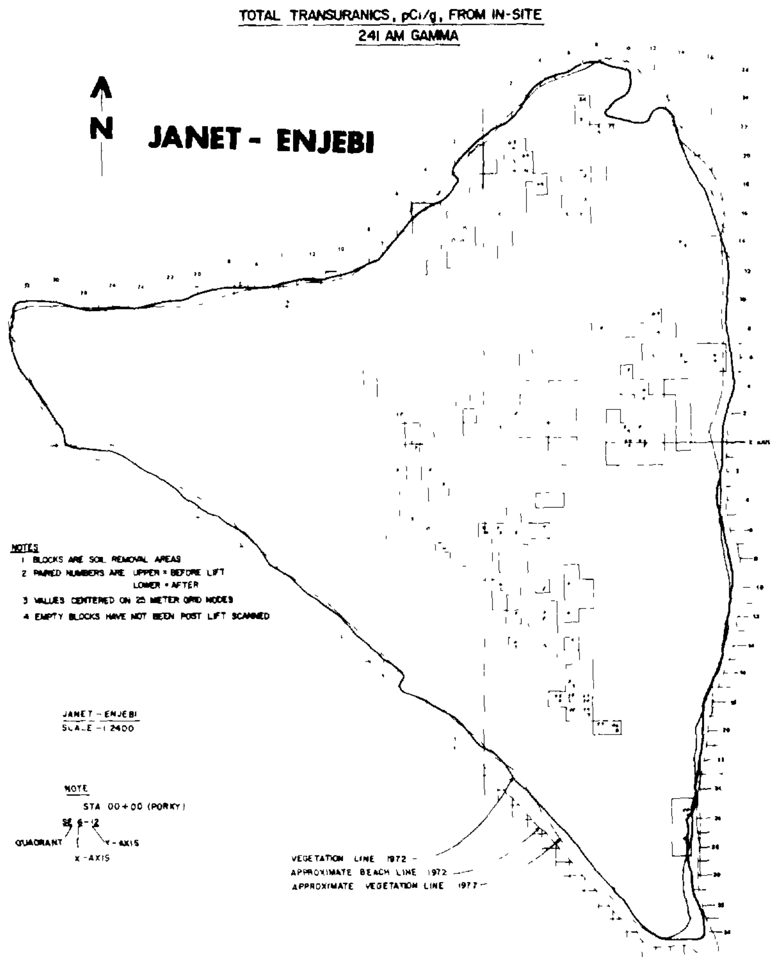


FIGURE 7-11 ENJEBI SOIL REMOVAL AREAS.

In August 1978, the Bair Committee visited the atoll and was asked for guidance on several matters, including the stringency of the 40-80-160 pCi/g criteria for residential, agricultural, and food-gathering islands. The Bair Committee responded that every effort must be expended to reach these levels and that only after it is clearly shown that these levels cannot be reached should a reconsideration be made.[13,14]

DOE-ERSP extracted soil samples from the Easy and X-Ray GZ areas on northwest Enjebi (Figure 7-8). Some 740 samples were taken from the sidewalls of trenches dug by backhoes to a depth of 120 centimeters (4 feet). On 30 September 1978, DOE-ERSP reported that the two areas had subsurface transuranics greater than 160 pCi/g, thereby exceeding Field Command's Operations Plan (OPLAN) Condition D. It was estimated that 1,300 cubic yards of soil would have to be removed to a depth of approximately 100 centimeters (3.3 feet).[15]

ENJEBI SOIL REMOVAL CONTINUES

On 3-6 October 1978, the Deputy Director, DNA, Major General Richard N. Cody, USAF, reviewed Enjebi soil cleanup operations at the atoll and decided to continue cleanup to 40 pCi/g surface levels. Approximately 12,621 cubic yards of soil above 45 pCi/g were removed between 24 August and 21 October 1978.

A fine grid (25 meters) IMP survey in early November 1978 revealed new areas requiring excision, even though 50-meter grid IMP data and statistical analysis had indicated, with 70 percent confidence, that such excision would not be required. This increase amounted to approximately 5,200 cubic yards. In addition, 29 areas over 40 pCi/g were identified. Soil removal operations continued with another 17,694 cubic yards of soil being removed from these locations to reduce surface contamination from 45 to 40 pCi/g. In addition, 2,600 cubic yards were removed from subsurface areas to bring them to less than 160 pCi/g. A total of 52,187 cubic yards of soil had been removed from the island when the Enjebi cleanup forces were redeployed on 21 April 1979, having completed all but the LLL tree farm and plowing experiment (Plow-X) areas.[16,17,18]

A week later, DOE-ERSP notified the CJTG that the Plow-X area could be cleaned. Soil cleanup in the Plow-X area was completed on 9 May 1979, resulting in the removal of another 820 cubic yards. This completed the Enjebi soil cleanup operation. Photographs of Enjebi before and after cleanup operations are at Figures 7-12, and 7-13. The final DOE-ERSP certificate indicated that, based on one-quarter hectare averaging, 97 percent of the island was less than 40 pCi/g (surface condition). A few areas, well distributed over the island, exceeded 40 pCi/g, but none

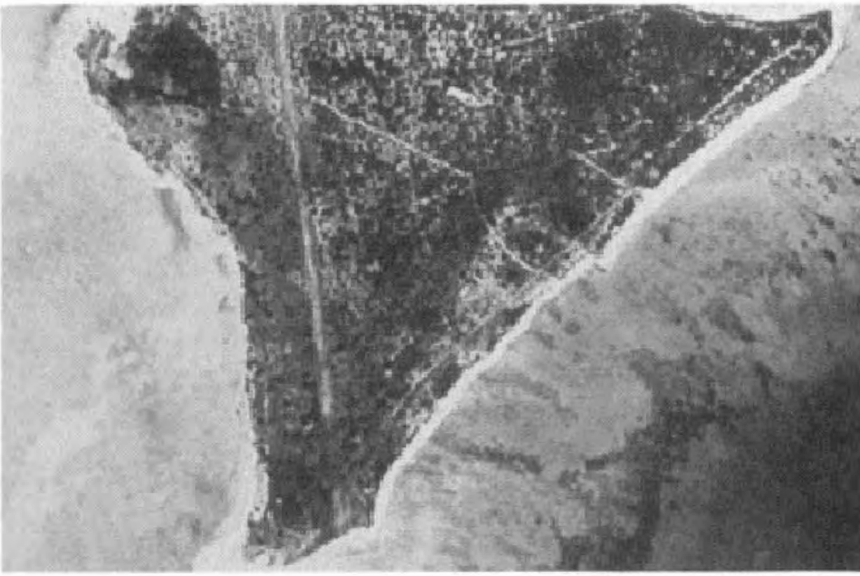


FIGURE 7-12. ENJEBI BEFORE CLEANUP.

FIGURE 7-13. ENJEBI AFTER CLEANUP.

exceeded 47 pCi/g. The island average was determined to be 20 pCi/g. The subsurface condition was less than 160 pCi/g averaged over one-sixteenth hectare.[19]

Cleanup of hazardous debris and contaminated soil on Enjebi was, as anticipated, a large, time-consuming task. One major factor was the time required for travel by boat between Enjebi and the base camps and between Enjebi and the disposal site on Runit. To minimize this problem, several of the smaller work forces camped on Enjebi while they completed their missions. Early plans called for the Enjebi cleanup forces to live in a tent camp on the island for the 6 months that cleanup effort was expected to take. A major reason for not implementing these plans was that use of Enjebi for a large base camp would make it more difficult to convince the dri-Enjebi that they should not begin living on the island until strontium and cesium levels decreased.

Enjebi soil removal operations also were hampered by two tropical storms, although to a lesser degree than Boken soil removal and Aomon Crypt operations which began while the Enjebi work was underway. The first of the storms was Typhoon Rita.

TYPHOON RITA

On the afternoon of 16 October 1978, Fleet Weather Central, Guam, issued a warning that a tropical storm which had been growing in the Pacific had reached the typhoon stage and would pass near Enewetak Atoll. A chart of the typhoon's path is at Figure 7-14. Cleanup operations were suspended the next morning to prepare for Typhoon Rita. Sandbags were placed on roofs, windows were taped, and other preventive measures were initiated based on lessons learned in two previous storms. On 18 October 1978, all visitors were transported on the normal Military Airlift Command channel airlift to Hickam AFB. A commercial tug which was offloading at Enewetak sortied out of the lagoon with its two barges, seeking safety at sea to the south of the atoll. As in the case of all tropical storms and typhoons, Rita was tracked continuously by Field Command and HQ DNA, and both echelons kept in continuous touch with the JTG and with Commander in Chief, Pacific. As Department of Defense (DOD) Project Manager for the cleanup operation, the Director, DNA was responsible for the evacuation decisions in the case of each tropical storm/typhoon. In this case, he decided not to evacuate the atoll.

Several alternatives to protect the atoll population were considered. Since Lojwa Camp was expected to receive the worst weather, most of the people there were moved to the main camp on Enewetak (Fred) Island. Over 400 people were evacuated from Lojwa between 0930 and 1300

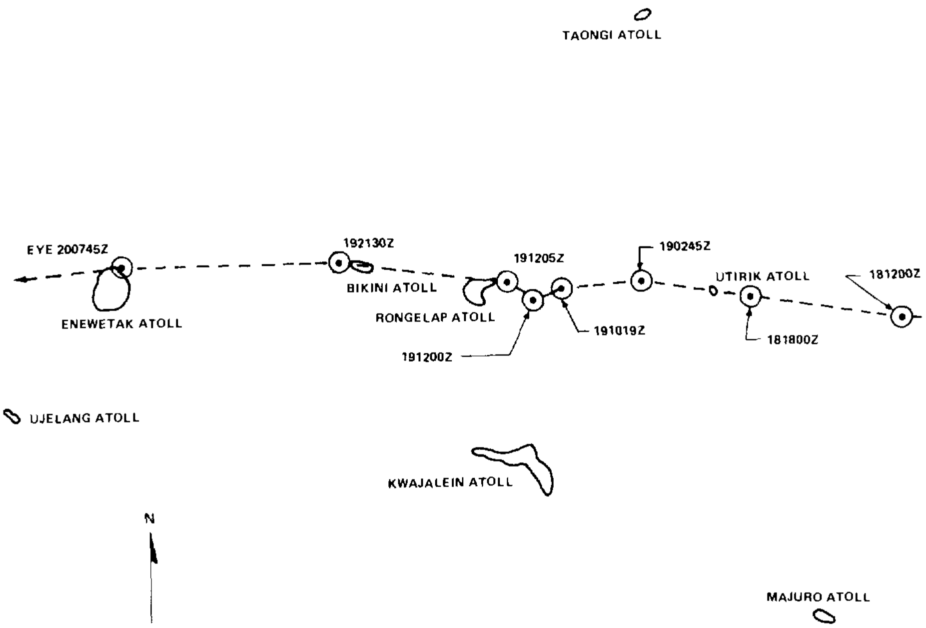


FIGURE 7-14. PATH OF TYPHOON RITA.

hours on 19 October 1978. Twelve Holmes & Narver, Inc., Pacific Test Division (H&N-PTD) and military personnel remained on Lojwa as a security and initial recovery force. Heavy rains began at 1600 and, at 1845 hours, the "take cover" warning was sounded.

The focal point of the storm was Lojwa, with the storm center passing approximately 15 miles north of the island at 1945 hours, 19 October 1978. Mr. A. J. Bennett, H&N Resident Manager for Lojwa, who had remained on the island, indicated that the winds had increased to approximately 45 knots, then had begun to drop off. At that stage, very strong gusts, estimated at 75 knots from rapidly changing directions, occurred, causing considerable damage.

The USAE maintenance shed on Lojwa was blown down, the reefer bank cover was blown into another building, roof vents and side panels were blown from several buildings, some electrical lines were snapped, and several tents were destroyed. Five LCM-8s had been secured to moorings off Lojwa. Two of these, which were tied to the same buoy, dragged their anchorage to a point 150 yards off the island of Bijire (Tilda), incurring some hull damage on coral heads. The LCM-8s which were moored one per buoy were not damaged. The USNE subsequently made temporary repairs to the damaged craft until permanent repairs could be made by a wet-well repair ship in November 1978 There was no significant damage to equipment or facilities at the other islands. There were no personnel injuries at Enewetak from Typhoon Rita, which later claimed over 200 lives in the Phillipine Islands.[20,21,22]

TYPHOON ALICE

Following Typhoon Rita, Enewetak operations returned to normal. However, on 29 December 1978, two men stationed at Lojwa Camp, Captain Jon R. Flores, USAF, (the camp doctor) and Private First Class Timothy P. Jarvis, USA, were lost while sailboating in the lagoon for recreation and became the fourth and fifth fatalities of the project. They had been sailing near the three-island complex of Aomon-Bijire-Lojwa. When they failed to return, a massive search and rescue effort was initiated, covering the lagoon, all the islands of the atoll, and the downwind ocean areas to the southwest. The search employed all available local boats and helicopters, as well as U.S. Coast Guard, Navy, and Air Force search and rescue aircraft from Pacific bases. The search continued without result until 3 January 1979, when it had to be discontinued because of worsening weather conditions from Typhoon Alice.[23,24] This typhoon, which had been east of Kwajalein Atoll on a northbound course, suddenly veered to the west, in the general direction of Enewetak (Figure 7-15).

The JTC Commander, Colonel Robert W. Bauchspies, USA, decided to take no chances with this unpredictable storm and ordered protective preparations to begin the morning of 4 January 1979. Boats were beached, buildings were secured, and preparations made to evacuate all but a small security and initial recovery force from Lojwa Camp to Enewetak Camp. Cargo vessels in the harbor ceased offloading and left the lagoon. The JTG prepared flight manifests for air evacuation of all atoll personnel to Kwajalein or Guam, should that become necessary. On the afternoon of 4 January 1979, all personnel from Lojwa Camp, except for a small initial recovery force, were brought to Enewetak Camp. The Director, DNA evaluated the reports from the atoll and decided not to evacuate the personnel from the atoll.

Typhoon Alice struck the atoll the morning of 5 January 1979 with devastating force. The "take cover" signal was sounded at 0720 hours. Power and radio communications went out in the next half-hour. Winds steady at 70 knots with gusts to 80 knots were recorded for over an hour before the instruments became inoperative at the height of the storm. Surf broke over much of the island, rolling stones as large as basketballs across the island from the ocean side to the lagoon. Water 4 feet deep flowed through the Mid-Pacific Research Laboratory area. Sections of road were washed out on the lagoon side of Enewetak Island and in the industrial area. Winds blew down the old water tower and ripped large sections of

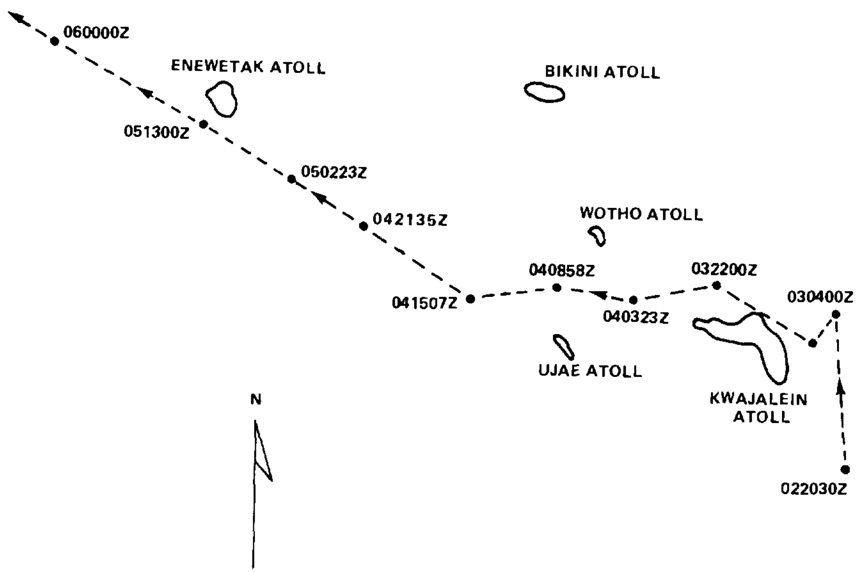


FIGURE 7-15. PATH OF TYPHOON ALICE.

sheet metal from the roofs and walls of many of the buildings. The dry stores warehouse (Bldg 37), new reefer bank (Bldg 544), and the "White House" female/guest quarters (Bldg 676) were totally demolished.

The worst was over by noon that day, and the "all clear" signal was sounded. Forty-knot winds, heavy rains, and high-surf conditions continued until 1600 hours. During this period, initial damage estimates were made. There were very minor injuries to two personnel. Property damage at Japtan and Lojwa was minor. Damage at Enewetak Camp was massive. Life-support systems were out with no power and no water pressure. To minimize the impact at Enewetak, return of personnel to Lojwa Camp was expedited.

Several empty refrigerated shipping containers were on hand awaiting transportation to Hawaii. To save as much frozen food as possible, these were pressed into service until the electrical distribution system could be repaired. Eighty percent of the freeze and chill subsistence was saved. Army portable generators were airlifted from Hawaii to augment those available on the atoll and to provide emergency power for communications and life-support systems. The Military Affiliate Radio Station antenna was jury-rigged to provide emergency communications until the military radio-teletype system could be repaired. Storm recovery assistance was obtained from Kwajalein Missile Range, which provided several portable generators, and from Johnston Atoll, which provided equipment and personnel to assist in repair of storm damage.

The initial recovery and repair effort after Typhoon Alice took 3 weeks and cost over $264,000. Subsequent repair and replacement of facilities required to support the cleanup project and rehabilitation program continued for months. Photographs of Typhoon Alice damage are at Figures 7-16 through 7-20.[25,26]

Two helicopters were damaged by windblown debris but were repaired and back in service within a week. Boat damage was relatively light. One LCU parted its steel mooring lines, bounced across several coral heads, and broached on a coral and sand beach. Damage included cracks up to 8 feet long, cracked frames, and buckled bulkheads. Repairs by the USNE augmented by a three-man repair team, took almost 4 weeks. One LCM-8 also broke loose but received only minor damage.[27]

One of the most adverse effects of Typhoon Alice was not discovered until some time later. Many of the channels which had been cleared into islands for soil removal operations had filled with sand, making access extremely difficult. Boken, Aomon, and Lujor channels were severely affected.

FIGURE 7-16. TYPHOON ALICE DAMAGE, THE "WHITE HOUSE."

FIGURE 7-17. TYPHOON ALICE DAMAGE, MAINTENANCE SHOP.

FIGURE 7-18. TYPHOON ALICE DAMAGE, MOTOR POOL AREA.

FIGURE 7-19. TYPHOON ALICE DAMAGE, DRY STORES.

FIGURE 7-20. TYPHOON ALICE DAMAGE, BILLETS.

BOKEN SOIL CLEANUP

Boken was the site of the Seminole test during the Redwing series, which left a large, water-filled crater. The sand spit linking Boken to the remains of Bokaidrikdrik (Helen), most of which was destroyed, enlarged to the point that, for practical purposes, the two now appear to be one island. The island was affected by the Mike and Koa thermonuclear tests, as well as by three barge shots conducted in the Mike Crater.

The DOE-ERSP fine soil survey of Boken began in September 1977 Results of the survey were furnished to Field Command on 27 April 1978. In situ data indicated that the island surface met requirements for its designated use as a food-gathering island without any soil cleanup; however, the area around the edge of Seminole Crater was considered a probable contaminated soil burial site. Therefore, extensive subsurface sampling was conducted by DOE-ERSP, resulting in the first requirement for soil removal from Boken. In the vicinity of grid node 13N1, there were three areas, varying in depths from 20 centimeters to 120 centimeters, where the average subsurface contamination over one-sixteenth hectare was greater than 160 pCi/g (Figure 7-21). Soil profile data from the sidewalls of trenches dug by backhoes indicated that over 150 cubic yards of surface soil and over 800 cubic yards of subsurface soil exceeded 400 pCi/g.[28]

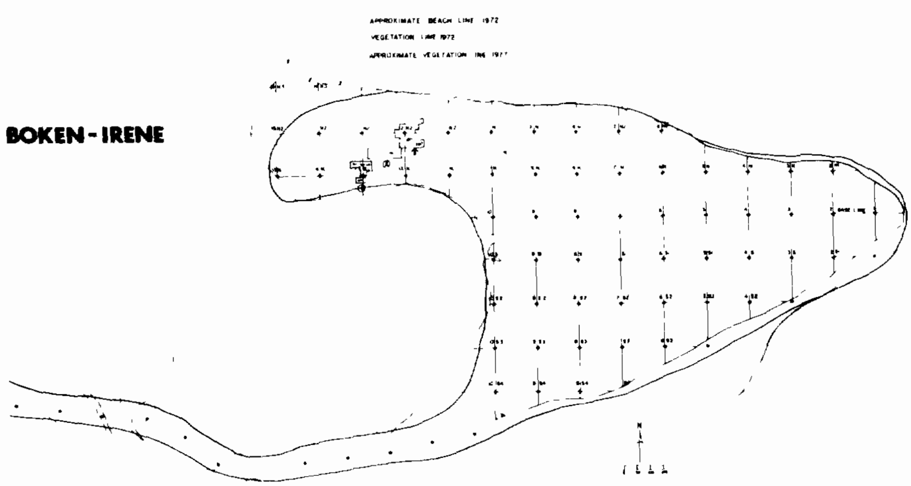


FIGURE 7-21 BOKEN SOIL REMOVAL AREAS.

Soil removal operations on Boken could not begin until soil cleanup criteria and priority issues were decided at the 4 May 1978 conference. Company B, USAE, began devegetation operations in late August 1978 and was prepared to begin excavation and removal of the contaminated soil when the island was suddenly invaded by tens of thousands of seabirds, principally sooty terns. It was the beginning of the nesting season, and eggs were being laid and incubated at a density of at least one per square meter. Soil cleanup operations were delayed about 3 months to allow time for the eggs to hatch and the young birds to become mobile. A photograph indicating the high bird density is shown in Figure 7-22.

When soil excavation began, it was accomplished primarily by dozer. In areas requiring deeper excavations, a 2-1/2-cubic-yard bucket loader was used. In late 1978, a high-tide channel was found and improved by USNE Water-Beach Cleanup Team (WBCT) and Explosive Ordnance Disposal (EOD) personnel using explosives. This channel was able to accommodate LCM-8 craft under extreme high tide conditions. The plan for movement of soil to Runit was to take one or two LCM-8 loads per day when tide conditions permitted. It was estimated that 2 months would be required to complete this soil movement operation. This plan had to be abandoned in early January 1979 after Typhoon Alice drastically altered the shoreline of Boken to the extent that there was no longer a usable channel for watercraft, and it was not feasible to attempt to reopen the channel.

FIGURE 7-22. BIRDS ON BOKEN.

The only apparent alternative for moving the soil was by Lighter, Amphibious Resupply, Cargo (LARC-LX). The soil had to be loaded on 20-ton trucks (approximately 8-10 cubic yards per truck) and transported, one truck at a time, aboard the LARC-LX to the neighboring Enjebi Island. One round trip consumed 65-70 minutes. At Enjebi, the soil was stockpiled on the beach for subsequent movement by bulk-haul LCU and LCM-8s to Runit. The movement of soil from Boken to Enjebi began in mid-January 1979 and was completed on 23 April 1979. A total of 3,397 cubic yards was removed in this initial soil cleanup effort.[29] Based on in situ data, DOE-ERSP notified the JTG that the surface of Boken met Condition B (80 pCi/g), that the subsurface met Condition D (160 pCi/g), that a reasonable search had been made for pockets of subsurface contamination, and that no areas remained with transuranic concentrations known to exceed the criteria.[30]

Subsequently, during the Fission Products Data Base Survey (described in a later section), analysis of subsurface samples taken from a 50-by-50-meter grid on Boken indicated that further investigation was required. Additional samples were taken on 25-meter, 12.5-meter, and 6.25-meter grids. When this data was analyzed, DOE-ERSP determined that five small subsurface areas required additional soil excision. The CJTG was notified of the requirement for the new Boken soil operation on 10 May 1979.[31] DOE-ERSP estimated that an additional 1,670 cubic yards of soil would have to be removed from grid nodes 14N1, 10N1, 9S3, 7S3, and 6S2 as shown in Figure 7-23.

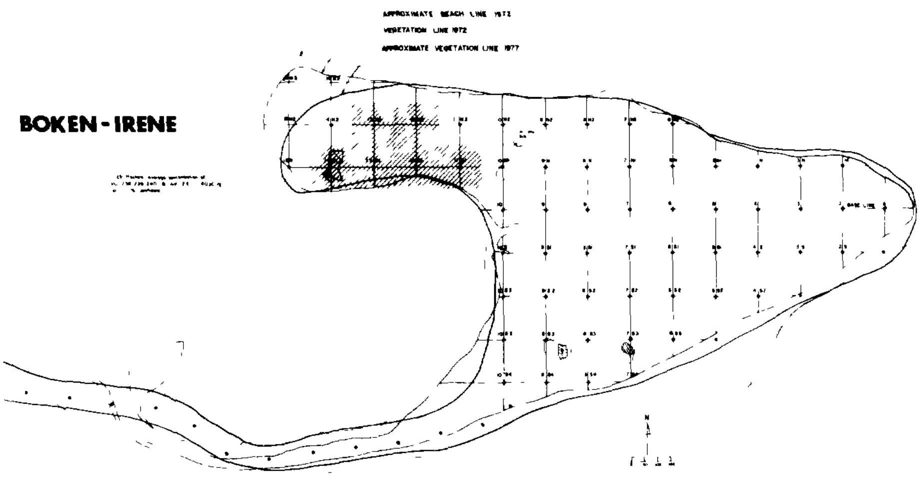


FIGURE 7-23. BOKEN SUBSURFACE SOIL REMOVAL AREAS.

The timing of the second soil removal operation was critical since all soil requiring containment was scheduled to be delivered to Runit by 16 July 1979 to meet the 15 September 1979 Cactus Dome Cap deadline. The large volume of soil to be moved and the severe time constraints rendered it infeasible to move the soil via Enjebi as in the previous operation. A more rapid means of soil transport was necessary. Extensive studies of the shoreline of Boken were again conducted to determine where and how bulk-haul craft could be used. Since the channel conditions prevented access by LCUs and LCM-8s, an innovative means to use these craft for bulk haul was absolutely necessary. Causeway sections had been used successfully in removing soil from Aomon, and it appeared possible to use them at Boken. When the lagoon area near the sand spit off Boken in the vicinity of Koa crater was investigated, it was found that LCUs could gain access at this location under some high-tide conditions. From the lip of Koa crater to the sand spit was 370 to 420 feet, depending on tide conditions. This distance could be bridged by causeway sections. All that was needed was to find a means to get the soil to the causeway. Since the sand on the spit was too fine to support 20-ton dump trucks, the LARC-LX was employed to transport them from the beach stockpile on Boken north of Seminole Crater across the crater and the sand spit to the landward end of the 360-foot causeway. The trucks were then required to back from the LARC-LX out the 360-foot causeway to discharge their loads on to the LCUs, which had navigated from Koa crater to the seaward end of the causeway. The truck then was driven forward off the LCUs, along the causeway and aboard the LARC-LX where it was ferried back across the sand spit and Seminole Crater to the beach stockpile site. A photograph of this procedure in operation is shown in Figure 7-24. Even though this method was time consuming, it proved to be much faster than the method previously used to remove soil from Boken, and it permitted the use of bulk-haul boats.

In addition to the LCU-Causeway-LARC combination, limited use was made of LCM-8s and 5-ton dump trucks. These all-wheel-drive dump trucks were able to negotiate the sand spit to the causeway. The LCM-8s could beach alongside the causeway only during high tides. Depending on the tides, they could accept two to four 5-ton dump truck loads each. Since they were partially loaded, the LCM-8s would then proceed to Lujor to fill the remainder of the craft with the soil excised as a result of subsurface contamination discovered there during the Fission Products Data Base Survey. With these plans fully established, Company B, USAE, began the excision on 11 June 1979, and all soil was transported to Runit by 7 July 1979, 9 days ahead of the deadline. Figures 7-25 and 7-26 show Boken before and after cleanup operations.

FIGURE 7-24. LARC-LX FERRY OPERATION.

FIGURE 7-25. BOKEN BEFORE CLEANUP.

FIGURE 7-26. BOKEN AFTER CLEANUP.

Boken soil cleanup operations were extremely difficult because of limited boat access, remoteness from base camps, and last-minute discovery of additional subsurface contamination. The second soil cleanup operation at Boken removed 1,540 cubic yards of soil. A total of 4,937 cubic yards containing an estimated 1.01 curies of transuranics was removed from the island.[32] Enough transuranics were removed to qualify the island for agriculture use, significantly better than the food-gathering use requested by the dri-Enewetak. The final DOE-ERSP certification indicated that the surface condition was less than 73 pCi/g averaged over one-half hectare, and the subsurface condition was less than 160 pCi/g averaged over one-sixteenth hectare.

AOMON CRYPT PROJECT

The EIS required removal of plutonium from three burial crypts on Aomon. Two of these were subsequently identified as concrete blocks containing contaminated debris. These were removed as described in Chapter 5. The third, which came to be known as the Aomon Crypt, was in an area on the lagoon side of the causeway between Aomon and Bijire where contaminated soil and debris had been dumped in a tidal pond and covered with clean soil (Figure 7-27).

FIGURE 7-27. AOMON CRYPT.

The original formation of the crypt apparently had not been documented, and discussions with personnel who had been on the atoll at that time yielded conflicting information. It was reported that the remains of the steel tower from the Kickapoo shot had been cut into sections no greater than 10 feet long and placed rather uniformly in the center of the crypt with a crane.[33] It also was reported that the crypt contained about 5,000 cubic yards of contaminated soil from the Yuma GZ area. Later investigation indicated that the soil volume from Yuma was approximately 1,500 cubic yards; however, it also indicated about 5,000 cubic feet of contaminated Yuma debris were present.[34]

In addition to incomplete knowledge on the exact contents of the crypt, its precise three-dimensional location was unknown, and the method by which the contaminated soil and debris would have to be removed was not at all certain. The area had an extremely high water table, and it was apparent that excavations of contaminated soil and debris would have to be performed under water.

EARLY SURVEYS OF THE CRYPT

The first investigations of the crypt area were made by the FRST in October 1977, using powered earth augers. They brought up samples of contaminated soil and metal and encountered a high water table which hampered digging below 6 feet.[35,36] Results were discussed by Field Command and JTG engineers during a conference in Albuquerque in February 1978. Most agreed that use of a steel sheetpiling enclosure, normal excavation techniques, and a drain pile should permit removal of the material without spreading contamination. Others felt that more data were required.

The second investigation was conducted in April 1978, using backhoes and hand augers. Red and green dye was poured into some of the holes in an attempt to trace the flow of tidal water. Results of this test were inconclusive and somewhat confusing. In some holes, the dye appeared to intensify in color rather than fade as it diluted in the ground water.[37,38]

At the 4 May 1978 conference, the Director, DNA decided that a major effort would be made to excavate the crypt. On 13 May 1978, the USAE submitted a preliminary design scheme for the excavation. This plan called for a 50-foot by 280-foot sheet pile enclosure, from which 12,000 cubic yards of contaminated material would be excavated. Test wells, borings, and backhoe samples had indicated that the water level was 2 feet below the surface, and unstable soil existed around the excavations.[39]

At the same conference, DOE-ERSP had indicated that they would identify experienced contractors to look at various solutions for cleaning out the Aomon Crypt. At a meeting of DOE and Field Command representatives at DOE-NV on 6 June 1978, a representative of Fenix and Scission, Inc. (F&S) presented a concept for removing the contaminated soil in the crypt. The proposed concept provided for a hydraulic dredging operation, using a specially fabricated jet dredge head.

Under the F&S proposal, the size of material removed by dredging would be limited to the screen mesh size of 2-3/4 inches. Special equipment requiring long delivery times and technical assistance would be needed. Settling tanks would be required for separating water and soil so that emptying the tanks would require additional equipment and add to the complexity. In short, the method appeared to be expensive in money, time, and complexity and had no particular advantage over more conventional methods. Therefore, it was not adopted.

At the June 1978 meeting, a recommendation was made to start a test excavation using a crane with dragline to characterize the contents of the crypt and the stability of the soil. It was proposed to start the test excavation while the investigation of the jet dredge concept was underway.

Another more detailed exploratory excavation was conducted on 26 July 1978. During this exploration, a 6-foot deep hole with the approximate dimensions of 10 feet by 12 feet was dug using both a hydraulically operated backhoe and a crane with clamshell. The water which rushed into the hole confirmed a constant water level 2 feet below the surface. It also undercut the walls, resulting in cave-ins. The clamshell proved to be more successful in lifting soil and allowing water to drain back into the hole, minimizing the spread of contamination. The test revealed the need for a four-wall enclosure as there was a 33 percent increase in the width and length of the hole through cave-ins over a 24-hour period. Additional investigations on 15 August and 29 September 1978 confirmed the results of the earlier tests; i.e., a constant water level 2 feet below the surface and unstable excavation walls which fell in on 1:3 to 1:10 slopes, depending on water movement.[40]

During the initial planning, Field Command requested that Pacific Ocean Division (POD) of the Corps of Engineers submit designs for excavations, including both open and sheet pile procedures.[41] A design report was submitted on 15 September 1978[42] and, in a letter dated 6 October 1978, POD recommended that the JTG proceed to excavate contaminated material without the use of sheetpiling. The proposed scheme provided for a series of systematic overlapping trench excavations since POD suspected that the contaminated material was no more than 6 feet deep within the boundaries of the old tidal pond. POD also believed that, even if it were required to go as deep as 18 to 20 feet, the excavation could be accomplished with available equipment operated by skilled personnel.

A meeting was to be held at POD offices in Honolulu on 6 November 1978 to make a final recommendation to DNA on procedures to be used for removal of contaminated soil and debris from the Aomon burial site. The essential decision to be made was whether to select the POD-recommended procedure or to place sheet pile around all four sides of the crypt. Also to be considered was the alternative to place sheetpiling around three sides, with the end walls extended to the causeway prior to excavation.[43]

AOMON CRYPT CONFERENCE: 8 NOVEMBER 1978

This meeting took place on 8 November 1978, attended by representatives of POD, JTG, H&N-PTD, DOE-Pacific Area Support Office, DOE-NV, DOE-Germantown, F&S, U.S. Army Support Command Hawaii, Field Command, and Headquarters DNA.[44] Based on decisions at this meeting, the CJTG was given the following guidance:[45]

a. Start a drilling and core sampling program to determine vertical and lateral extent of radioactive contamination within the crypt.
b. After completion of initial core sampling, begin excavating without containment about 1 December 1978 in accordance with operational concepts developed during the meeting.

c. Preserve the capability to execute the sheet pile containment option. All sheet pile and other necessary supplies and equipment needed to execute that option would be obtained and shipped to the atoll on the next barge.
d. Provide a desilting capability for removing suspended particles from water.
e. Complete the project, including backfilling and backfill profile samples, not later than 30 May 1979.

During the meeting, DOE representatives, in concert with Field Command representatives, provided radiological guidance as follows:

a. Debris will be recovered throughout the crypt.
b. An attempt will be made to excavate transuranic concentrations exceeding 400 pCi/g at any depth encountered. Water-saturated samples will be filtered and field scanned.
c. Sediments will be sampled at predesignated grid nodes and analyzed using field techniques to document activity at the final excavated depth. Each grid will be 5 meters on a side (25 square meters).
d. After backfilling has been accomplished, profile samples will be collected at the sampling nodes to a depth of 180 centimeters. The core profile samples collected will be homogenized and aliquoted, yielding one concentration value representing that grid to ensure that values do not exceed 400 pCi/g.
e. Recovered contaminated soil piles and debris will be samples and monitored to obtain an estimated inventory of radioactive material recovered.

CRYPT SURVEYS: NOVEMBER 1978

Based on instructions from the 8 November 1978 conference, a 5-by-5-meter grid was established by DOE-ERSP and was surveyed and staked by a USAE surveyor. This grid, shown in Figure 7-28, was used for all subsequent surveys and operations in the Aomon Crypt. The surface of the Aomon Crypt was surveyed by DOE-ERSP using the IMP on a 25-meter grid. No surface readings above 40 pCi/g were found.[46]

A magnetic survey[47] of the Aomon Crypt was carried out by U.S. Oceanography of Honolulu, Hawaii, during the period 17-20 November 1978. A proton procession magnetometer with a dual sensing element on a 30-meter cable was used to determine the location and amount of ferric material buried in the crypt area. Positioning was accomplished using the 5-by-5-meter grid system established by the USAE surveyor.

To obtain an average reading for the total field intensity of the area, approximately 20 readings were made outside the grid area, in locations

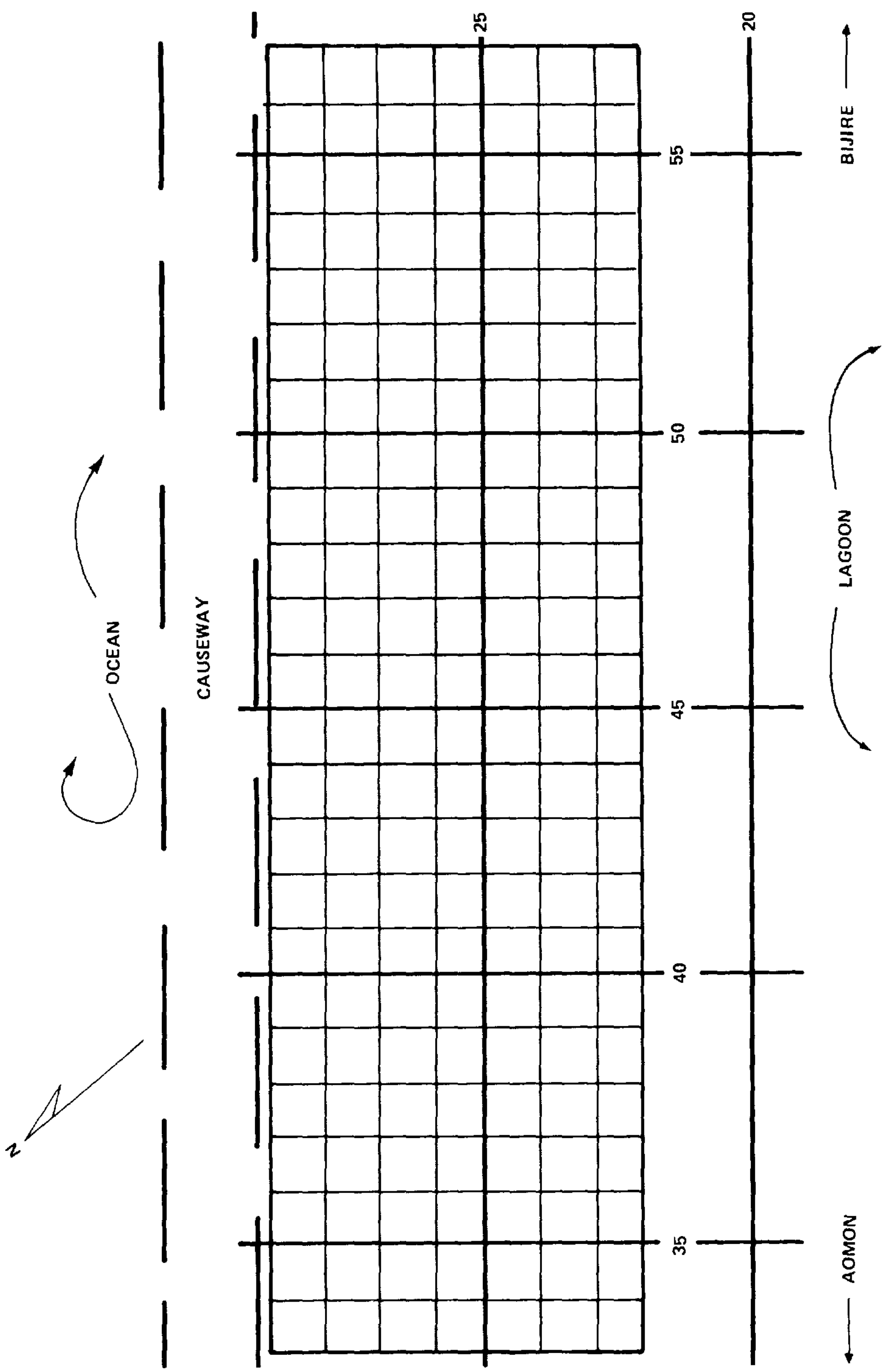


FIGURE 7-28. AOMON CRYPT GRID.

free of ferric interference. The effects of the causeway's steel support members and retaining wall were found to be minimal beyond about 10 meters. The actual measurements of field intensity were made on the existing grid with at least three samples taken at each node to minimize erroneous readings. At each point, a number from one to ten was assigned (the higher the number, the greater the probability of ferrous metal).

The results of this survey are shown at Figure 7-29. As was expressed by U.S. Oceanography, the magnetometer can be used to give very rough estimates of ferric material present. Notwithstanding this uncertainty, the use of the magnetometer survey data in combination with other survey results greatly assisted in the overall project.

DEEP-DRILL SAMPLING

Deep-drill sampling was conducted by personnel from the U.S. Army Engineer District, Mobile, Alabama, from 26 November 1978 to 14 January 1979 (Figure 7-30). The primary purpose was to locate the areas of soil contamination in the crypt area. To achieve this objective, soil samples were extracted at the nodes of the preestablished 5-by-5-meter grid at depth intervals of 2 feet. Drilling proceeded until the drill bit struck either the base coral reef or metal. This data, when combined with the magnetometer survey, gave a better approximation of the location of buried debris. The samples gathered were field screened using the IMP and analyzed through chemical analysis at the radiological laboratory on Enewetak Island. Horizontal locations of the contaminated soil above 400 pCi/g (disregarding depth) (Figure 7-31) and the estimates of debris locations from drilling (Figure 7-32) were used in conjunction with the magnetometer survey for further exploratory activities and designation of the sheet pile containment area.

AOMON CRYPT CLEANUP CONCEPTS

The objective of the Aomon Crypt Project was to remove all debris and subsurface contaminated soil above 400 pCi/g. The Bair Committee had determined that the Aomon Crypt was a special case; the 160 pCi/g criteria for subsurface contamination should not apply. As a result of the exploratory efforts, it was concluded that a sheet pile enclosure would be required for excavation of the heavily contaminated soil and debris around the center (node 45NE25) of the 5-by-5-meter grid system (Figure 7-33). With two exceptions, no other soil contamination was found above 400

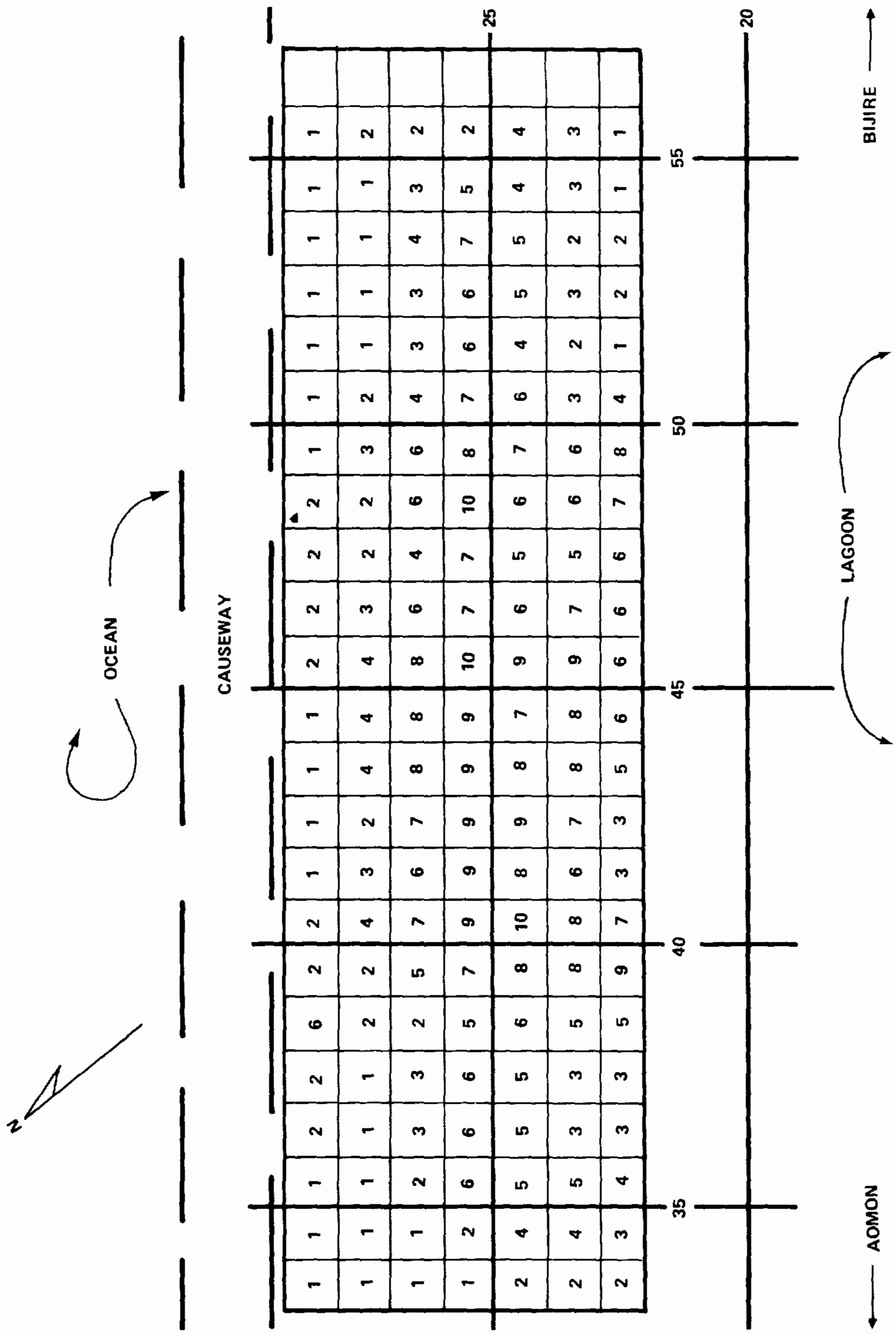


FIGURE 7-29. MAGNETOMETER READINGS.

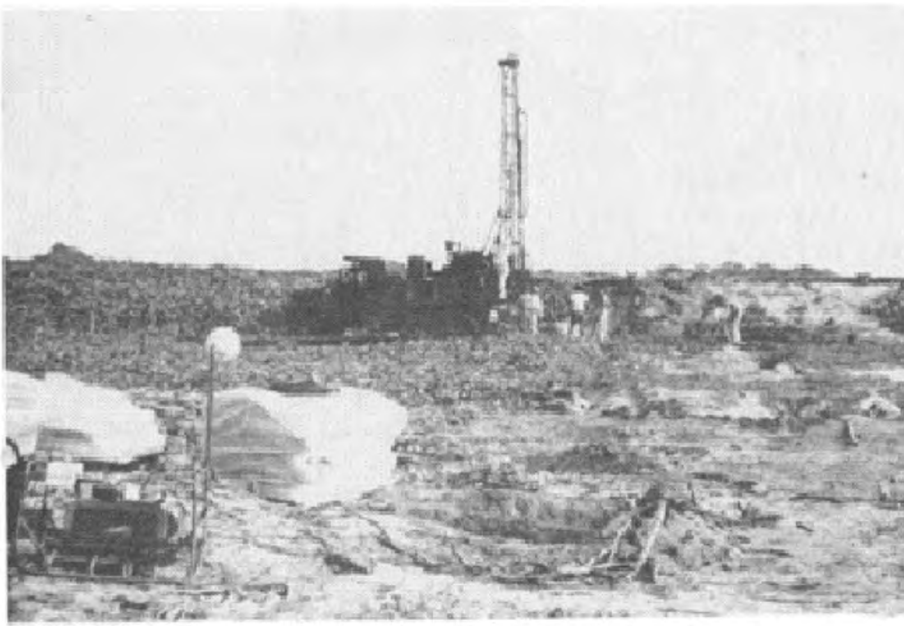
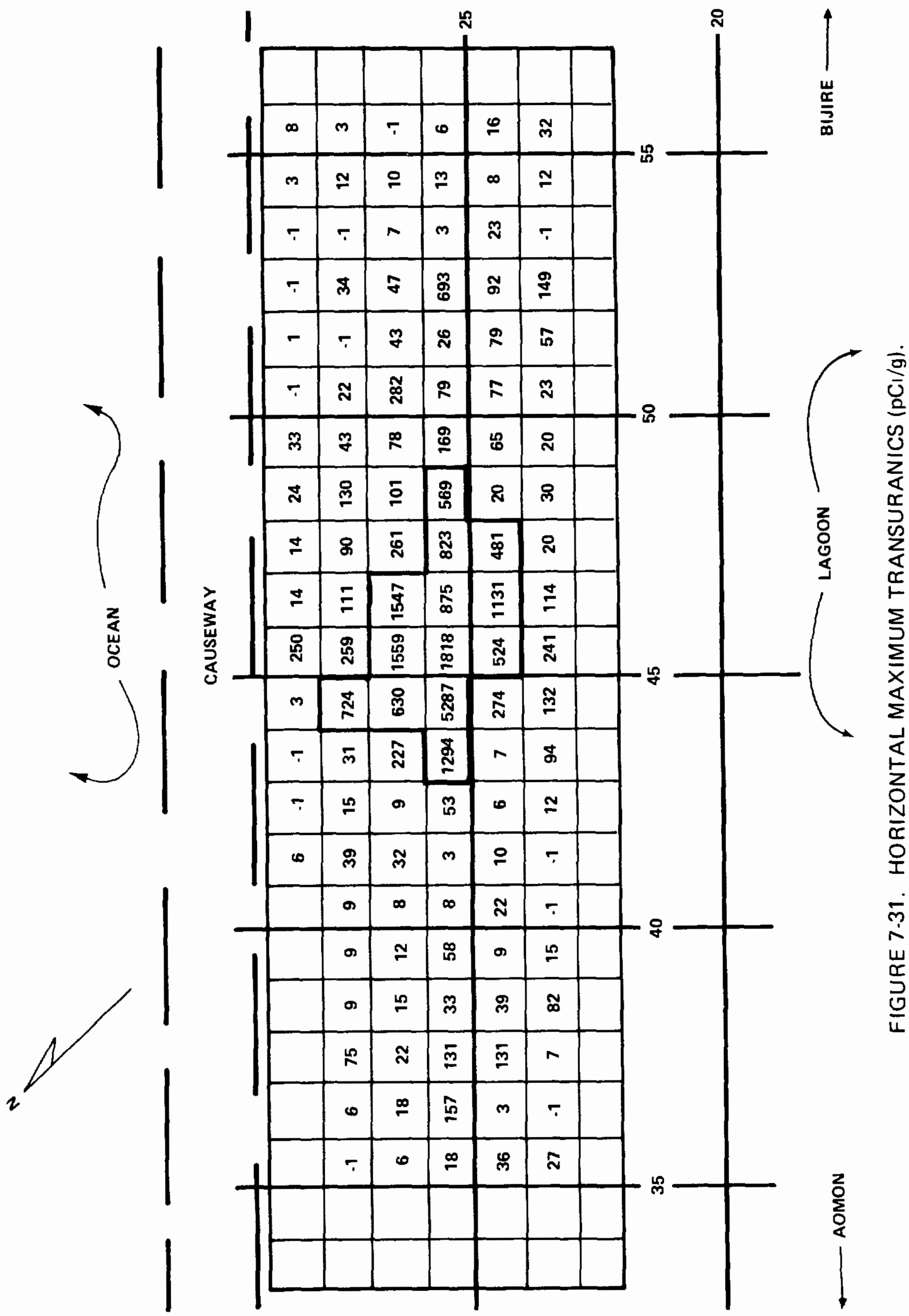


FIGURE 7-30. DEEP DRILL SAMPLING.



						6	-1	-1	3	250	14	14	24	33	-1	1	-1	-1	3	8	
		-1	6	75	9	9	9	39	15	31	724	259	111	90	130	43	22	-1	34	-1	12	3	
		6	18	22	15	12	8	32	9	227	630	1559	1547	261	101	78	282	43	47	7	10	-1	
		18	157	131	33	58	8	3	53	1294	5287	1818	875	823	569	169	79	26	693	3	13	6	
		36	3	131	39	9	22	10	6	7	274	524	1131	481	20	65	77	79	92	23	8	16	
		27	-1	7	82	15	-1	-1	12	94	132	241	114	20	30	20	23	57	149	-1	12	32	

FIGURE 7-31. HORIZONTAL MAXIMUM TRANSURANICS (pCi/g).

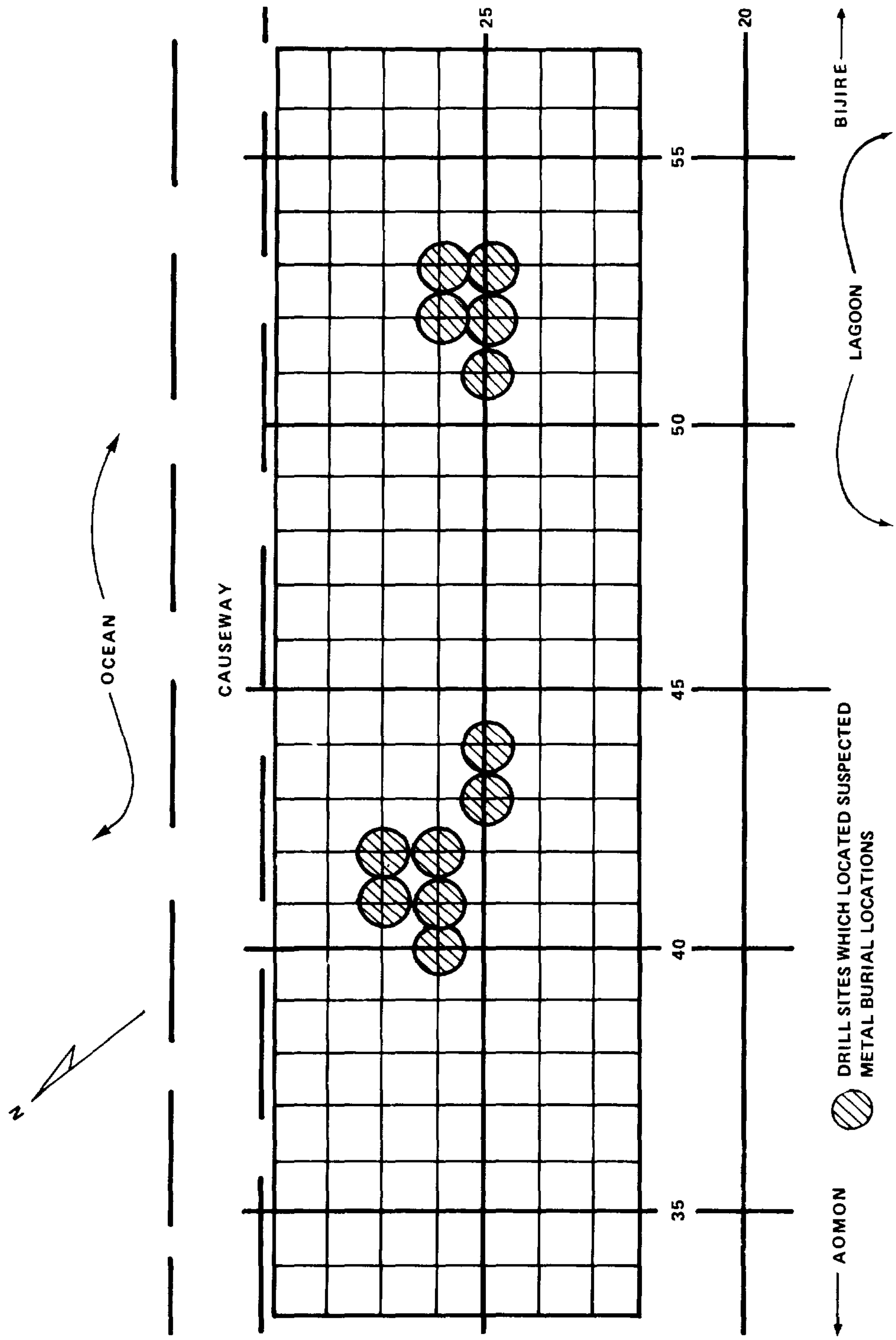


FIGURE 7-32. CORE DRILL - METAL LOCATION.

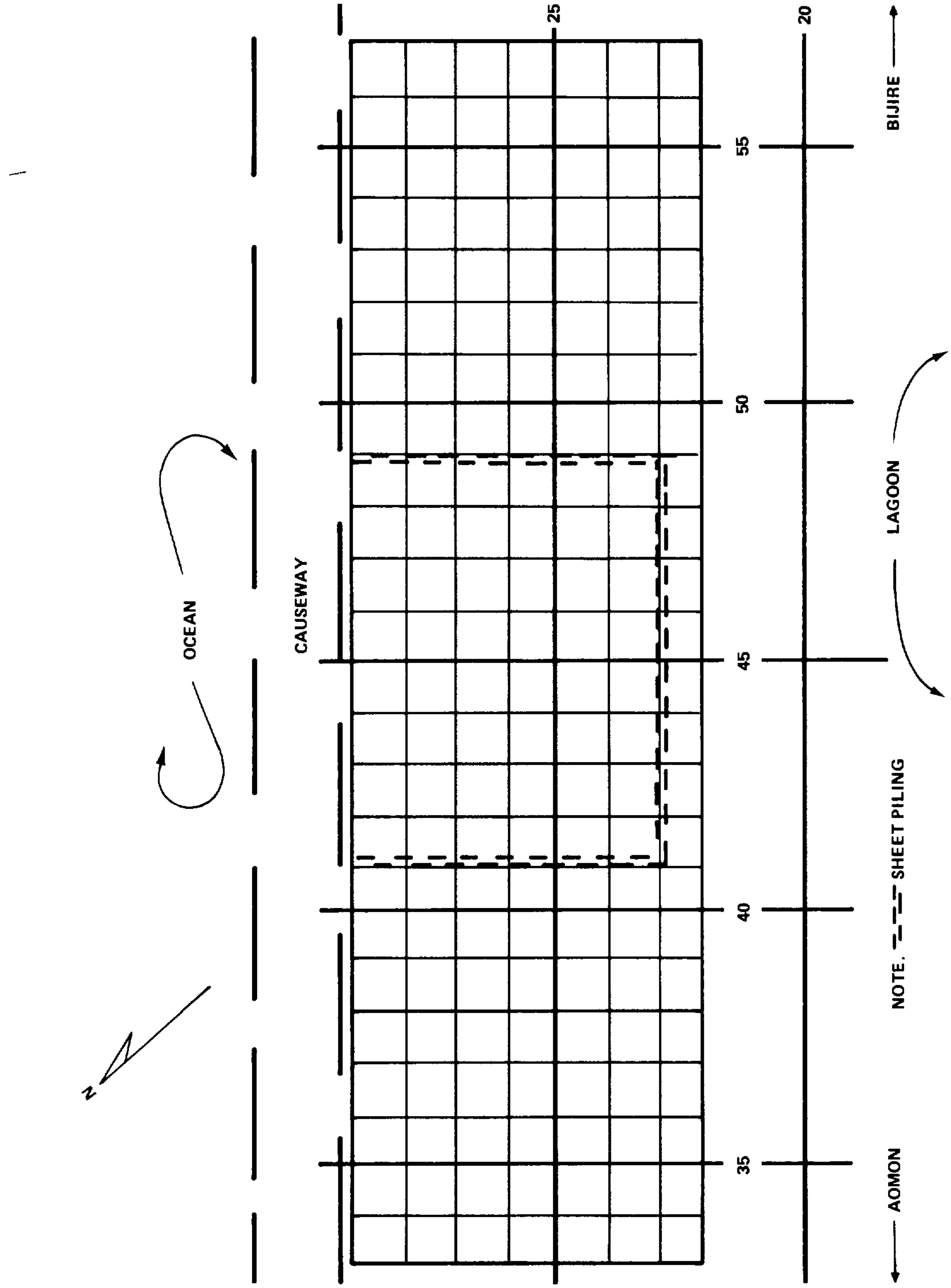


FIGURE 7-33. SHEET PILE CONTAINMENT AREA.

pCi/g. In these two cases, debris would be removed without sheet pile containment.

The following steps comprised the operational concept:

a. Remove debris or suspected debris from the noncontaminated soil areas first. Soil removed would be analyzed by DOE-ERSP. If soil contamination was less than 400 pCi/g, it was to be used to fill the hole after the debris was removed. If the contamination exceeded the criteria, it was to be stockpiled for transportation to Runit. The completed excavation was to be filled with clean beach sand.

b. All soil determined by DOE-ERSP to exceed 400 pCi/g was to be removed and taken to Runit. Since the heart of the area contained both debris and contaminated soil, it was to be stockpiled separately. Due to the depth of this contaminated soil, sheet pile containment was necessary.

c. By careful analysis and close supervision, much of the debris was to be removed without disturbing the earth to eliminate the possibility of lateral movement of suspended transuranics into noncontaminated areas.

d. Upon completion of excavation, the remaining soil in the enclosure was to be sampled by DOE-ERSP to ensure that the soil met the established criteria.

e. The isolation area would then be backfilled with clean soil. The cleanliness of the backfill soil was to be verified by DOE-ERSP.

f. Upon completion of all backfill operations, DOE-ERSP was to resurvey the entire crypt area, surface and subsurface, to assure that established criteria had been achieved.

Because of the complexity of the operation and the need for specialized equipment not available to the USAE, the J3, HQ JTG assumed responsibility for the Aomon Crypt cleanup. All JTG elements and agencies would provide personnel and equipment as required and available. The composition of the Aomon Crypt work forces varied from day to day.

The responsibilities assigned to individual elements and agencies were as follows:

a. HQ JTG (augmented by Captain Ronald Penn, of the USAE, who acted as Project Officer):
   (1) Provide overall command and control.
   (2) Direct personnel and equipment requirements from elements and agencies.

b. USAE:
   (1) Provide survey support.
   (2) Move contaminated soil and debris.
   (3) Provide LARC-LX to a ment USNE water craft.

(4) Backfill excavated areas.
(5) Clean and decontaminate sheet pile upon completion of the project.
(6) Establish and maintain land routes for the movement of equipment, and contaminated soil and debris in the vicinity of the Aomon Crypt and Aomon.
(7) Prepare a beach ramp for loading of soil and debris.
(8) Provide other assistance as required.

c. USNE:
(1) Provide water craft for movement of equipment, debris, and contaminated soil to and from the Aomon Crypt.
(2) Clear channel(s) of obstructions to allow access to the beach.
(3) Assist in the channel dredging operations.

d. USAF Element: Provide FRST personnel for radiation control and safety.

e. DOE-ERSP:
(1) Perform all analysis required for contaminated soil removal operations.
(2) Develop equipment suitable for underwater soil sampling.
(3) Resurvey the entire crypt in sufficient detail to allow certification of radiological condition.

f. H&N-PTD:
(1) Provide 45-ton crane and operators to emplace sheet pile, excavate soil and debris, and remove sheet pile after backfill operations.
(2) Design, build, and operate a sand dredge to clear a channel in the vicinity of the Aomon Crypt.
(3) Provide maintenance support for specialized equipment.

INITIAL EXCAVATION OF THE CRYPT

Initial excavation began on 15 January 1979 (Figure 7-34). Based on the exploratory operations, it was determined there was a possibility that three areas contained debris and/or contaminated soil. The central, and largest, area of suspected contamination would be isolated using a sheet pile enclosure. The other two smaller areas were located on the eastern and western sides of the sheet pile enclosure.

The eastern area was the smallest and was thought to contain debris and a small amount of soil contaminated above 400 pCi/g. On 15 January 1979, this location was excavated. The horizontal dimensions of the excavation were 5 by 15 meters and its depth was approximately 9 feet. No debris was

FIGURE 7-34. AOMON CRYPT INITIAL EXCAVATIONS.

found and the soil was found to be below 40 pCi/g. Consequently, the soil was replaced.

The western area excavation began on 16 January 1979. Approximately 1,700 cubic yards of soil and 170 cubic yards of debris were removed. The debris was found to be contaminated with plutonium and coated with an asphaltic compound. As it was being removed, the asphaltic compound flaked off causing the soil to become contaminated with plutonium. All 170 cubic yards of debris were transported to Runit. About 786 cubic yards of the contaminated soil were moved to Runit. The remaining soil was used to refill the excavation. This refilled area provided the footing for the 45-ton crane while the sheet pile enclosure was being constructed around the central area. Once the enclosure was in place, debris was removed first; then contaminated soil was excavated.

When all the debris and soil were removed from the sheet pile enclosed area, the bottom soil was sampled by DOE-ERSP. Fourteen 5-by-5-meter grids were found to contain soil contamination in excess of 400 pCi/g; additional excavation in these areas was required. As soil was excavated, iterative bottom sampling was conducted until all bottom soil was below the 400 pCi/g criteria. The operation was completed on 30 April 1979 after a total of 335 cubic yards of debris and 7,800 cubic yards of contaminated soil had been removed and transported to Runit. Excavations to a depth of 24 feet were necessary in the enclosed area. Once excavation within the enclosure was completed, the western area was reexcavated and the bottom was sampled again. Approximately 1,200 additional cubic yards of soil were excavated from this area and removed to Runit.

After excavation within the enclosure was complete, DOE-ERSP requested that the 14 areas (Figure 7-35) which had required additional soil removal be covered with a stabilizing soil-cement mixture to prevent the migration of any of this contaminated soil to the surface. The soil-cement was prepared outside the enclosure by mixing cement with backfill sand (approximately four bags per cubic yard). The soil-cement mixture was then placed on the bottom with the clamshell. The clamshell was carefully controlled by a guide who directed the crane operator to place the mixture over the 14 points as precisely as possible. Subsequent investigation revealed that the soil-cement mixture did form a rigid coating. Upon the completion of placement of soil-cement mixture, the final backfill operation in the sheet pile enclosure began.

AOMON CRYPT RADIOLOGICAL SUPPORT

While the established radiation protection program was adequate for a large portion of the excavation operation, certain aspects peculiar to the excavation required special attention. Enewetak Standing Operating Procedure 608-14, Radiation Safety at the Aomon Crypt Excavation Site, was written to address the special requirement. The Aomon hotline, which was near the crypt, was manned by not less than two FRST members. The FRST operated a standard hotline point at the Bijire end of the causeway, employing standard radiological safety and control procedures. When operations were underway, a FRST member was always present to insure that appropriate radiation safety procedures were being followed and to monitor personnel, equipment, and debris for radioactive contamination. An additional FRST member was also present whenever drilling operations were underway. Because the soil and debris were saturated with water upon being removed from the crypt, protective masks normally were not required during excavation. However, when the drier soil was being moved from the crypt area to the stockpile and from the stockpile to the Cactus Crater, additional precautions were taken, such as requiring the dump truck drivers and bucket loader operators to wear protective masks. Air sampling was done in accordance with established procedures, with five air samplers being used: one at the Aomon hotline; one downwind of the temporary soil stockpile in the crypt; one downwind on Aomon; and two in the area of ongoing operations. Handling of debris by personnel, rather than by machine, was kept to a minimum to avoid the possibility of a person being cut and the wound becoming contaminated. When

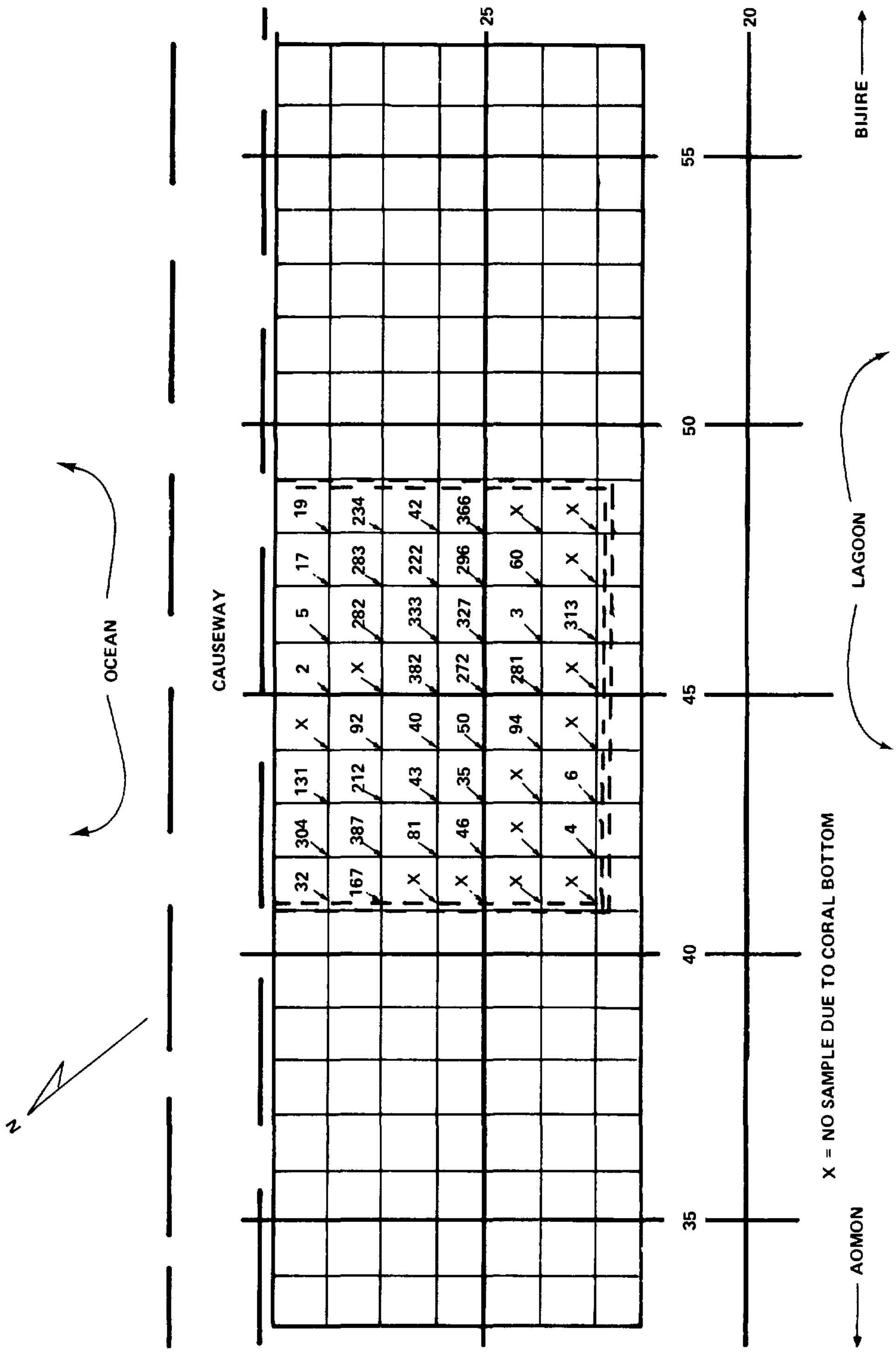


FIGURE 7-35. FINAL BOTTOM SAMPLING (TRU pCi/g).

handling of debris was necessary, personnel wore anticontamination clothing and gloves to protect against cuts. When personnel were required to walk through mud brought up from the crypt, they wore rubber boots. The radiation safety procedures at the Aomon Crypt were closely monitored to assure that personnel were being adequately protected.

DOE-ERSP was responsible for all soil sampling and analysis. Prior to operations, they conducted studies to determine the radiological condition of the surface and subsurface soil. One of these studies was the in situ characterization of the soil surface using the IMP van. The other was laboratory chemical analysis in conjunction with the deep drilling exploration previously mentioned.

When excavation began, DOE-ERSP was faced with the unusual requirement to sample soil underwater. A bottom sampling device, nicknamed the "bomb," was borrowed from Mid-Pacific Research Laboratory (MPRL). This bomb (shown in Figures 7-36 and 7-37) was very efficient and simple to operate. The soil sampling portion of the device consisted of two spring-loaded steel half-cylinders with an automatic tripping mechanism. The bomb was lowered by a rope which was knotted at 12-inch intervals to gauge the depth at which the samples were taken. When the trip mechanism touched the bottom, the weight of the device released the spring, causing the two half cylinders to close in on

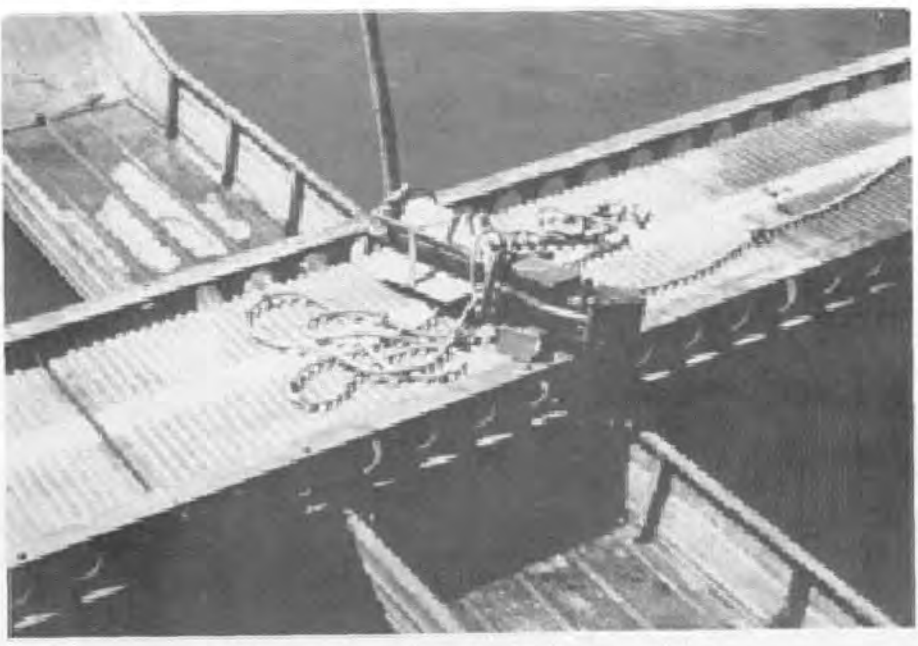


FIGURE 7-36. BOTTOM SAMPLING DEVICE.

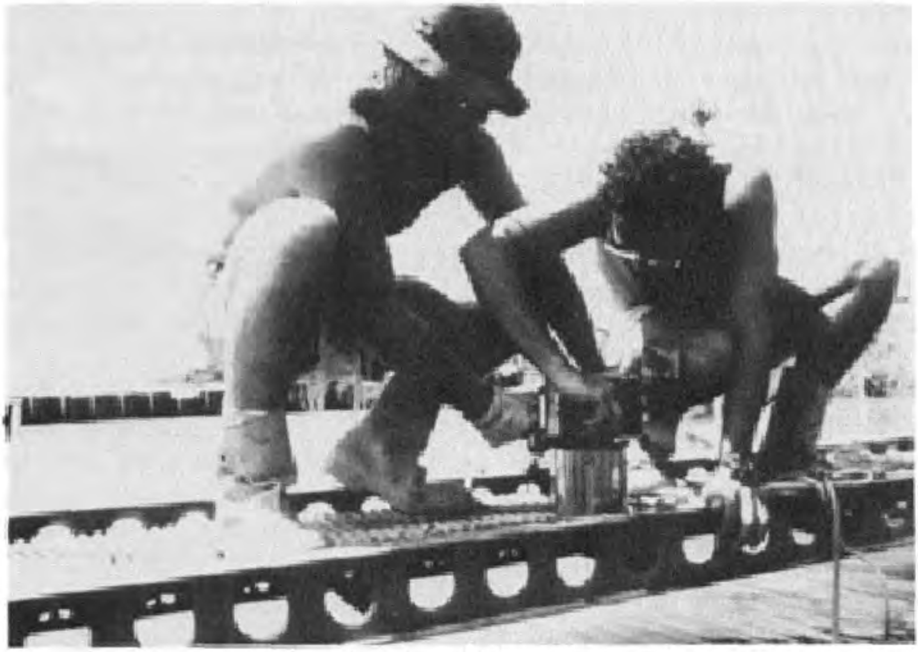


FIGURE 7-37. REMOVING A SOIL SAMPLE.

the soil sample. The bomb was then lifted from the water and the soil sample was placed in a 1-gallon soil sample can. All samples were taken at nodes of the 5-by-5-meter grid system used throughout the project. The soil sample was dried, and preliminary readings of radioactivity were taken with the IMP. The soil samples were then sent to Enewetak for final chemical analysis.

AOMON CRYPT SITE RESTORATION

Site restoration began on 7 May 1979 and was accomplished by Company B, USAE. The backfill material was clean beach sand from Bijire and from the lagoon shore of the land bridge between Bijire and Aomon (Figure 7-38). Prior to backfill, DOE-ERSP ascertained that the beach sand met the desired criteria. As soon as enough backfill had been placed to assure proper support for the 45-ton crane, sheet pile extraction began. After the backfill and sheet pile extraction was complete, the entire Aomon Crypt area was brought to grade and contoured to allow proper drainage toward the lagoon. Approximately 12,000 cubic yards of beach sand were used to restore the site. The operation was completed on 30 May 1979.

FIGURE 7-38. AOMON CRYPT SITE RESTORATION.

Extracted sheet pile was monitored by the FRST, and those sections requiring decontamination were cleaned on site by the USAE. A large portion of the sheet pile (85 percent) was declared reusable and was subsequently moved to Enewetak Camp for future shipment to Johnston Atoll. Unusable sheet pile was treated as debris and dumped at site Bravo.

Upon completion of the excavation and restoration operation, DOE-ERSP again performed an in situ survey with the IMP. Additionally, they used a simplified drill mechanism to obtain a 5-foot depth sample from 26 locations over the backfilled area. These depth samples were homogenized, analyzed, and found to meet the required criteria. As on all other soil removal projects, the work site, beach soil and debris stockpile areas, as well as all routes taken by the trucks in delivering the soil to the water craft were surveyed by the IMP.

AOMON CRYPT TRANSPORTATION PROBLEMS

The movement of all debris from the crypt to Runit was accomplished between 1 February 1979 and 23 May 1979 using 20-ton dump trucks and LARC-LXs. All debris from the Aomon Crypt was treated as contaminated debris and entombed within the Cactus Crater Dome.

Soil transportation from the Aomon Crypt was intended to operate as it did on all other islands; that is, LCM-8s and LCUs would be bulk loaded at the beach-landing areas using 20-ton trucks.

In early 1978 exploratory efforts, a channel was available to the lagoon beach directly opposite the crypt. This channel could be used by LCM-8 craft during moderate tide conditions, and the plan was to transport all excavated soil from the crypt using this site. Unfortunately, Typhoon Alice radically changed this channel, as well as all other beach areas on the Bijire/Aomon island complex. Following Typhoon Alice, the beach was accessible only during tides in excess of 4.5 feet, and this condition became increasingly worse. Three extensive sandbars had been created at distances of approximately 100 feet, 380 feet and 700 feet from the shore. To clear channels for unlimited watercraft use, a sand dredge was designed and built by H&N-PTD. It was anticipated that channels could be cut through these sandbars to allow access by LCM-8 and LCU craft. Soil transportation operations were held in abeyance from late January 1979 until the end of May 1979 when the dredging operation was complete.

The sand dredge (Figure 7-39) consisted of a five-pontoon steel barge with a pump and winch mounted on the superstructure. The pump had a maximum capacity of 70 cubic yards per hour under ideal conditions. In the Enewetak environment, 50 percent of the maximum capacity was

FIGURE 7-39. SAND DREDGE.

anticipated. The construction of the dredge on Enewetak began on 13 March 1979 and was completed on 30 March. On 31 March, the dredge was towed to the Aomon Crypt channel. During buoying operations, the intake tower (ladder) was damaged. Repairs delayed operations until 7 April. During the initial dredging tests, small pieces of coral mixed with the sand and clogged the intake and discharge lines. This necessitated repeated uncoupling of the lines and hand cleaning. On 11 April, adverse sea conditions caused one of the anchor spuds to fracture, causing more delay. The continual clogging of the lines required a modification of the design. On 18 April, two dredge experts were brought to the atoll. At their recommendation, a cage and high-pressure water pump were added to the intake line to jet the sand into suspension. These modifications proved to be satisfactory and, by 1 May, the pump capacity averaged 35 cubic yards of sand per hour.

While the dredge was under construction, the three sandbars off Aomon had increased in size, further complicating the impending dredge operations. It was felt that the sand dredge no longer could clear a channel at this location in time to preclude a work stoppage.

A coastline reconnaissance was conducted by the WBCT and the original site for removal of soil from Aomon appeared to be the most promising (Figure 7-40). The one sandbar at this location started at the shoreline and

FIGURE 7-40. AOMON COASTLINE.

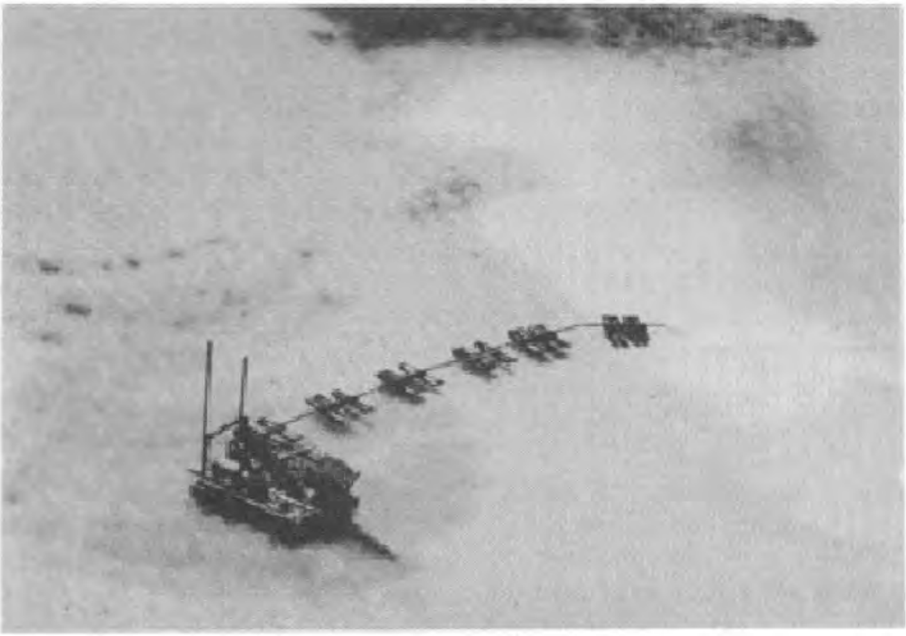


FIGURE 7-41. AOMON SANDBAR DREDGING.

extended approximately 500 feet into the lagoon. The size of this sandbar and the low capacity of the sand dredge made dredging in this area infeasible. After several brainstorming sessions in the JTG, it was decided to use a four-section causeway (360 feet) to bridge the majority of the sandbar from the shore. Under this scheme, dredging was only necessary to clear a portion of the sandbar and to clear a turnaround area for watercraft at the end of the causeway. This dredging operation was successful and was completed on 16 May 1979 (Figure 7-41). H&N operators were assisted in the operation by USNE personnel. Figure 7-42 shows the area cleared with the sand dredge and the road system which was developed for the Aomon Crypt project.

Between the new loading area and the Aomon Crypt stockpile, there was an area of soft sand which could be traversed only by the all-wheel-drive 5-ton dump trucks. The inability to use the larger capacity 20-ton dump trucks would delay soil removal and containment operations. To overcome this problem, the USAE constructed a soil-cement road to the loading site and a turnaround area which allowed the use of the larger capacity vehicles.

A second problem developed in using the new loading location for soil from the Aomon Crypt. The causeway section was not designed to mate with either the LCM-8 or the LCU. The Boat Transportation Team was

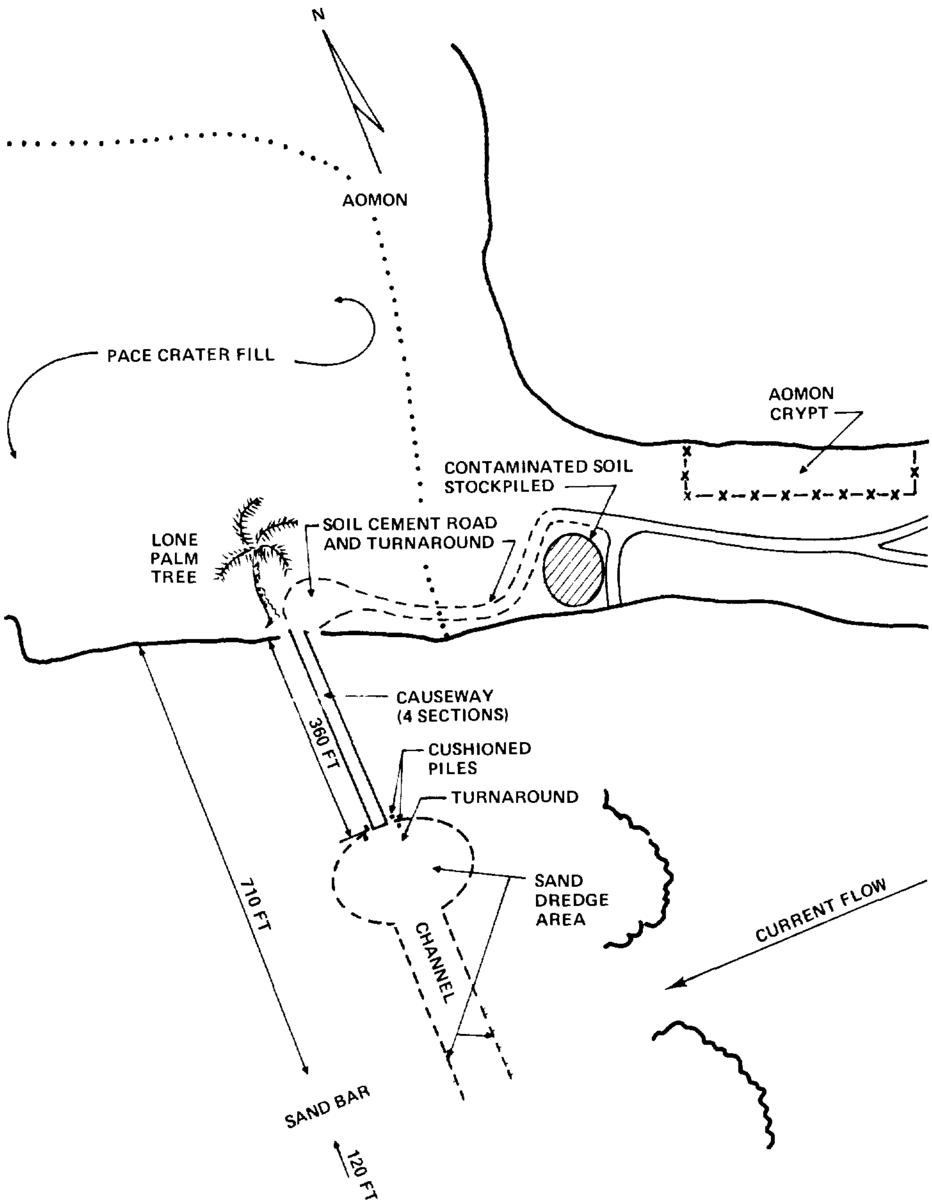


FIGURE 7-42. AREA CLEARED BY SAND DREDGE AND SOIL HAUL ROAD SYSTEM.

able to design a marriage block which allowed the LCU to connect with the seaward end of the causeway. However, the LCM-8 was too low and could not be married to the causeway; so, it was not used for this effort. The causeway section was anchored on the shore with 8-inch H-beams driven into the beach and anchored on the seaward end with two H-beams secured to the causeway to allow it to rise and fall with the tide.

The time constraints imposed by the need to move the soil to Runit in a timely manner to avoid a slow-down in crater-containment operations required expeditious accomplishment of the total effort. This entire transport system was completed on 19 May 1979 and is depicted in Figure 7-43.

The first soil removal using the 360-foot causeway system was scheduled to begin on 19 May. The first 20-ton truck to negotiate the causeway and attempt entry into the LCU met with mishap and lost a radiator as the truck backed onto the LCU from the freefloating causeway. Another modification—the welding of intermediate ramps to the deck of the LCU to allow for proper transition between the causeway and the LCU—was made in less than 24 hours (Figure 7-44). On 20 May, soil transportation was in full operation. The soil transported, using LCUs in the bulk-haul mode, totalled 9,776 cubic yards, and the operation was completed on 19 June 1979.

FIGURE 7-43. AOMON CRYPT SOIL LOADING SYSTEM.

FIGURE 7-44. LCU LOADING WITH RAMP AND CAUSEWAY.

PACE SITE RESTORATION

As a result of the Pacific Cratering Experiment (PACE) and related court actions described in Chapter 2, the JTG was required to restore the PACE test site on Aomon to its 1971 condition. Soil which had been removed from the 19-acre site was to be regraded to the original contours, except that materials used to fill a salt pond to the north of the test area would remain in place, and the pond area would be left filled. All parties agreed that the test bed restoration should take place during the cleanup and rehabilitation of Aomon. This requirement was identified in the EIS but not in Field Command's OPLAN 600-77. Accordingly, the JTG was officially tasked to restore the PACE site in January 1978.[48]

Company B, USAE, began the restoration effort in July 1978. The major earthmoving activity was accomplished using D7 and D8 dozers. While this type of cut-and-fill earthmoving operation would have been more efficiently accomplished by using other earthmoving equipment, such as tractor-scraper combinations, the choice of equipment was restricted by the types available to the cleanup forces on the atoll. The cut-fill estimate by the USAE indicated that soil movement of 101,000 cubic yards would be necessary to complete the restoration operation. The initial estimated date of completion was January 1979. As work progressed, the completion date slipped due to equipment breakdowns and diversions of resources to increased soil removal efforts on the northern islands. However, work did progress smoothly and, in May 1979, the PACE area was restored to the satisfaction of the people, with natural drainage toward the lagoon.[49] A total of 141,000 cubic yards of soil had been relocated. Figures 7-45 and 7-46 show the PACE test site before and after the restoration operation.

During the restoration operation, a number of problems surfaced. The most urgent one was locating enough soil to fill the PACE test area.[50] When the soil had been removed originally, it had been stockpiled north and east of the test site. The northern stockpile was subject to tidal and wave action, and much of it was washed away. In addition, some of the soil had been used to fill the salt pond and was to be left there. Consequently, there was a shortage of soil to fill the test bed. This problem was resolved by using soil from a ridge which extended from the PACE crater toward the Kickapoo GZ location on the ocean side of Aomon and soil washed up along the beach to the west of the crater.

The second problem concerned the radiological condition of the fill soil. It was found through a DOE-ERSP investigation that the PACE test site was uncontaminated. It was necessary to fill the craters with soil having a radiological characterization equal to or less than the criteria for the proposed island usage—residential (40 pCi/g). Upon further DOE-ERSP investigation, the soil (original stockpiles and proposed borrow sites) was found to be suitable for the purpose.

The third problem concerned the northern portion of the test area. This area had to be restored early in the project to provide a haul road from the Kickapoo GZ location to the lagoon beach where LCM-8 and LCU craft were loaded for transport of contaminated soil to Runit. The PACE site restoration in this section was given a high priority and was rapidly completed, allowing the contaminated soil cleanup work to proceed on schedule.

FIELD COMMAND'S DRAFT DOSE ESTIMATE STUDY

While soil cleanup was progressing, Dr. Bramlitt was developing the study requested by the Director, DNA during the 4 May 1978 conference to determine dose from all radionuclides (both transuranics and fission products) as they might affect the EIS Case 3 lifestyle. The draft sudy was completed on 6 July 1978. It indicated that the Case 3 lifestyle might lead to dose rates in excess of guidelines which had been prescribed by the Atomic Energy Commission (AEC); however, the reason had little to do with transuranic elements. Dose from transuranic elements was found to be well within guidelines proposed by the Environment Protection Agency

FIGURE 7-45. PACE TEST SITE - BEFORE RESTORATION.

FIGURE 7-46. PACE TEST SITE - AFTER RESTORATION.

(EPA). Dr. Bramlitt's calculations for transuranic element dose generally agreed with those of the March 1978 LLL study except that Dr. Bramlitt's inhalation dose to bone was well below the LLL estimate. Also, Dr. Bramlitt had concluded that Runit could safely be used for coconut agriculture, in contrast to the assumptions of earlier studies.

The most significant comment received on Dr. Bramlitt's draft dose estimate study was that significant differences were evident between this study and the LLL draft dose estimate of March 1978. In particular, it was recognized that, because of an error in computation, the inhalation dose to bone from transuranic elements in the LLL study should have been a factor of ten lower than was presented.[51] Thus, it was possible that these high LLL dose estimates had been taken into consideration by the DOE Enewetak Advisory Group when it recommended, on 27 April 1978, the reduction of soil transuranic cleanup criteria from 40/100/400 pCi/g to 40/80/160 pCi/g. While DOE had maintained that cleanup to 40/80/160 pCi/g would lead to 13 mrad/year bone does (as compared to the 3 mrad/year EPA guideline), the Bramlitt data indicated that cleanup to 40/100/400 pCi/g would produce only 5 mrad/year bone dose.

Dr. Bramlitt's study indicated that the most significant predicted dose under the Case 3 lifestyle was from fission products ingested as a result of consuming coconuts grown in the northern islands. These radionuclides, primarily strontium and cesium, are by-products of fission reactions such as occur in nuclear explosions. The AEC Task Group had recommended a lifestyle for Enewetak which would limit residence to southern islands but would permit coconut agriculture in the northeast.[52] Utilizing NVO-140 data and methodology, the estimated doses to individuals would be no more than 30 percent of the AEC's recommendations.[53] The methodology used by Dr. Bramlitt differed in several respects from the methodology used in the previous estimates.

First, the Bramlitt estimates considered that each Enewetak person would obtain subsistence coconuts from specific northeast islands, rather than from the entire group of northeast islands. Thus, those persons having agriculture rights limited to a more highly contaminated northeast island were predicted to receive a higher dose than if some of their coconuts came from the lowercontaminated islands. Second, the Bramlitt estimates assumed coconut consumption to be much greater than previously estimated. The increase in consumption was based upon statements from individuals living at Ujelang, and it made allowances for other pathways involving coconuts for which there were no radiological data; e.g., fermented coconut sap, skin lotions, cooking oils, and meat consumed from animals raised on coconuts. Additionally, the recently discovered higher radiation levels among the people of Bikini Atoll were attributed to larger amounts of coconut in their diet than had been previously estimated.[54] Third, the Bramlitt estimates used Bikini data made available after publication of NVO-140. The Bikini data predicted greater uptake of radionuclides by coconuts.

Dr. Bramlitt's draft study recommended: (1) evaluating the impact of not planting coconuts on northeast islands; (2) collecting additional data on fission products at Enewetak while support forces were available; (3) reevaluating the diet assumed for the dri-Enewetak after cleanup; and (4) reassessing the dose for the postcleanup use of Enewetak Atoll.

The Director, DNA was briefed on the dose estimate study on 21 July 1978. The draft study then was distributed on 27 July 1978 to DOE (Headquarters and NV), members of the Enewetak Advisory Group (Bair Committee), and the Armed Forces Radiobiological Research Institute with a request for expeditious review, since the study indicated that changes might be desirable in the cleanup or rehabilitation programs then underway.

Based in part on the new data from measurements of the Bikini people and the recent experience of having to relocate them from Bikini Atoll, DOE recommended to DOI that coconut trees not be planted on the northern islands of Enewetak Atoll. It is possible that Dr. Bramlitt's dose estimate, raising much the same type of question, reinforced the DOE staff thinking. While this staff view had little effect on the DOD cleanup effort, it had the potential to exert a significant effect on the DOI rehabilitation and resettlement effort—and thus upon the overall Enewetak operation. Accordingly, the Director, DNA involved DOD actively in all aspects of the issue.

DNA did not concur with the DOE recommendation and favored planting as planned, based on several arguments. First, DNA believed the actual facts of radionuclide levels in soil, radionuclide uptake in coconuts, usage patterns for coconuts, assimilation of radioactive isotopes in the body, and health effects of this assimilation were all so imperfectly understood that the real degree of risk was quite unclear. Second, there was no immediate risk in planting, as coconut tree maturation time was about 8 years, during which period there would be ample time to reevaluate the risks, if any, adequately. Third, planting could be done now at virtually no increased costs (since it had been planned from the start, and all necessary material and manpower had already been procured), while planting later would cost many millions of dollars (if approval of such a project could ever be gained). Finally, even if—8 years in the future—consumption of coconuts appeared unwise, the coconut tree stands would still be valuable in stabilizing the soil and providing humus for the northern islands. DNA recognized, however, that the issue was one for DOI, not DOD, to decide.

FISSION PRODUCTS DATA BASE SURVEY DECISION

In addition to posing a possible conflict on coconut tree planting, strontium and cesium posed another, more serious problem. The AEC Task Group Report and EIS had considered soil contamination by these fission products to be the principal constraint on the resettlement of the northern islands. On the other hand, the transuranic concentrations were generally low and did not contribute significantly to dose. The transuranic concentrations could be removed by excising a moderate amount of soil on or near the surface. Unlike the transuranics, strontium and cesium were water soluble and had soaked deep into the soil and the lens water of the northern islands. It had been estimated that ten times as much soil (779,000 cubic yards) would have to be excised to remove the hazardous fission products as would be required to remove the transuranics hot spots. It had been estimated that over 239,000 cubic yards of soil would have had to be removed from Enjebi alone to reduce strontium and cesium to residential levels. AEC and DNA had agreed that the cost and potential adverse environmental impacts were prohibitive. The only clearly practical course was to excise the transuranic concentrations and let natural decay reduce the fission products to acceptable levels. Use of the northern islands for residence or subsistence agriculture would be deferred until ongoing experiments indicated the fission products had reached acceptable levels. This policy had been adopted by the U.S. Government, and the people of Enewetak had been so advised by the Director, DNA in 1974.[55]

All of this, however, was based upon a long series of assumptions—assumptions about concentrations, availability, resuspension, uptake, living patterns, diet, body burden, health effects, etc. What had not been realized was that the real decision as to what levels of risk were acceptable could only be made by the dri-Enewetak, not by the U.S. Government. These "risk-benefit analyses" not only required a clear understanding of the uncertainties in the above assumptions, but also had to recognize that the benefits to the dri-Enewetak from certain resettlement options might offset health risks which arbitrary U.S. Government policies would view as unacceptable. As the cleanup and rehabilitation project moved toward completion, issues of health effects came under closer and closer scrutiny. Both the Bramlitt study and the DOE concerns over northern island tree planting acted as catalysts in this process. At the 4 May 1978 decision conference, all organizations—and the representatives for the dri-Enewetak—generally accepted the fact that northern island residence would not be possible in the immediate future.[56]

There was a change in the people's attitude during the next few months. In meetings at Enewetak on 1-6 December 1978, dri-Enjebi members of the Planning Council expressed their desire for Enjebi residence immediately. Their legal counsel, Mr. Mitchell, challenged the fission products standards for residence and coconut planting as being overly conservative and that they may be quite ill-advised for the actual circumstances of the dri-Enewetak. The DOE representative, Mr. Joe Deal, explained that the cleanup criteria were based on Federal radiation protection standards, had been formally approved by AEC/DOE, and were unlikely to be changed.

Faced with what he perceived as general nonresponsiveness to a very real and urgent need of the people, Mr. Mitchell advised that he would employ an independent ad hoc team of experts to advise the people on dose assessment and risk so that the people could decide for themselves how to use the northern islands.

The DOE representative was questioned by the dri-Enewetak regarding the standards, predicted doses, and risks. They did not understand how DOE could oppose northern planting and resettlement now when soil cleanup had barely begun and no final dose estimate could be made until the cleanup and final radiological survey were completed. Mr. Deal reminded the people that all the calculations and predictions before cleanup began showed that the people would exceed the Federal standards if they lived on Enjebi. He advised the people that he believed another study, based on more recent data, could be completed by May 1979; and that, if they desired such a study, he would recommend that one be preapred.[57] The Council members expressed their desire to have the study. From the DNA viewpoint, the new survey proposed to the dri-Enewetak by Mr. Deal was urgently needed and essential to satisfactory completion of the overall project and resettlement.

FISSION PRODUCTS DATA BASE SURVEY

In December 1978, DOE initiated plans for a final dose assessment to serve as the basis for an information document with which the Enewetak people could decide their resettlement options.[58] LLL was requested to complete this final dose assessment. It was to be based on: (1) an extensive survey of the dietary habits of the Enewetak people; and (2) the latest radiological data. The latest data available on fission product levels was the 1972 AEC Radiological Survey (NVO-140). Even though many soil profile samples had been taken since cleanup began, none had been analyzed for fission products due to lack of resources. To develop the best possible assessment, a new survey, focusing on fission products, was essential. On 10 January 1979, DOE-NV recommended to DOE-Headquarters in Germantown, Maryland, that DOE-NV be given a tasking assignment and that DNA be requested to provide JTG and Service element support to obtain soil samples for the fission products analysis.[59] In a letter of 30 January to Director, DNA, Dr. James Liverman, Deputy Assistant Secretary for Environment, DOE, requested an assessment of the support DOD could provide to the survey in the form of soil sampling teams, backhoes and operators, boat transport, and the like.[60] In his 9 February 1979 response, VADM Monroe stated that a meeting would be held on 12 February at Field Command with representatives from agencies involved in the cleanup project and rehabilitation program to definitize the extent of support required and what could actually be provided by DOD elements, keeping in mind that plans for the wrapup of the project, demobilization and retrograde were fairly well advanced.[61]

VADM Monroe, who chaired the conference, opened by describing his perception of the tasking to prepare the atoll for return to the people and his concern for the impact on the Services of undertaking an additional mission with cleanup yet to be completed:

a. The project was an immensely difficult task, undertaken with little certainty about its outcome and dependent on continuation of the remarkable cooperation which had accompanied the efforts to this point.
b. This more detailed survey of the northern islands was essential to decisions that DOI and TTPI must make on planting coconuts on the

northern islands and resettlement of Enjebi, and all agencies were affected. However, basic responsibilities for cleanup (DOD), radiological assessment (DOE), and rehabilitation (DOI) were not changed.

c. As Director, DNA, he had dual responsibilities: (1) to safeguard the Service elements' resources and not let Enewetak become a bottomless pit; and (2) to insure that DOD acquitted itself properly in meeting its commitments.

d. 15 April 1980 was a firm end date; the new DOE task should not impact on that date.

Mr. Bruce Church, DOE-NV, briefed the conferees on the proposed survey. Their plan required collecting six soil samples from each of 1,101 pits approximately 3 feet deep. The pits would be located on 50-meter grids on Ananij (Bruce) and all of the northern islands from Biken (Leroy) clockwise to Billae (Wilma). Samples would be prepared and analyzed for cesium-137 at Enewetak, then shipped to Eberline Instrument Corporation, Albuquerque, for strontium-90 analysis. Any cesium-137 analysis not accomplished at Enewetak would be completed in Albuquerque. The survey was scheduled to begin 1 March 1979 and be completed by 30 September 1979. DOE proposed first priority be given to the soil sample collection on Enjebi, with an objective of completing the sampling by 31 March and completing the analysis by April. Second priority was proposed for the islands Boken to Billae (less Enjebi); and third priority was proposed for the islands Biken to Louj (Daisy). DOD was requested to support the operation with backhoes with operators, boat transportation, base support service on Lojwa, soil sampling personnel, and Radiological Laboratory technicians.

Colonel Robert W. Bauchspies, USA, Commander, JTG, presented briefings on the status of island access by watercraft and an island-by-island evaluation of the proposed workload. After Field Command briefings on the status of cleanup operations and demobilization, the Service representatives discussed their capabilities to support the DOE surveys. VADM Monroe advised DOE that the schedule for on-atoll sample-taking would have to be accelerated. Failure to complete this effort in March and April 1979 would have two adverse effects: (1) it would interfere with demobilization actions scheduled for that summer and fall, and (2) it would delay the fission product data to such a degree that DOI's decisions on coconut planting could not be made in time for the planting to be accomplished in conjunction with cleanup and rehabilitation efforts. Discussions led to the following resolutions:

a. Priorities. Enjebi and the six northern agricultural islands would be surveyed simultaneously, using two teams on Enjebi and one for the six northern islands scheduled for coconut tree planting: Alembel

(Vera), Lojwa, Aomon, Bijire, Aej (Olive), and Ananij. (Ananij was included even though it lies in the southeast quadrant.) Data on these islands was required for decisions to be made in May 1979 by DOI and the dri-Enewetak. Sampling on islands which required access by LARC—Bokoluo (Alice), Bokombako (Belle), Kirunu (Clara), Louj, Bokinwotme (Edna), and Boken—would be completed before the September 1979 Navy Opportune Sealift (OPLIFT), which would retrograde the three serviceable LARCs. Detailed schedules would be accomplished on atoll within these parameters.

b. Base Camp Support. Billeting and messing support for the Enjebi sampling teams would be provided by the DOE research vessel, Liktanur II. Other base camp support for sampling parties would be provided from the Lojwa Camp.
c. Intra-atoll Transportation. Intra-atoll transportation, other than that provided by the Liktanur II and LARCs, would be provided by the USNE. Three LARCs would be retained until the September 1979 OPLIFT for transportation of equipment to limited access islands.
d. Equipment. DOE would provide two leased backhoes to dig soil sample pits and would transport them and repair parts to Enewetak. The USAE would furnish two backhoes with operators, plus maintenance and operators for the DOE backhoes.
e. Personnel. In addition to backhoe operators, the USAE would furnish two rodmen for surveying parties. The U.S. Navy would review Rad Lab personnel assignments with a view to retaining all personnel until their normal tour completion dates in order to provide added Rad Lab support. The U.S. Air Force would replace the in situ van operator scheduled to depart in March 1979 and would replace seven Rad Lab Team members, whose tours expired that spring, to provide continued support through the fall. H&N would furnish surveyors—in addition to the two Army rodmen—as necessary.
f. Radiation Laboratory. DOE would extend operation of the Rad Lab from the scheduled demobilization date of 30 June 1979 to 30 September 1979, and would provide additional technicians for the survey.

DOE advised that the soil profile samples would be analyzed for transuranics as well as fission products. Based on Field Command and Service representatives' expressed concern, it was decided that, if these profiles revealed additional subsurface transuranic concentrations which the final in situ surveys had not detected, such concentrations which exceeded island use criteria would be excised.[62,63]

On 22 February 1979, an H&N survey team, providing their own small boat support, began resurveying and restaking Billae on the 50-meter grid which had been established for the 1977 transuranic characterization survey. Additional DOE, LLL, and contractor personnel arrived on the atoll during the next 2 weeks and, with backhoe support by the USAE, began collecting soil samples. Using procedures prescribed by LLL, six vertical profile soil samples of about 1,000 cubic centimeters each were taken from a backhoe trench wall at each grid point, at intervals from the surface to a depth of 60 centimeters, the principal root zone of food plants. Initial dose estimates were to be based on samples taken at 100-meter grid intervals. If additional information became necessary, the other available soil samples from the 50-meter grid would be analyzed.[64]

Where subsurface transuranic contamination was discovered, samples were taken on even smaller grids (25, 12.5, 6.25 meters) to define precisely the area for additional soil removal. Five areas of previously unknown subsurface transuranic concentrations which exceeded Condition D (160 pCi/g over one-sixteenth hectare) were found on Boken and one on Lujor. These were subsequently removed. The Fission Products Data Base Survey sampling effort was given high priority and completed in less than 2 months, compared to the expected 6 months. Some results of the DOE Fission Products Data Base Survey are compared with results of the 1972 AEC radiological survey at Figure 7-47.[65]

	Sr-90		Cs-137	
	1972	1979	1972	1979
Enjebi (Janet)	44	23.7	16	13 7
Aej (Olive)	4.5	1.5	0.16	3.8
Lujor (Pearl)	17		7.6	
Aomon (Sally)	8.4	3.1	3.0	1 9
Bijire (Tilda)	8.7	4.2	1.0	3.1
Lojwa (Ursula)	6.8	2.4	1.7	1.1
Alembel (Vera)	6.3	0.4	2.0	2.8
Billae (Wilma)	3.3	0.2	1.3	0.8

NOTE: Mean average pCi/g in top 15 cm per 1972 Enewetak Radiological Survey by AEC and 1979 Fission Products Data Base Survey by DOE.

FIGURE 7-47. COMPARISON OF FISSION PRODUCTS SOIL CONCENTRATIONS 1972 - 1979.

LUJOR SOIL CLEANUP

The final island to undergo soil cleanup, exclusive of Runit, was Lujor. It had been the site of the Inca shot during Operation Redwing. Inca produced heavy local contamination due, in part, to involvement of a large amount of pierced steel planking placed at the site. The 1972 Radiological Survey identified a "hot spot" some distance from the Inca GZ which had plutonium levels as high as 530 pCi/g and strontium-90 levels in the 35 to 140 pCi/g range[66] (Figure 7-48).

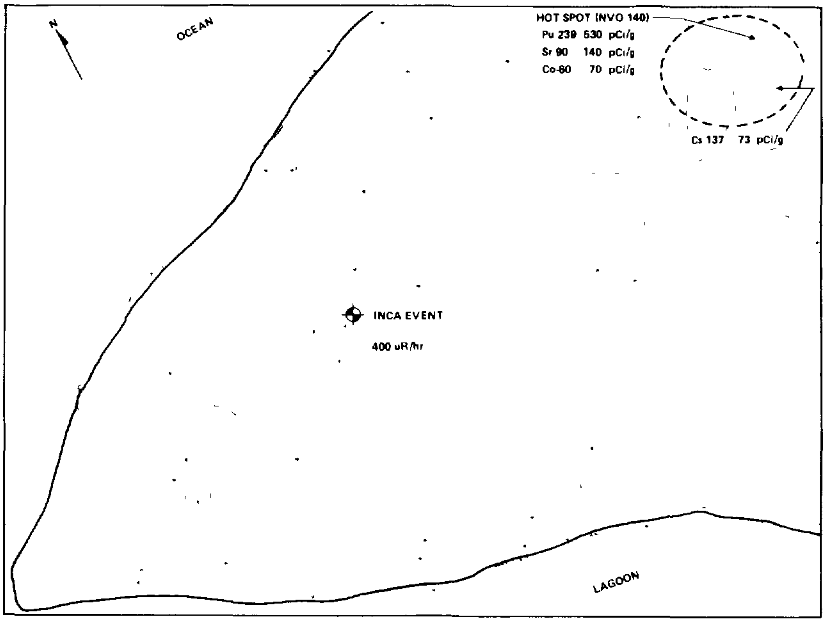


FIGURE 7-48. SITE LUJOR (PEARL) SHOWING LOCATION INCA EVENT AND "HOT SPOT."

In the 1972 survey, it was estimated that soil cleanup on Lujor would involve only 600 cubic yards of soil over 40 pCi/g. However, based on the 1977-78 characterization by DOE-ERSP, the estimate for soil cleanup to agricultural levels (80 pCi/g) presented at the 4 May 1978 conference was 24,700 cubic yards, adjusted by the Treat Factor to 49,400 cubic yards. No decision on Lujor soil cleanup was made at that conference. It was held in abeyance until actual data could be obtained on alternative cleanup techniques and on cleanup rates of the higher priority islands (Aomon, Enjebi, Boken, etc.). The scope of effort changed markedly when Lujor was re-IMPed after debris cleanup. Contamination levels had been reduced below 160 pCi/g. Much of the contamination apparently had been in the debris, such as the metal matting, or in the soil which had been windrowed with the brush in devegetating the area. No further action was taken on Lujor until February 1979.

At the 12 February 1979 meeting on the Fission Products Data Base Survey, conferees were briefed that soil excision was almost 90 days ahead of schedule, and crater containment was 45 to 60 days ahead of schedule. In light of the advantageous situation, consideration was given to accelerating the cleanup of Runit. However, Mr. Thomas Jeffers, head of DNA's Logistics Directorate, raised the possibility of using the available time to undertake Lujor soil cleanup and thereby reduce the contamination to a level which would meet the criteria for agriculture use. VADM Monroe directed the JTG to develop plans for the options of cleanup of both Lujor and Runit, or Runit along.[67]

The JTG staff and Service element commanders reacted somewhat pessimistically to the prospect of a Lujor soil cleanup. As had been discovered during debris cleanup on the island, the soil was so fine that it could only be traversed by tracked or four-wheel drive vehicles. Boat access was extremely difficult and tide constrained. Lujor and Aej, the next island north, formed a funnel, with the wide end toward the ocean and the narrow end exiting to the lagoon at the only possible access channel to Lujor (Figure 7-49). The channel itself was crooked and dotted

FIGURE 7-49. LUJOR/AEJ ACCESS CHANNEL.

with coral pinnacles, the landing area was a narrow point of sand, and the current through the funnel was extremely strong. DOE-ERSP re-IMPed the island and estimated that 24,500 cubic yards of soil, much of it in the brush windrows, was over 80 pCi/g.

The consensus on Enewetak was that Lujor could not be cleaned if the target date for completing the crater cap were to be met.[68] However, the JTG Commander, Western Command Project Officer, and the new Director of Enewetak Operations at Field Command (Colonel Robert L. Peters, USA, who had replaced COL Treat in November 1978) believed it was possible to clean Lujor, as well as Runit.[69] Review of the amount of soil remaining to be encrypted from Boken, Enjebi, and Aomon determined that sufficient volumn remained in the Cactus Crater dome to accommodate all of that soil plus that to be removed from Lujor without exceeding a dome height of 25 feet. Even then, up to 12,000 cubic yards from the highest areas of contamination on Runit; i.e., Fig-Quince still could be accommodated. The alternative was to devote all resources to cleanup of Runit, to do no cleanup of Lujor, and to risk—after moving significant amounts of soil and excavating in depth—no change in the overall island status for Runit.

Favorable aspects of the Lujor proposal included: (1) the Lujor effort would have a significant impact since its status would be changed to the benefit of the dri-Enewetak; (2) the final status of Lujor would meet the original agreed position/condition in the EIS and Master Plan; (3) excavated soil could be transported and accommodated in the Cactus Crater as designed within current time schedules; and (4) intensive effort could be applied simultaneously to both Runit (to keep the soil-cement operation in high gear) and Lujor, to the benefit of the total project. Despite the expected problems with access to Lujor, soil trafficability, additional bulk-haul boat configuration requirements, and increased strain on already over-taxed and worn equipment, the Director, DNA decided at a March 1979 meeting to attempt the cleanup of Lujor soil over 80 pCi/g and, concurrently, to clean Runit using the remaining resources.[70] Within a week, the USNE's WBCT and EOD teams began operations to widen and deepen the channel. Using thousands of pounds of explosives, the channel eventually was altered to accommodate both LCM-8 and LCU craft. Channel improvement operations were completed in mid-April 1979.

Initial attempts to bring LCM-8s into shore were hazardous, but successful. The strong tradewinds, in combination with the swift current in the channel, demanded the highest skills on the part of the boat coxswains and crews. The difficulties experienced by the LCM-8s indicated that even greater hazards would be experienced by the larger LCU craft. Under close supervision, and using the best boat operators available, an LCU, using full power, negotiated the channel with extreme difficulty after four separate attempts. The wind, the current, and the multiple turns made the approach virtually impossible. Once the LCU reached the beach area, a 90-degree turn was required under full power to beach the craft. The exit from the beach area also was hazardous in that a full reversal of engine thrust was required. On the trial run, despite best efforts, the LCU was forced onto a coral shelf when attempting to exit the channel. It was clearly obvious that the bulk-haul LCUs could not be used without major damage to the craft.

From these trials, it was decided that all soil movement from Lujor would be accomplished using bulk-haul LCM-8s only. Based on this decision, and the constraint to deliver all soil to Runit in sufficient time to complete soil-cement operations, the conversion of three additional LCM-8s was requested and approved. All of the training and experience gained in soil cleanup on other islands paid off on Lujor. Soil excision began on 7 April 1979 in the areas indicated in Figure 7-50. The noncommissioned officer in charge of soil removal and his men removed 6-inch layers of the fine soil with the skill of surgeons. Cross contamination of layers was reduced to a minimum by their careful efforts and by a highly effective worksite layout. By removing the windrows and other high levels of contamination first, the halo effect was reduced and the amount of adjacent soil requiring removal was lessened. As a result of these actions, soil cleanup to agriculture levels was achieved by removing only 14,513 cubic yards of surface soil as opposed to the 24,500 cubic yards estimate, plus 416 cubic yards of subsurface contamination discovered during the Fission Products Data Base Survey.

The Army provided an additional 5-cubic-yard bucket loader for the Lujor operation, vastly improving soil removal and bulk-haul efficiency. Army equipment operators, Navy boat crews, and Air Force FRST members worked from first light until dusk to accomplish the mission, and they set new soil transport records almost daily. They increased soil removal rates from some 1,500 cubic yards per week to over 4,000 cubic yards, reaching a peak of 4,288 cubic yards during the week of 26 May-1 June 1979.

Crater containment had fallen 6 weeks behind schedule due to lack of soil. The increased soil transport efforts, plus equally outstanding efforts by the crater containment crews once they were provided working material, soon put the operation back on schedule.

The initial soil cleanup of Lujor was completed on 8 June 1979. A second cleanup of subsurface contamination discovered by the fission products survey was completed on 7-8 July 1979.[71] Figures 7-51 and 7-52 show the island before and after cleanup. The island was certified by the DOE-ERSP as having no half-hectare averaging greater than 63 pCi/g of surface contamination and less than 160 pCi/g subsurface, qualifying it for

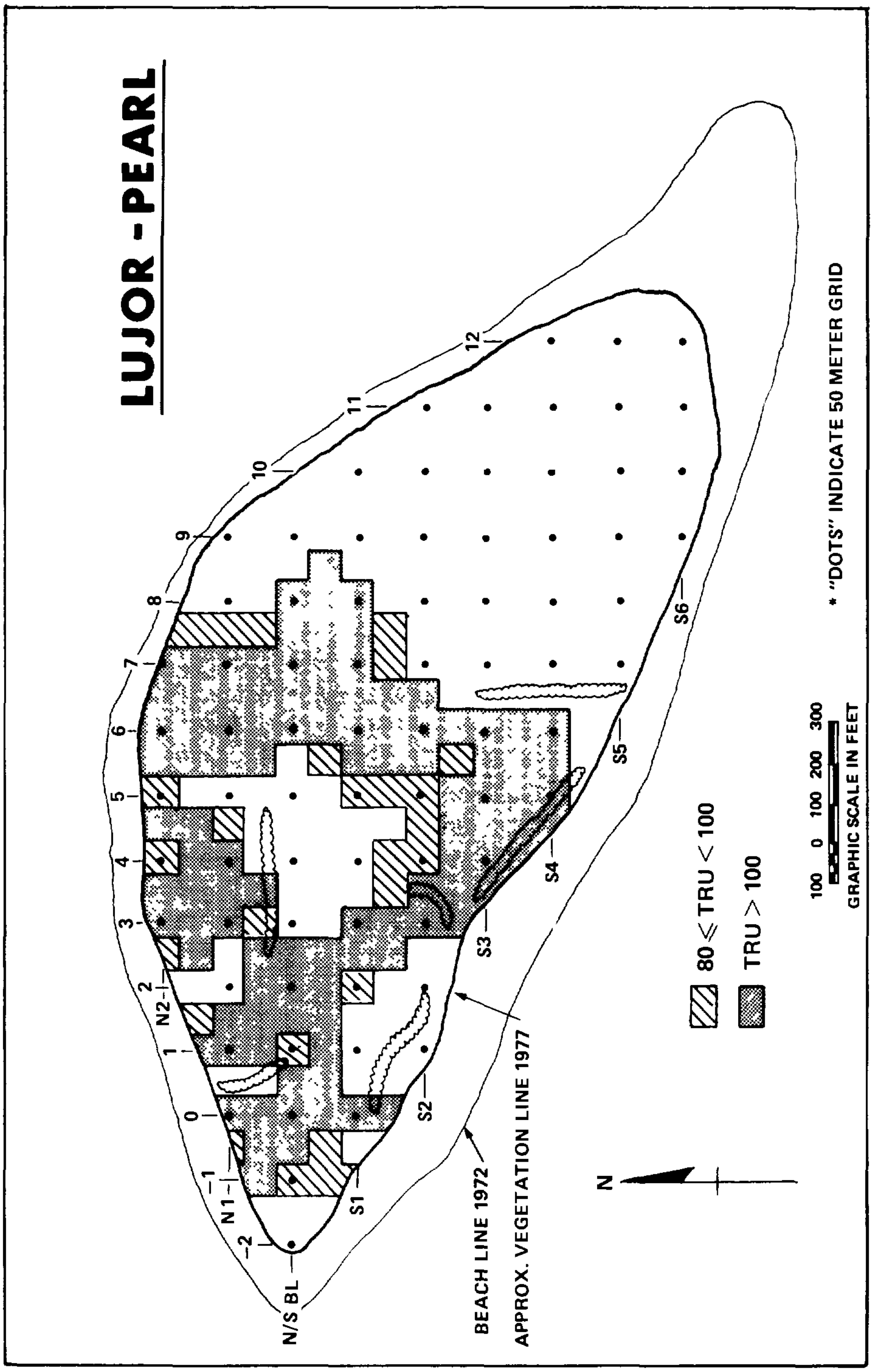


FIGURE 7-50. LUJOR SOIL CLEANUP AREAS.

FIGURE 7-51. LUJOR BEFORE CLEANUP.

FIGURE 7-52. LUJOR AFTER CLEANUP.

agricultural use. The only soil cleanup work remaining was cleanup and containment of soil on Runit, described in the following chapter.

In summarizing the island soil cleanup, in addition to islands where soil cleanup operations were actually conducted, all other islands on the atoll were characterized, either by soil survey or in situ, or both. The characterization indicated that each island would qualify, as a minimum, for its planned use—without cleanup. The table at Figure 7-53 displays the final DOE-ERSP characterization of the islands requiring soil cleanup, exclusive of Runit, as well as all islands meeting the required criteria without cleanup.[72]

Island Name	Code Name	Planned Use Condition[1]	Final Soil Survey (Isle Avg) (pCi/g)	Final Qualification Condition[1]
Taiwel	(Percy)	A	6	C
Bokenelab	(Mary)	A	19	C
Mary's Daughter	(Fern)	A	139[2]	A
Lujor[6]	(Pearl)	B	63[3]	B
Pearl's Daughter	(Gwen)	A	123	A
Aej	(Olive)	B	54[2]	B
Billae	(Wilma)	A	3	C
Alembel	(Vera)	B	7	C
Elle	(Nancy)	A	52[2]	B
Boken[6]	(Irene)	A	80[2]	B
Bokoluo	(Alice)	A	140[2]	A
Bokombako	(Belle)	A	95	A
Mijikadrek	(Kate)	A	20	C
Kidrinen	(Lucy)	A	77[2]	B
Louj	(Daisy)	A	43	B
Bokinwotme	(Edna)	A	33	C
Edna's Daughter	[4]	A	103	A
Kirunu	(Clara)	A	65[2]	B
Eleleron	(Ruby)	A	8	C
Aomon[6]	(Sally)	B	7 5	C
Sally's Child	(Zoe)	A	21	C
Bijire	(Tilda)	B	7	C
Enjebi[6]	(Janet)	C	20	C
Runit	(Yvonne)	(Covered in Chapter 8)		
Boko	(Sam)	A	0 3	C
Munjor	(Tom)	A	0 3	C
Inedral	(Uriah)	A	0 2	C
[5]	(Van)	A	0 2	C
Jinedrol	(Alvin)	A	0 3	C
Ananij	(Bruce)	B	0 2	C
Jinimi	(Clyde)	A	0 15	C
Japtan	(David)	C	0 2	C
Jedrol	(Rex)	A	0 2	C
Biken	(Leroy)	A	2 5	C
Kidrenen	(Keith)	A	0 3	C
Boken	(Irwin)	A	0 4	C
Ribewon	(James)	A	0 2	C
Mut	(Henry)	A	0 4	C
Ikuren	(Glenn)	A	0 2	C
Bokandretok	(Walt)	A	0 2	C
Medren[6]	(Elmer)	C	0 3	C
Enewetak	(Fred)	C	0 5	C
Lojwa	(Ursula)	B	1 9	C

NOTES
1 Conditions A Food gathering, B Agriculture, C Residence
2 ¼ hectare average
3 ½ hectare average
4 No code name
5 No Marshallese name
6 Soil removal operations actually conducted on these islands

FIGURE 7-53. FINAL DOE-ERSP CONFIGURATION.

CHAPTER 8

RUNIT (YVONNE) CLEANUP AND CRATER CONTAINMENT

PRECLEANUP CONDITIONS

Runit is the fifth largest island in the atoll, containing approximately 91 acres. The island and adjoining reef were used for nine nuclear events, and nine more were detonated on barges in the nearby lagoon (see Figure 8-1).[1] Cleanup of Runit, like other islands with several ground zeros, was complicated by actions taken to prepare for and clean up after some of the events.

Contamination from the Zebra event of Operation Sandstone on 15 May 1948 was pushed into the Zebra Crater and covered with clean soil in 1951 to prepare for the Dog event of Operation Greenhouse. After the Blackfoot event of Operation Redwing in 1956, the tower area was scraped to reduce radiation to a safe level for personnel reentry. During the same operation, the Erie event produced heavy contamination with much of the test device and tower debris remaining in the ground zero (GZ) area. Experimental specimens, propelled by the Erie explosion, were blown as deep as 5 feet into the earth and as far as 300 feet west of the GZ. Their recovery required moving a reported 100,000 cubic yards of earth from depths up to 5 feet and spreading it in 2-inch layers to be searched. In 1957, this soil was returned to the excision area which was then leveled. In the Quince event of Operation Hardtack I in 1958, only the high explosive component was detonated, scattering plutonium over a large area. To prepare for the Fig event scheduled 12 days later, 3 to 5 inches of contaminated soil were removed from a 60-foot square around the Quince GZ and disposed of in the lagoon. The Fig event itself was a very low order nuclear detonation. It left a highly contaminated crater which was filled, leveled, and covered with clean soil.[2] These actions left the same marble-cake effect of swirling layers of clean and contaminated soil on Runit as was caused (to a lesser degree) by similar actions on Aomon (Sally) and Enjebi (Janet) after several nuclear tests. However, the Fig and Quince shots left numerous plutonium contaminated fragments of centimeter-range dimensions in addition to fallout contamination. It was these fragments which led to the quarantine of Runit described in Chapter 2.

For the Lacrosse event of Operation Redwing in 1956, massive amounts of soil from Runit were used to construct an island and connecting causeway on the northern reef. These were vaporized or blown away in the detonation, leaving a crater roughly 55 feet deep and 400 feet in diameter.

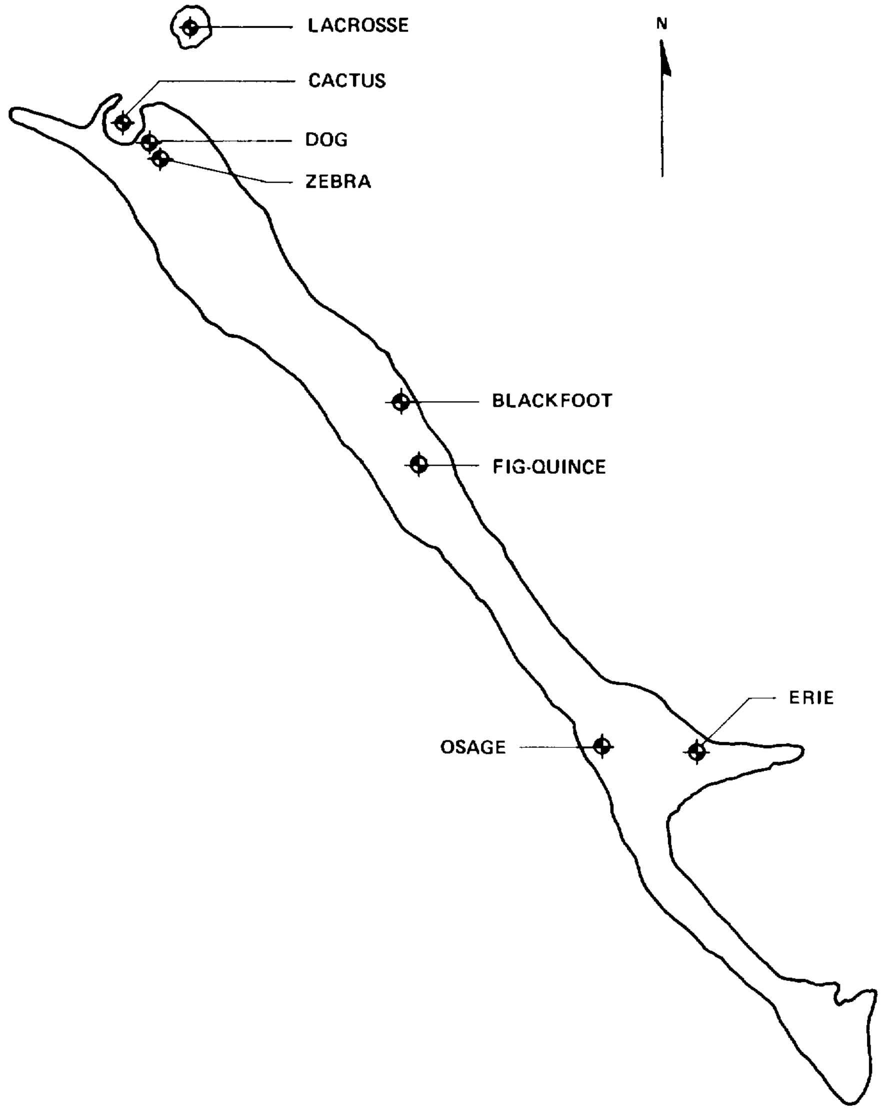


FIGURE 8-1. RUNIT GROUND ZEROS.

Another large volume of soil was bulldozed onto the reef in 1958 to provide a site for the Cactus event of Operation Hardtack I. The Cactus shot left a crater approximately 37 feet deep and 346 feet in diameter (Figure 8-2).

The northern half of Runit was significantly contaminated; however, only one shot, Erie, was detonated on the southern part of the island. South Runit—the area south of Station 1310, a large bunker in the center of the island (Figure 8-3)—was used primarily as a base camp, with an airstrip, boat landings, and other support facilities. By the time cleanup began, vines and grass covered most of the island, bordered by heavy brush (See Figure 8-4).[3] In the absence of human activity, Runit had become the roosting and nesting ground for one of the largest tern colonies on the atoll, numbering thousands of birds.

There were two reported burial sites on Runit: one near Station 1310 where a jar of plutonium-contaminated sand was buried, and the other a small, fenced area where another jar of contaminated sand, a box of contaminated material, and two small discs were believed to be buried. Other hazardous items on Runit included several bunkers, nine derelict landing craft which had been beached for shore protection (Figure 8-5), contaminated concrete blocks and slabs, wooden towers, and large quantities of contaminated metal scrap. An estimated 4,064 cubic yards of contaminated debris were to be removed from Runit, 56 percent of all the contaminated debris identified in the Environmental Impact Statement (EIS). An additional 6,155 cubic yards of noncontaminated debris were identified for removal in the EIS.[4]

Runit was one of four islands identified in the EIS (Vol. I, Table 5-4) for cleanup of plutonium concentrations over 400 pico curies per gram (pCi/g). It was estimated that there were less than 1,500 cubic yards of soil on the surface with such concentrations.[5] The EIS estimate of soil volumes to be removed to reduce the concentrations on Runit to less than 40 pCi/g was 63,725 cubic yards. This was in general agreement with the Department of Energy-Enewetak Radiological Support Project (DOE-ERSP) estimates in April 1978.[6] The desired use of Runit by the dri-Enewetak, in the first edition of the Master Plan, was for agriculture, to restore the large groves of coconuts it had once borne. Levels of strontium and cesium, the principal radiological constraints on agriculture throughout the atoll, were considerably lower on Runit than on Enjebi or other northern islands proposed for agriculture. It was estimated that 20,000 cubic yards of soil would have to be removed to bring Runit to below 80 pCi/g, the Bair Committee guideline for agriculture, or 14,500 cubic yards to reduce concentrations below 160 pCi/g and qualify Runit for visitation and food-gathering use.[7] The material was to be placed in the craters where it would not be readily available to man and where it could

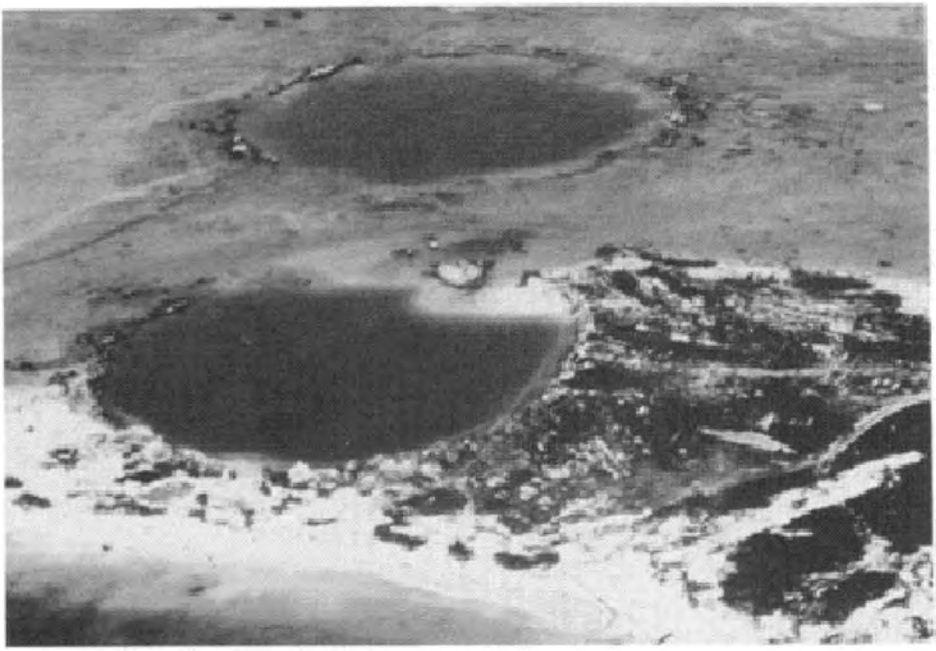


FIGURE 8-2. CACTUS AND LACROSSE CRATERS ON RUNIT.

FIGURE 8-3. STATION 1310, RUNIT.

FIGURE 8-4. RUNIT VEGETATION.

FIGURE 8-5. DERELICT LANDING CRAFT.

be monitored and retrieved if a means of permanent disposal was perfected.

CRATER CONTAINMENT DESIGN

After much consideration, the Director, Defense Nuclear Agency (DNA) decided in early 1975 that the only generally acceptable method for disposing of contaminated debris and soil from the Enewetak Cleanup Project was by mixing it with cement and placing it in recoverable storage in Lacrosse and, if necessary, Cactus craters. Events leading to this decision are described in Chapter 2. One of the key factors in the decision was a feasibility study prepared by the Pacific Ocean Division (POD) of the Corps of Engineers in March 1975. The study considered several options for crater containment, including: precast soil-cement blocks; lining and dewatering the craters and placing soil-cement slurry in them; or pumping the slurry through pipe to the bottom of the crater, keeping the discharge end of the pipe at least 1 foot beneath the top of the previously poured slurry to form a monolithic mass. The last option, called the "tremie" method, was recommended by POD not only because it was the fastest and least expensive, but because the other methods would achieve no significantly higher degree of protection. Properly accomplished, the tremie method would stabilize and fix the contaminated material in place as well as the other methods.[8,9]

In August 1976, once funds had been approved for the project, DNA requested that POD develop a design for crater containment using the tremie method.[10] The initial design was developed based on Field Command's Concept Plan 1-76 (CONPLAN 1-76) and on criteria provided by engineers from Field Command's Albuquerque and Honolulu offices in a series of conferences with POD.[11,12,13] The design was revised based on subsequent conferences with representatives from Field Command and the Military Service elements.[14] Development of the design was complicated by several factors.

In the EIS, it was estimated that Case 3 cleanup would require containment of 79,000 cubic yards of soil, to bring the plutonium concentrations over 400 pCi/g to below 40 pCi/g on Aomon, Lujor and Runit, and 7,262 cubic yards of contaminated debris. The Field Command CONPLAN 1-76 estimate for soil over 40 pCi/g, including Enjebi, was 125,000 cubic yards. Field Command asked POD to develop a design to contain up to 200,000 cubic yards as a worst case and to minimize costs by using only one of the two craters.[15] This required a decision on which crater to use.

POD was provided geological data from the Pacific Cratering Experiment (PACE) and the Exploratory Project on Enewetak (EXPOE) projects. The geology of the northern tip of Runit is a complex mosaic with great variability in both horizontal and vertical composition, cementation, and structure. Added to its natural geologic complexity are the blast and shock effects of three lowyield nuclear detonations near the Cactus Crater and of the Lacrosse detonation. A review of Lacrosse Crater's geology revealed that it is surrounded by a well-cemented reef plate, which contains some large radial and tangential fractures. The crater is rimmed by an 8- to 10-foot thick rim of well-cemented back-reef sand and gravel whose physical properties are like that of beach rock.[16]

Cactus Crater's geology is more complicated than that of Lacrosse Crater. It is located between the backreef and lagoon environments in what was a man-made extension of the island on the lagoon side of the reef. Much of the underlying rock was severely fractured by three nuclear detonations (Zebra, Dog, Cactus). The beachrock on the northwestern portion clockwise to the southeastern portion of the crater is 3 to 6 feet thick, providing a satisfactory base for construction. Beachrock is limited on the lagoon side of the crater and what there is on the island side is fractured. The northwestern tip of Runit may be only a very recent transient sandbar and is undergoing rapid erosion back to the original island shape. The original island shape can be defined by the beachrock as it is elsewhere on the atoll. This geology caused some doubt as to the survivability of a containment structure placed in Cactus Crater. Would its contents be eroded away and undercut by tidal action on the ground water from the lagoon side? Could this be prevented by creating artificial beachrock or by grouting the existing, highly fractured rock? Could it exceed 10 feet in height (the maximum height—equilibrium point—to which typhoon waves will pile up sand and gravel) and yet survive the waves of severe typhoons (1 every 50 to 100 years frequency)?[17]

Cactus Crater is on the lagoon edge of the reef plate which serves as the foundation for all Enewetak islands, more on a sandbar than on solid rock, while Lacrosse Crater is centered within the reef plate. Yet, it was clear that Cactus was more accessible and could be used for containment much more economically and efficiently. There was a question of cost versus benefit, as well as of the real necessity for absolute integrity of the structure over millenia. Considering all factors, including permanent versus interim storage. Cactus Crater was selected.[18,19]

To provide storage options up to 200,000 cubic yards of soil plus over 7,000 cubic yards of debris, Field Command proposed a cylindrical structure with walls not to exceed 9 feet in height.[20] POD's proposal was a domed structure, not over 30 feet high, to be elongated as necessary based on the total volume of material to be contained. The 30-foot limit was based on construction considerations and not on environmental, geological, or radiological considerations. Up to that height, the cap structure would remain basically a series of slabs with no vertical walls; i.e., a paving project which could be accomplished with a minimum of design, equipment, and skill. POD estimated the volume of Cactus Crater up to a height of 3 feet above the reef, where tremie operations would no longer be required, as 51,917 cubic yards.[21] POD estimated that this would contain 29,870 cubic yards of loose contaminated soil mixed in a slurry. Additional soil would be placed on top of the slurry to which cement would be mixed by a disc-harrow, water would be applied, and the mixture compacted. Depending on the amount of material added in this soil-cement operation, the volume of the dome would be increased, first by increasing the diameter of the keywall up to 430 feet and the dome height up to 30 feet, then by extending the dome inland as far as necessary. The POD design would accommodate up to the 200,000-cubic-yard worst case identified by Field Command and could accommodate more by simply increasing the extension (Figures 8-6, 8-7).[22]

The POD designers assumed that sufficient contaminated soil would be stockpiled before the tremie operation began so that it could proceed efficiently and that, by the time the tremie operation was completed, an estimate of the contaminated soil remaining could be made accurately enough that the shape and size of the dome could be determined.[23]

To prevent scouring and undermining of the container by wave action, POD designed a keywall to be constructed completely around the contaminated material. The keywall was to be keyed 1 foot into the reef bedrock, where firm reef existed, and embedded to a depth of 8 feet below the top of the adjacent surface in areas where the reef was fractured or where no reef existed (Figure 8-8).[24] The keywall would not prevent migration of fine material from the crater bottom through ground water action in the fractured rock and areas where no beach rock existed.

Surveys in 1974 and 1975 indicated that a thick layer of material on the crater bottoms and in the fractures was more contaminated than the sediment covering it Furthermore, this contamination was leaking into the lagoon from Cactus Crater.[25,26] There was no EIS requirement to clean out the crater and fractures nor did there appear to be a practical means of accomplishing the task. DNA had advised POD that leakproof containment was not required or intended.[27] POD believed that the tremie method would fix the material added during the cleanup project in place and prevent washouts through the Cactus Crater bottom if the slurry was placed properly. However, POD was concerned that the troop engineers had little experience with tremie placement of slurry and recommended that Field Command engage a qualified contractor to oversee and provide

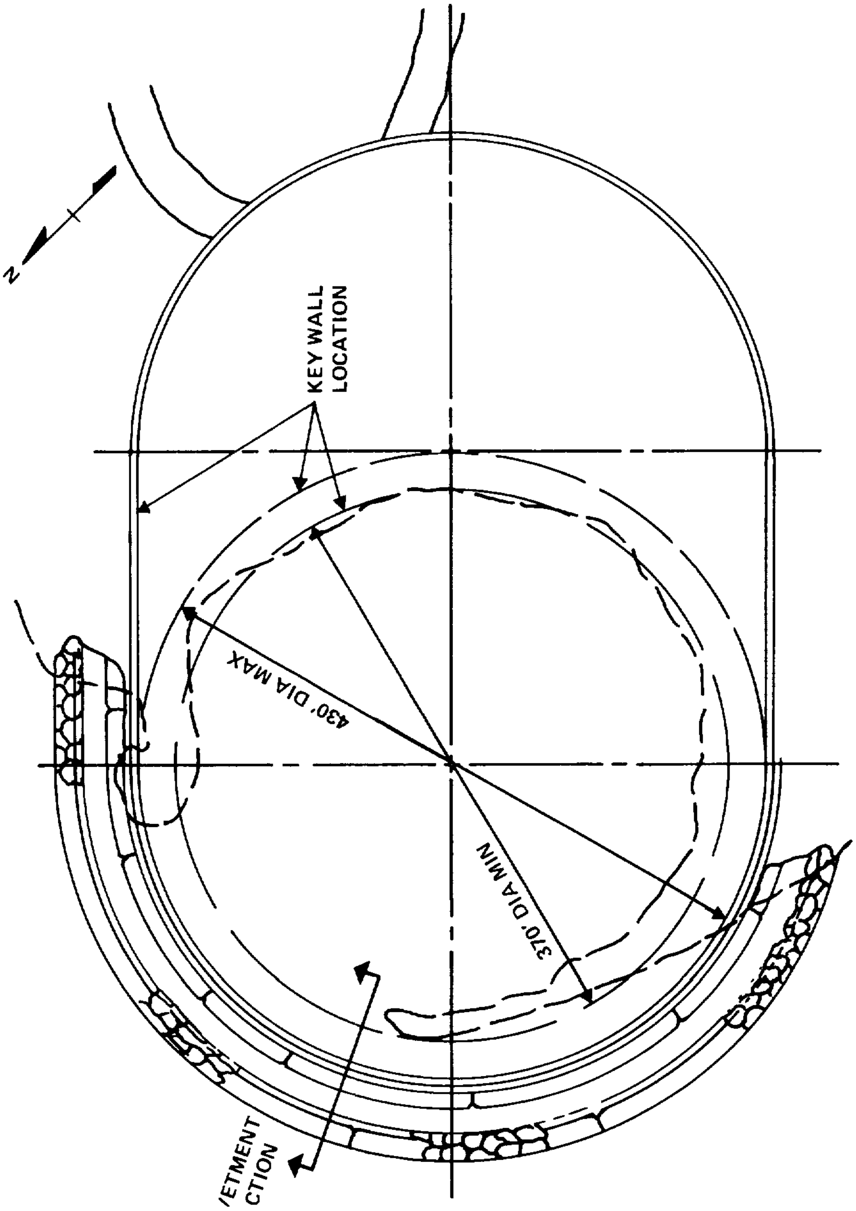
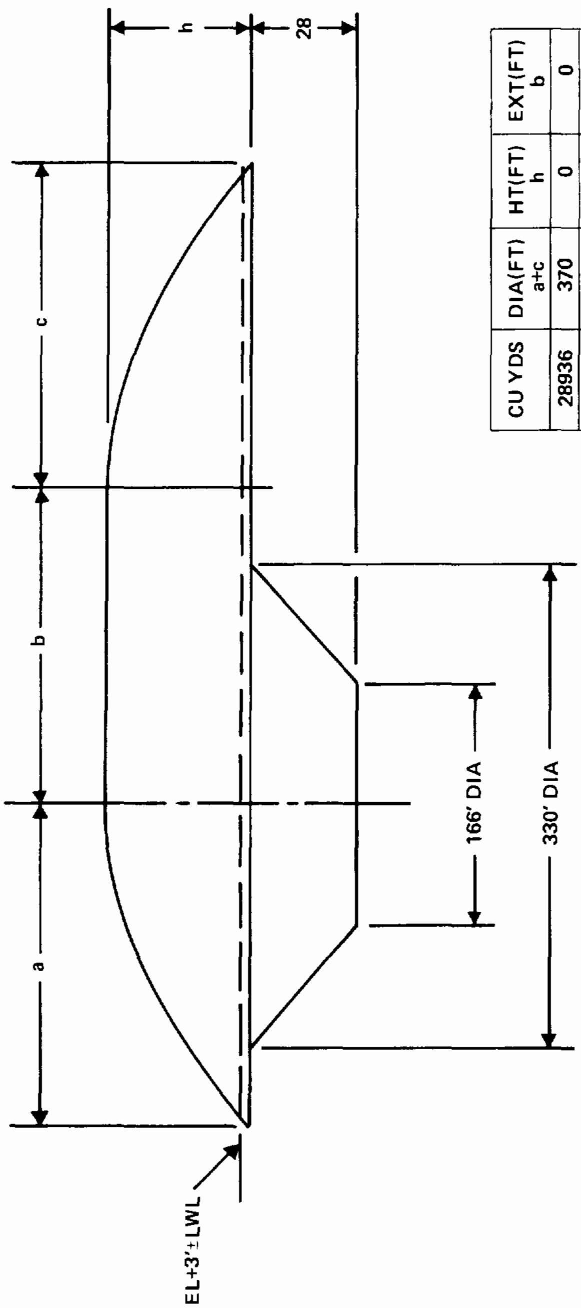


FIGURE 8-6. CACTUS CRATER CONTAINER DESIGN - OVERHEAD.



CU YDS	DIA(FT) a+c	HT(FT) h	EXT(FT) b
28936	370	0	0
48866	370	10	0
89163	370	30	0
115979	430	30	20
139511	430	30	100
198341	430	30	300

FIGURE 8-7. CACTUS CRATER DESIGN PROFILE.

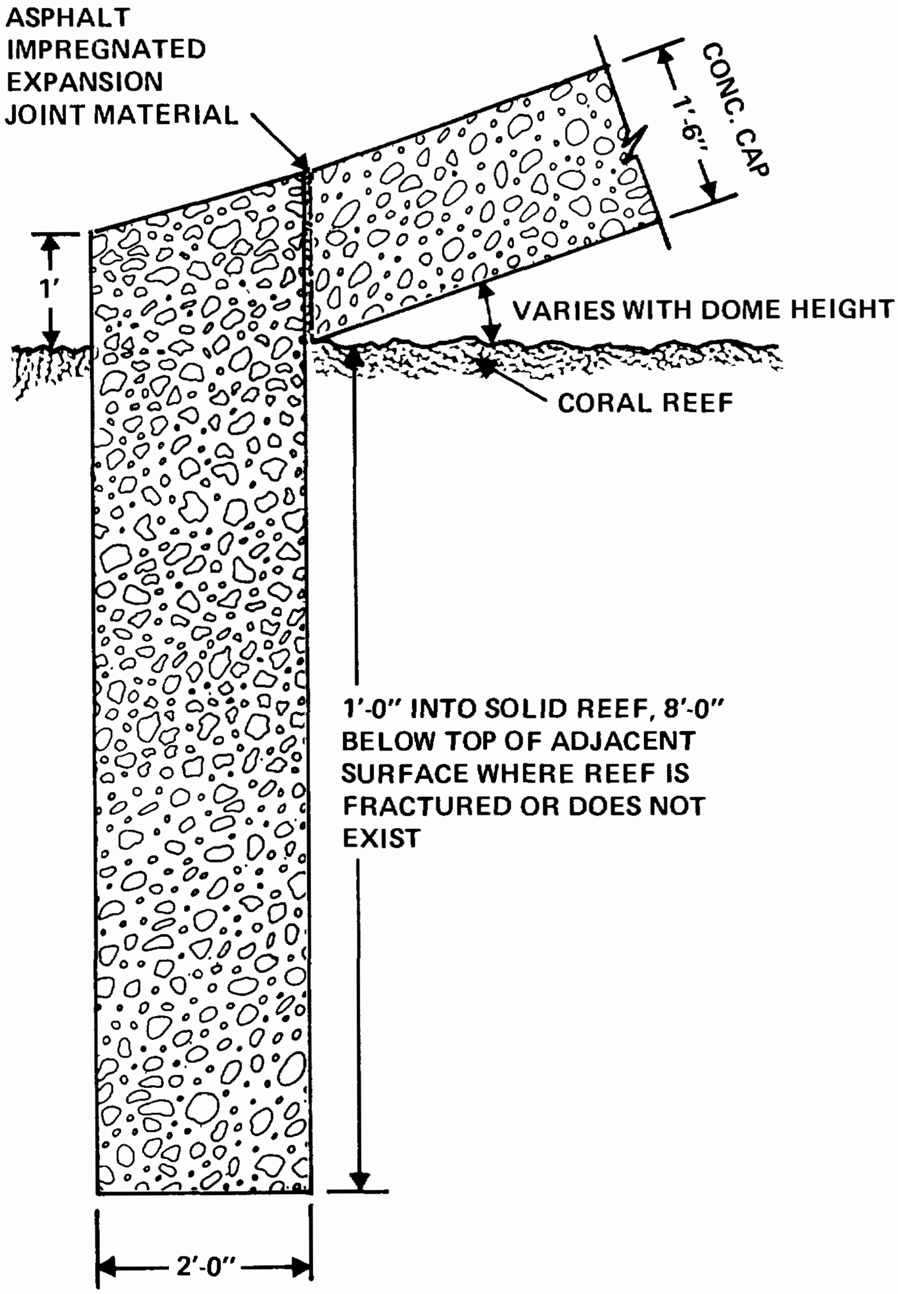


FIGURE 8-8. KEYWALL DESIGN.

technical guidance to the troops on containment operations and especially on mixing the slurry and placing it by the tremie.[28,29]

To develop formulas for the slurry and soil-cement mixtures, POD engaged the U.S. Army Corps of Engineers Waterways Experiment Station (WES). Using samples of Enewetak sand, Type I Portland cement, salt water, and bentonite-attapulgite, WES prepared several different mixtures and evaluated them for mixability, pumpability, placeability, and strength. Bentonite is a fresh-water clay which is used as a colloidal suspending agent, or lubricant, in drilling wells and pumping concrete, while attapulgite is a salt-water clay used for the same purposes. The Enewetak sand contained a high percentage of calcium, little silica, and was very angular and sharp. It lacked the fine particles which normally promote pumpability in sanded grouts; consequently, higher proportions of bentonite and water were required in the mixture so that it could be pumped through the tremie pipes.[30]

The samples of Enewetak sand which had been furnished for the experiments was not sufficient for full-scale field tests. WES prepared a substitute using crushed limestone and an expanded clay combined 50/50 by weight so as to match as nearly as possible the physical characteristics of Enewetak sand. This material was mixed with cement, bentonite, and salt water in various proportions and pumped through a tremie pipe into a test pit filled with salt water.[31] Field tests also were made on various soil-cement mixtures to be used in stabilizing contaminated soil once the crater itself was full. Based on these experiments, formulas were developed for use at Enewetak. The report by WES concluded by emphasizing the need for quality control in the makeup of the slurry and soil-cement mixtures.

In adopting the mixtures recommended by WES, Field Command chose to use Type II cement which provided greater strength when used with salt water and was no more expensive than the Type I used in the experiment. After considerable discussion, attapulgite was chosen as the colloidal agent. The mixture adopted by Field Command for tremie slurry was three bags of cement and one-half bag (50 pounds) of attapulgite per cubic yard of mix. For the soil-cement mixture, two bags of cement were to be used for each cubic yard of soil.[32]

To protect the containment structure from the initial shock of wave action during construction, POD designed a mole, or revetment, to be located on the ocean side of the keywall (Figure 8-9). It was to be constructed of armor stone (pieces of blast rock, concrete, or other rocks weighing over 1,500 pounds) and choked with smaller rock and aggregate.[33]

Design of the crater containment worksite was complicated by the apparent presence of concentrations of highly contaminated material found on the rim of Cactus Crater by earlier radiological surveys

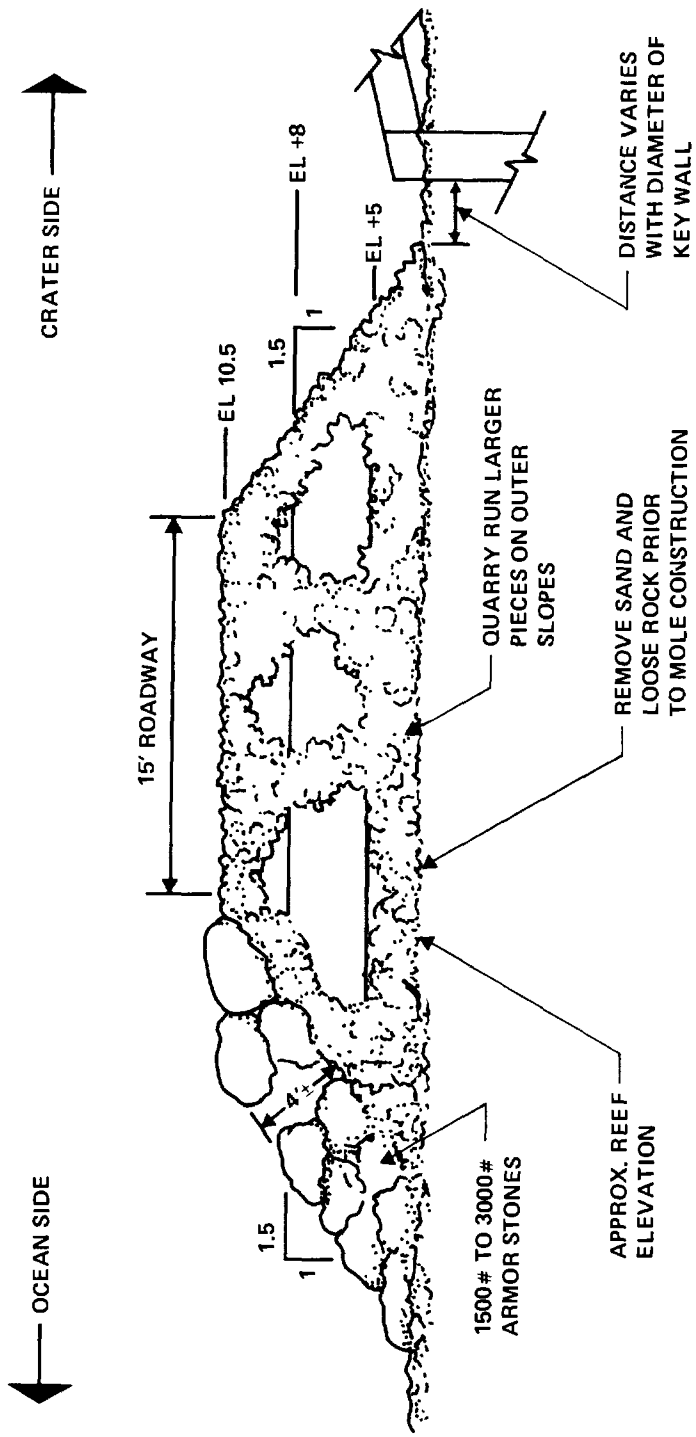


FIGURE 8-9. MOLE DESIGN.

(Figure 8-10). These concentrations would have to be considered in the layout and preparation of the worksite. However, it was planned that most of the areas with excessive readings would be bulldozed directly into the container area during the final soil cleanup and soil-cement operations or simply covered by the dome extension, depending on the total volume of soil to be contained.

FIELD RADIATION SUPPORT TEAM (FRST) ACTIONS ON RUNIT

Crater containment required extensive preparation of work sites for processing the contaminated material on the northern end of the island and construction of storage, maintenance, and administrative facilities on the southern end. Before this work could begin, meticulous radiological safety and control procedures had to be implemented. Shortly after D-Day, a temporary hotline was established at the boat landing by the FRST and the entire island was treated as a radiologically controlled area pending further identification of radiological contamination. A survey of the Erie event area indicated that some contamination was present but that it was limited to a relatively low level, (Chapter 4). During the survey, contaminated debris found south of Station 1310 was removed and stockpiled on the northern end of the island. A permanent hot line was then established across the island from the lagoon to the ocean at Station 1310. No protective clothing was required south of this line after July 1977; however, the entire island of Runit was treated as a controlled island until the project was completed.

In August 1977, the Radiological Safety Audit and Inspection Team (RSAIT), which was established by the Director, DNA to provide an independent review of radiological control and safety at frequent intervals, conducted its first inspection. A member of the team, Dr. John Auxier of the Oak Ridge National Laboratory, recovered several plutonium contaminated fragments in the Fig-Quince area and took several samples of plutonium contaminated soil. Using some of the soil samples, he attempted to conduct a test, in which known plutonium contaminated soil was purposely resuspended upwind of high-volume air samplers, to determine if an airborne plutonium hazard existed. He was unable to complete the experiment during his visit because inclement weather damaged the air sampler filters. However, a member of the FRST, following Dr. Auxier's instructions, completed the experiment in the following weeks. No significant levels of plutonium were detected on any of the filters which indicated that, in the Enewetak environment, there was no significant hazard from airborne plutonium. Based on results of these experiments and the RSAIT inspection, radiological protection measures were modified.[34]

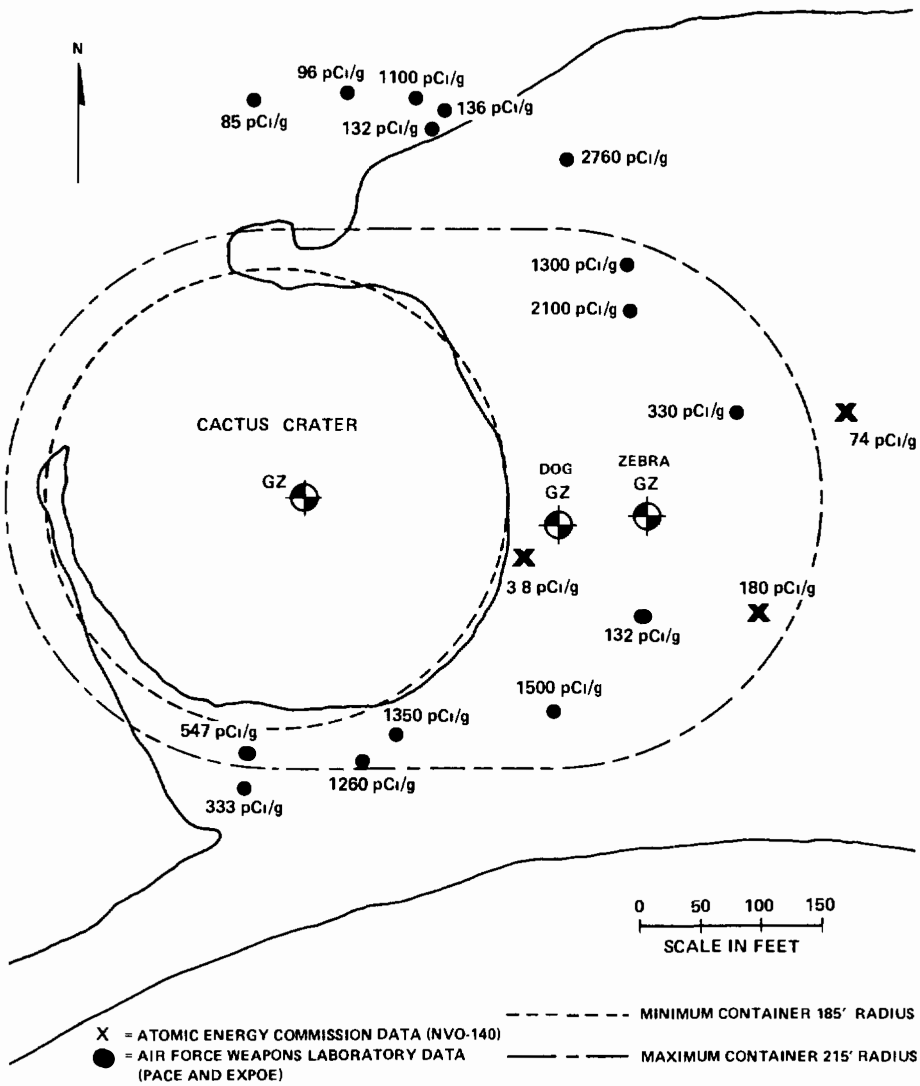


FIGURE 8-10. PRE-1977 RADIOACTIVITY READINGS NEAR THE CACTUS CRATER CONTAINER SITE.

In October 1977, the Commander, Field Command requested a complete radiological characterization of Runit in order to assure that resources were available to complete the cleanup of the island as required by Case 3 of the EIS. In response to this request (described in Chapter 4), the U.S. Army Element (USAE), using hand tools, cleared brush from the entire Fig-Quince area so that the FRST could search it for the plutonium contaminated fragments known to be on Runit. Removal of these fragments was necessary in order to minimize their effect on DOE-ERSP's characterization of Runit soil contamination. To locate the particles, the FRST used equipment and techniques developed by the Air Force Weapons Laboratory team to clean up similar fragments at Johnston Atoll in 1974. Small areas were marked off and surveyed with hand-held FIDLER probes (Figure 8-11). When a "hot spot" was located, it was removed with shovels and placed in a plastic bag. Since isolating the centimeter-range fragments from the shovelful of soil was overly time consuming, most of the material bagged was soil. Between 28 November and 23 December 1977, 437 bags and 9 additional samples were collected by the FRST. Each bag was tied, numbered, and stored in a bunker on Runit pending determination by DOE of their final disposition. DOE-ERSP believed that some of the fragments might be high grade plutonium which could be extracted economically for reuse and, therefore, should not be placed in the crater.[35,36]

FIGURE 8-11. A FIDLER SURVEY ON RUNIT.

The other FRST tasks for characterization of Runit were a complete survey of contaminated debris, with assistance by the U.S. Navy Water Beach Cleanup Team (WBCT), and collection of subsurface soil samples from trenches dug by the USAE. These tasks were completed on schedule. However, the full DOE-ERSP precleanup radiological characterization of Runit requested by Field Command could not be completed at this time due to other priority tasks.

RUNIT SITE PREPARATION

Preparation of work sites and facilities on Runit for support of crater containment operations began in June 1977, using designs developed by the 20th Engineer Brigade based on the crater containment concepts of POD. Figure 8-12 shows the location of Runit facilities.

At DNA's direction, the troops from Company A, USAE, were required to wear full anti-contamination (anti-C) protection including full suit, mask, boots, and gloves, when they began framing the administrative building on the southern end of Runit. Subsequently, based on additional radiological data and recommendations by a special radiological survey team from Field Command, this requirement was revoked for southern Runit on 15 July 1977. Meanwhile, in keeping with the high priority given rad safe measures, the USAE crew wearing full anti-C protection in 90-degree heat and 90 percent humidity, had completely framed and roofed the structure.[37] Other facilities, including a decontamination building, latrine, and concrete boat ramps, were prefabricated at Enewetak Camp and transported by boat for installation at Runit.

By 7 August 1977, construction of the operations, maintenance, and food service facilities on southern Runit were complete. A gate house, shower room, and decontamination pad were constructed at the hotline between the contaminated (northern) and the noncontaminated (southern) portions of the island (Figure 8-13). In September 1977, a part of the old runway was converted to a helicopter pad (Figure 8-14).

Site preparation on northern Runit had to await completion of the DOE-ERSP in situ soil survey of that area. The Joint Task Group (JTG) proceeded with that work which had to be accomplished to support cleanup operations and would least affect results of the in situ survey. By 15 November 1977, the concrete ramps were in place to debark trucks with contaminated material on northern Runit. Completion of the contaminated debris and soil stockpile sites and the road connecting them to the ramp area was delayed until 18 December 1977 (Figure 8-15). Meanwhile, stockpiling of debris had begun.[38]

Before crater containment operations could begin, concrete batch plant

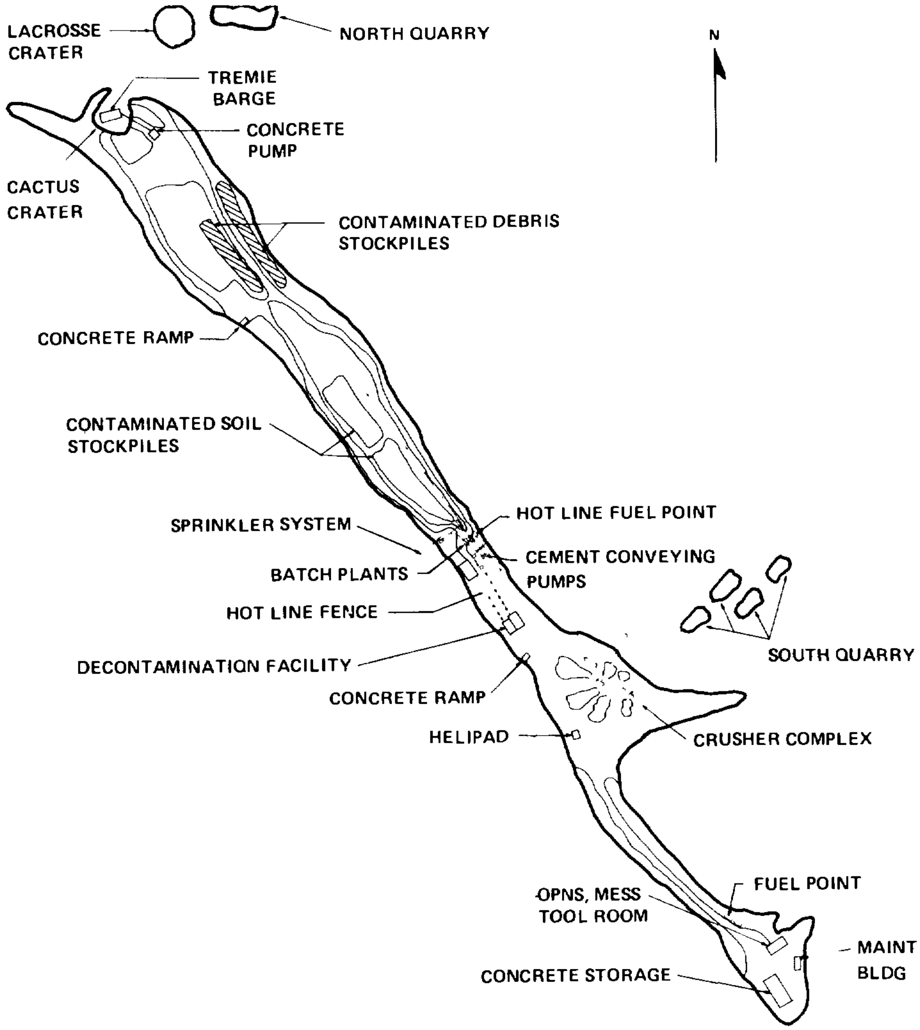


FIGURE 8-12. RUNIT FACILITIES.

FIGURE 8-13. RUNIT HOT LINE.

FIGURE 8-14. HELICOPTER PAD.

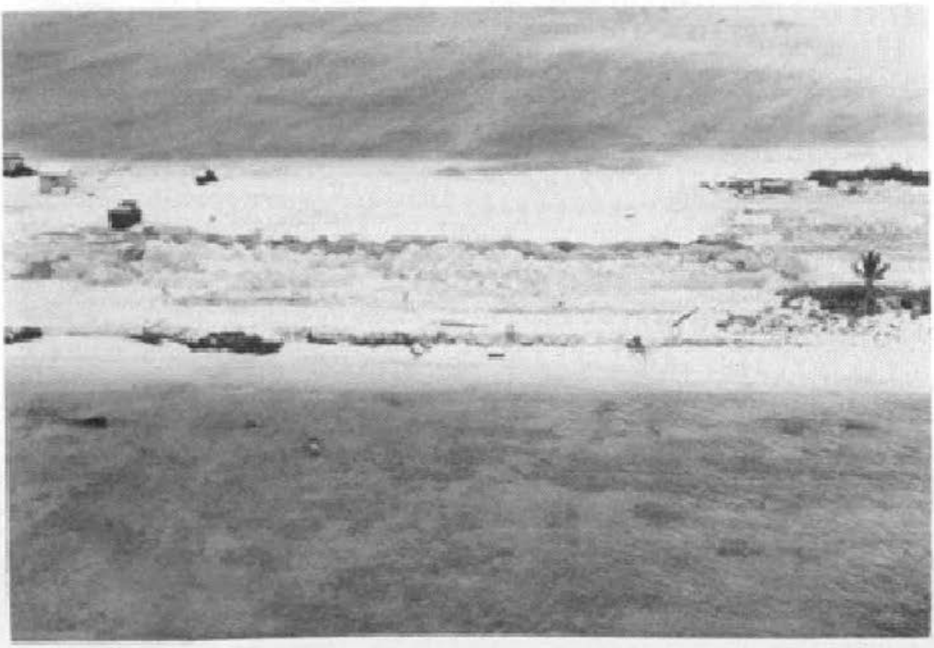


FIGURE 8-15. DEBRIS AND SOIL STOCKPILE SITES.

facilities had to be constructed just north of the hotline. During tremie operations, transit-mix trucks would be loaded at the batch plant with contaminated soil, cement, and attapulgite. These materials would be charged with water and mixed as the truck was driven from the batch plant to the crater, where the mix would be discharged into the tremie pump. Batch plant facilities included a sprinkler system to control dust, a 1-1/2-inch screening plant to separate large rocks, branches, and similar extraneous material from the contaminated soil, feeder belts, and the plant itself. Materials placed in the hoppers were measured and gravity fed into the transit-mix trucks (Figure 8-16). Foundations and pads for the batch plant facilities were constructed in February 1978 by personnel from Company B, USAE, assigned to assist Company A in Runit site preparation work. They also completed the large cement storage warehouse, installed a power distribution system, and constructed the northern island road system while Company A completed installation of the batch plant and rock crusher plant.[39] Before work could begin on the haul roads between the batch plant and the crater, an IMP survey of the routes was required. Since DOE's soil characterization work on Runit was still being delayed, priorities were adjusted to permit the survey and completion of the roads.[40]

Runit site construction and the crater containment operations required large quantities of aggregate and rock. Until a quarry could be opened on

FIGURE 8-16. BATCH PLANT OPERATION.

Runit, aggregate from an old stockpile on Enjebi was used. In November 1977, the JTG began quarry operations at the site designated in the quarry permit issued by POD; i.e., on the reef just south of the Runit hotline (Figure 8-17). Quarry operations were constrained by the time and heights of tides which did not always coincide with normal working hours. In December 1977, permission was granted to billet troops overnight on South Runit to facilitate quarrying at low tide and to save time lost in commuting from Lojwa Camp.[41]

A crushing and screening plant, obtained from existing Department of Defense (DOD) assets, was installed near the quarry. Its capacity was more than adequate to keep the project supplied with aggregate (Figures 8-18, 8-19, 8-20). Crushed coral rock was processed and separated into four sizes: 1-1/2 inches and larger, 3/4 to 1-1/2-inch aggregate, 3/4-inch to number 4 aggregate, and fines. The latter three sizes were used for the production of clean concrete. When the plant began operations, the aggregate was washed, but this step was later dropped as unnecessary.

The Commander, JTG (CJTG) was able to work around many of the planning and scheduling constraints on Runit site preparation. Runit construction also was constrained by shortages of plumbing and electrical supplies caused by a severe winter in the eastern United States, as was other camp construction at Enewetak. Nevertheless, Runit stockpile sites were ready to accept contaminated debris and soil from the other islands

FIGURE 8-17. QUARRY ON RUNIT.

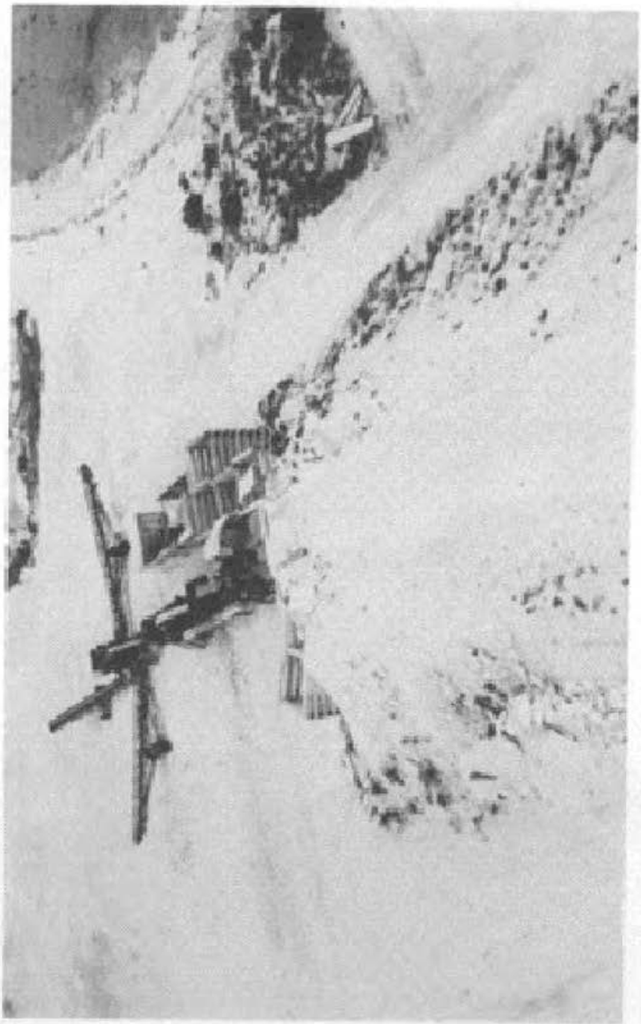


FIGURE 8-18. CRUSHING AND SCREENING PLANT.

FIGURE 8-19. CRUSHING OPERATION.

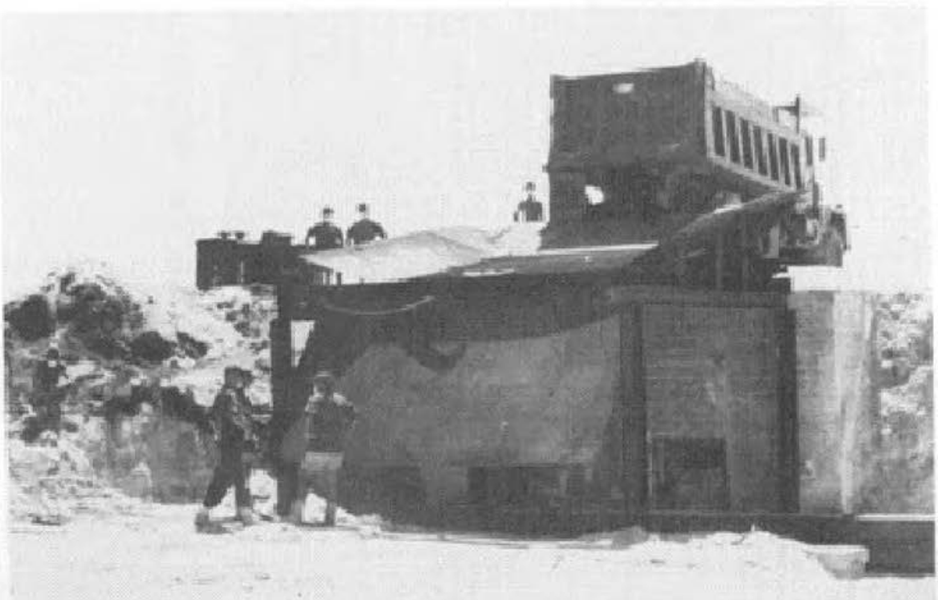


FIGURE 8-20. ROCK CRUSHER.

on schedule on 15 November 1977, and crater containment facilities were ready to begin operation on 15 May 1978.[42]

CRATER CONTAINMENT PROCEDURES

Concepts for the POD crater containment design and procedures in CONPLAN 1-76 for its execution were developed concurrently. According to the plans, a mole was to be constructed during the site preparation phase (15 June 1977-15 April 1978) to minimize the effects of tides and storms and reduce the quantity of radiological particles which could escape to the ocean during containment operations. Later in this phase, when cleanup operations began, contaminated soil and debris from the other islands would be stockpiled on Runit.[43] Originally, all contaminated debris, including that from Runit, was to be collected before the tremie placement operations were complete in order to insure that it was properly encased in slurry.[44] The POD design and the Field Command Operations Plan 600-77 (OPLAN) subsequently were amended to allow encasing contaminated debris during the soil-cement phase by forming a dike around the debris and pumping contaminated slurry mix within the diked area.[45,46] When sufficient soil was stockpiled to assure effective tremie placement of the slurry, containment operations would begin.[47,48] Effective placement requires a stockpile large enough to permit as near a continuous flow of slurry as possible to provide as monolithic a mass as possible. Stockpiled material would be screened to the maximum size permitted by the concrete pump. Oversize material would be handled in the same manner as contaminated debris; i.e., encased in the slurry.[49]

During tremie operations, construction would start on the northeast half of the keywall. By the time tremie operations were complete, most of the remaining contaminated soil should have been stockpiled so that the required volume and shape of the dome could be determined.[50] The remaining keywall could then be constructed concurrent with soil-cement operations. The sequence and timing of these actions were critical. They were planned so as to permit the most timely and effective completion of the project. However, they had to be modified to compensate for unexpected events.

MOLE CONSTRUCTION

The POD design called for construction of a mole; i.e., a massive wall of large stones or dike (see Figure 8-9), around the ocean side of Cactus Crater prior to beginning containment operations in order to minimize the effects of tides and storms on the containment site.[51,52] It was designed to last only 2 years, until containment was complete.[53,54] Due to unforseen on-site changes, construction of the mole began 4 April 1978, approximately 9 months later than envisioned in the earlier planning. This late start did not permit its completion prior to the beginning of containment operations.

Construction of the mole was initially constrained by difficulties in rock deliveries from the quarry on South Runit. On 1 April 1978, the POD quarry permit was amended to permit an additional quarry on the reef adjacent to Lacrosse Crater. Use of this quarry considerably reduced the haul distance and eliminated delays in crossing the hotline. The mole construction rate increased substantially after the new quarry was opened. Even so, the mole was only 20 percent complete when tremie operations began.[55] When Typhoon Alice struck in early January 1979, the heavy seas and huge waves dumped large amounts of sand into the crater.[56] Since the mole was still less than half complete, a fair evaluation of its effectiveness against such storm actions could not be made.

To facilitate mole construction and debris cleanup, the CJTG recommended that the numerous contaminated concrete blocks near the north quarry be used in the mole.[57] Field Command did not concur because of the contaminated nature of the material.[58] Much later, however, approval was given to use rejected keywall sections of noncontaminated concrete in constructing the mole.

Construction on the mole was completed on 21 October 1979, several weeks after the crater container had been capped.[59] It was far enough along during the capping operations, however, to serve its intended purpose. The mole was subsequently improved to the extent that it would provide continuing protection for the containment structure.

TREMIE OPERATIONS

Due to delays in starting soil cleanup, there were only about 3,700 cubic yards of soil in the Runit stockpile when tremie placement began.[60] The tremie facility consisted of a concrete pump which forced slurry through a 5-inch flexible pipe constructed across a floating footbridge to a crane mounted on a barge floating in Cactus Crater (Figure 8-21). The feeder pipe was connected to an 8-inch-diameter pipe suspended from the crane boom as a placement device (Figure 8-22). Cables anchored on the shore and connected to winches on each corner of the barge were used to move the barge about in the crater.

The tremie mix was deposited into transit-mix trucks at the batch plant in the industrial area north of the hot line. The mix contained three bags of

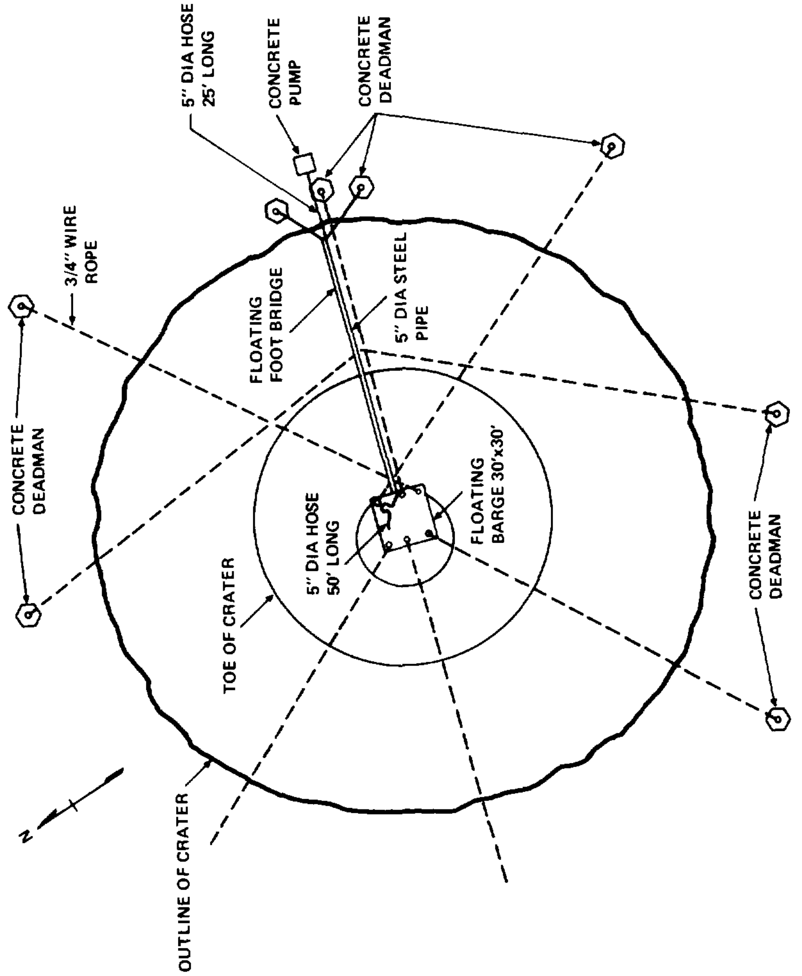


FIGURE 8-21. TREMIE OPERATION.

FIGURE 8-22. TREMIE BARGE AND CRANE.

cement and one-half bag of attapulgite per cubic yard of contaminated soil. The contaminated soil had been filtered through a 1-1/2-inch screen at the screen plant, with oversized material treated as debris. This step was essential because the concrete pump could not accommodate aggregate larger than 1-1/2-inch nominal diameter. Attapulgite clay was used to improve the workability, lubrication, and cohesiveness of the slurry in the pumping and underwater placement operation. Water was added and the materials were mixed in the transit-mix truck en route to the tremie pump. There the slurry was pumped through the pipeline and deposited on the crater floor.

OPLAN 600-77 stated that contract consultant services, if required, would be provided during actual tremie placement operations.[61] In response to an inquiry from Field Command, U.S. Army Support Command, Hawaii (USASCH) advised that such services were desirable, not only for tremie mix and placement but for quarry and batch plant operation.[62] As a result, Field Command arranged for POD to provide necessary technical assistance.[63,64] On 13 June 1978, four technical representatives arrived at Enewetak to assist in the final calibration and startup of tremie operations. On 15 June 1978, the first 40 cubic yards of contaminated slurry were batched and tremied onto the floor of Cactus Crater. Based on the advice and assistance of the technical representatives, adjustments were made to the plant operation to improve output. By the end of June, 1,223 cubic yards of slurry had been tremied.

The technicians advised that it would be unrealistic to plan on more than 250 cubic yards sustained daily output, even with maximum use of daylight hours. In July, additional personnel were assigned to the tremie operation to provide two-team, double-shift operations covering all daylight hours. At the technicians' recommendation, Field Command procured another spare tremie pump, this one a duplicate of the primary pump, to replace the spare which had been obtained from excess and had proved inoperable.[65] Equipment problems continued to hamper tremie operations until 26 September 1978 when a master mechanic was provided by Holmes & Narver, at the request of USASCH and Field Command, to maintain and repair equipment which exceeded USAE maintenance capability.[66,67] The mechanic, Mr. James W. Shively, proved invaluable in keeping the crater containment equipment in operating condition despite a vareity of adverse conditions and continuous personnel turnover.[68]

On 2 October 1978, Navy divers entered Cactus Crater to inspect the material placed there. The existing surfaces of the material appeared even.[69] However, core drilling, after the dome had been capped and the project completed (March 1980), revealed some segregation and laitance.[70] The segregation and laitance was probably caused by: (1) placing the slurry during daylight hours only, in lieu of 24-hour-a-day operation; (2) periodic pump failures; (3) difficulties in controlling the discharge end of the tremie pipe; and (4) improper dumping of some oversize material.

The POD/Field Command decision to handle oversize material as debris and encapsulate it in the slurry was not a part of the POD design or the OPLAN. Lacking specific guidance, the JTG disposed of contaminated material too large for the tremie pump by bulldozing it in at the edge of the crater. An estimated 7,109 cubic yards of oversized material were placed in this manner (Figure 8-23).[71] When the tremie pump could not handle a load of slurry, the slurry was discharged from the transit-mix trucks into excavated trenches and allowed to harden (Figure 8-24). The hardened slurry then was loaded into a dump truck and placed in the crater. This "processed tremie" method was used only when necessary and was limited to eight loads per day unless approved by CJTG.[72]

Contaminated debris stockpiled on Runit from the other islands was placed in the crater during the tremie operation. Slurry was used to choke the material and encase the debris into the concrete mass produced by the tremie process. Approximately 4,500 cubic yards of contaminated debris were disposed of in this manner.

As the tremie operation progressed and the fill approached the surface of the water, slurry was placed by both the tremie barge and, in inaccessible areas around the crater rim, by using transit-mix trucks (Figure 8-25). Tremie operations were completed on 10 February 1979, 2 months ahead of schedule. The crater was filled to approximately 3 feet

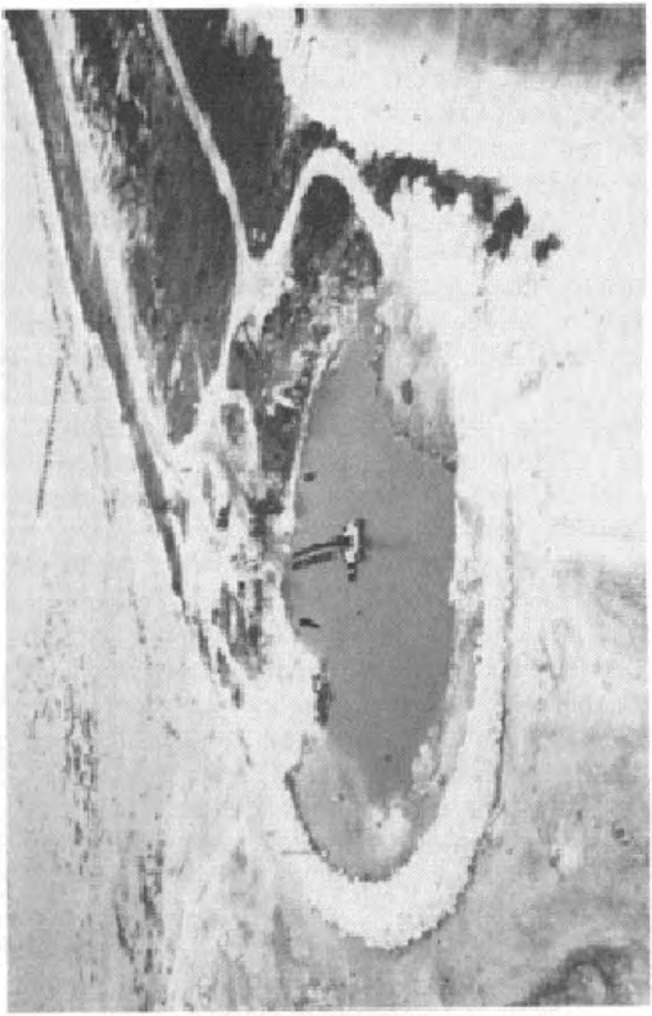


FIGURE 8-23. PLACEMENT OF OVERSIZED MATERIAL.

FIGURE 8-24. TREMIE IN EXCAVATED TRENCHES.

FIGURE 8-25. TREMIE OPERATIONS NEARING COMPLETION.

above the reef level to an average keywall diameter of 377 feet. The total crater fill included 4,500 cubic yards of contaminated debris, 7,109 cubic yards of oversize material, 47,500 cubic yards of loose soil, and an undetermined amount of sand deposited by storm and tidal action. The soil compaction ratio for loose soil to volume filled in the tremie operation was 1.23:1.[73]

THE STOCKPILE SIZE QUESTION

When tremie operations ended on 10 February 1979, CJTG noted a significant difference between the actual size of the stockpile of remaining contaminated soil on Runit and the running balance sheet calculation of stockpiled soil, as reported by USAE and maintained on JTG records. A physical survey indicated there were approximately 3,500 cubic yards in the stockpile rather than the 28,121 cubic yards carried on JTG books based on USAE reports of volume of soil transported to Runit less the USAE reports of volume of soil encapsulated by tremie operations.[74] A similar discrepancy had appeared in reporting soil remaining to be transported from Enjebi to Runit. Detailed investigation revealed that several factors were involved in these discrepancies including estimating errors, counting errors, variations in truck loading, not taking into account the expansion of volume which occurs when soil is removed from its natural location, and the compaction which occurs when soil is combined into a slurry. When the error was reported during the 12 February Fission Products Survey Conference, it was perceived by the planners there as a mixed blessing. It meant that additional dome capacity and time, as well as the resources, would be available for containing contaminated soil from other locations; e.g., Lujor and Runit.

KEYWALL CONSTRUCTION

The keywall was designed to prevent scouring and undercutting of the containment structure. The design mix was for six bags of cement (Type II) per cubic yard of concrete, subject to final determination in the field.[75] This would produce concrete with a compression strength of not less than 3,000 pounds per square inch (psi) at 28 days. The USAE determined by field tests that a 6.3 bag mix consistently gave results in excess of 3,000 psi compression strength. Construction of the keywall in 10-foot sections was specified in the design.

USAE surveyors laid out and staked the centerline for the keywall during the first week in October 1978.[76] The minimum radius provided in the design was selected to begin the keywall; i.e., a radius of approximately 185 feet from the center of the crater. Using the 185-foot radius, an arc was surveyed and staked out on the reef. The arc fell about 12 feet outside the crater lip. Excavation to place keywall forms began on the reef the following week,[77] and the first 10-foot section of keywall was placed the week of 6 November 1978.[78] A field engineering decision was made to change the form length to 12 feet to accommodate use of standard size plywood. This resulted in fewer forms being required for the northern half (48 in lieu of 58) without detracting from the roundness of the keywall.[79]

Keywall construction was hampered by reef and tide conditions. Excavation and forming could be accomplished only during that half of a day when the tide was out. The excavations were full of water even at low tide, causing difficult and unpleasant working conditions and hampering excavation (Figure 8-26). Tidal water in trenches also hampered the proper placement of concrete (Figure 8-27). Dumping concrete into the water-filled forms resulted in laitance in some sections, as was revealed by subsequent core samples.[80]

Concrete for the keywall was mixed using a type 16S concrete mixer until tremie operations were completed. Thereafter, the batch plant, which was decontaminated on 27 February 1979, was used to produce clean concrete, which was then transported to the keywall construction site by transit-mix trucks.

FIGURE 8-26. BUILDING THE KEYWALL.

FIGURE 8-27. PLACING CEMENT IN KEYWALL FORMS.

Eighty percent (40 sections) of the keywall located on the reef was complete when tremie operations ceased.[81] At this point, the total amount of contaminated material to be contained should have been known, the configuration of the dome determined, the location of the remaining keywall staked out and all surrounding material within the dome area removed to an elevation of 10 feet.[82] Instead, because soil cleanup began late, there were only 3,500 cubic yards in the stockpile and the balance to be contained was unknown.

At the 12 February 1979 Fission Products Survey Conference chaired by the Director, DNA in Albuquerque, conferees were briefed on current project status (Figure 8-28) and advised that soil-cement operations would begin soon with less than 12,000 cubic yards of soil remaining to be contained from the islands other than Runit. It was estimated that there were between 18,000 and 42,400 cubic yards of soil which might be excised from Runit, more than enough to fill a circular dome up to 30 feet in height. The Director, DNA initially decided to proceed with cleanup of Runit to 160 pCi/g, but subsequently requested that an optional plan be developed for cleanup of Lujor soil to 80 pCi/g, concurrent with the Runit cleanup.[83] The options were discussed further during a visit to Enewetak by the Commander, Field Command on 16-21 February 1979, including options for the shape and configuration of the dome. However, no specific decision on the shape was made.

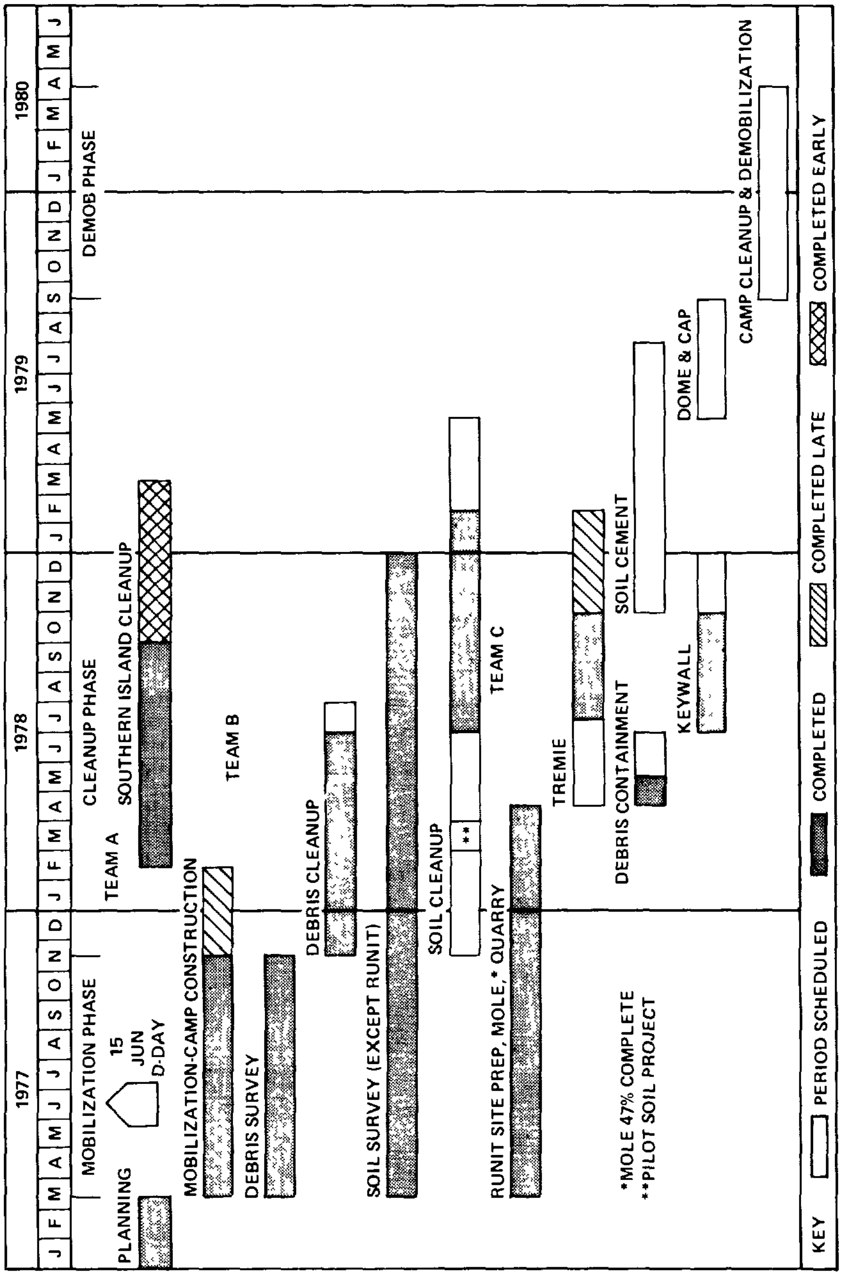


FIGURE 8-28. ENEWETAK CLEANUP PROJECT STATUS, 12 FEB 79.

Following an inspection by helicopter, it was discovered that inward distortion of the circle existed, not apparent from the ground. It also was discovered that extending the keywall circle throughout the remaining arc would run it directly into the high banks of ejecta on the island side. The CJTG directed that 31 recently placed keywall sections be removed and replaced with properly aligned sections [85]

The banks had been a concern because it was believed that they contained high levels of subsurface soil contamination. After the misaligned keywall sections were removed, the CJTG directed that the banks be bulldozed, the soil be placed in the soil-cement mix in the crater, and the keywall correctly aligned. It was then in the crater, and the keywall correctly aligned. It was then discovered that the banks contained a large quantity of contaminated debris, but that the soil contamination was less than 40 pCi/g.[86]

Subsequent helicopter surveys revealed that some of the replacement sections were slightly out of line This had no effect on the function or durability of the keywall but detracted from the aesthetic appearance of the dome. As a result, 24 more sections were removed and replaced.[87,88,89] Misalignment of these sections was caused by the incorrect use of a template to turn the angles between sections This problem was solved by using survey procedures to establish the proper location of each section. A total of 55 misaligned keywall sections were removed and used as armor stone in constructing the mole.

The completed keywall contained 99 sections, 95 of which were 12 feet long; three, 10 feet long; and one, 9.4 feet long. The circumference was 1,179.4 feet, and the nominal diameter was 377 feet.[90] An estimated 528 cubic yards of concrete were used in the keywall construction.

SOIL-CEMENT OPERATIONS

Once the crater was filled to 3 feet above the reef, the tremie barge was stabilized in the tremie, the crane was removed, and the remaining contaminated materials were stabilized and contained using a soil-cement process. Thereafter, contaminated soil was delivered to the containment site by truck and dumped on the already processed material. A grader was used to spread the soil in approximately 6-inch layers (Figure 8-29). Bags of cement were then placed in a pattern designed to provide two bags per cubic yard and cut open (Figure 8-30). The dry cement was mixed dry with the soil by a disc harrow towed by a dozer (Figure 8-31). Water then was distributed over the dry mixture (Figure 8-32). A vibratory roller-compactor was used next to compact the soil-cement mixture (Figure 8-33). Tests were made with a cone penetrometer to insure that the design strength of 300 psi was achieved.

FIGURE 8-29. SPREADING SOIL WITH A GRADER.

FIGURE 8-30. CEMENT BAGS PLACED FOR SOIL-CEMENT MIX.

FIGURE 8-31. MIXING SOIL AND CEMENT WITH DISC HARROW.

FIGURE 8-32. SPRINKLING SOIL-CEMENT MIXTURE.

FIGURE 8-33. COMPACTING SOIL-CEMENT MIXTURE.

Soil-cement procedures were tested the week of 11 February 1979. Full-scale operation began the following week and continued until 26 July 1979. The mound which resulted rose 25 feet above the tremie level, or 28 feet above reef level. Approximately 1,143 cubic yards of contaminated debris and 49,492 cubic yards of soil were contained in the soil-cement mound. The compaction factor for soil placed by this process was 1.01:1. Subsequent core sampling revealed that the soil-cement was packed firmly, fairly impermeable, and did not represent a source threat of radionuclides.[91] In all, over 104,000 cubic yards of contaminated soil were placed in the Cactus Crater containment structure by the combined tremie and soil-cement operations (Figure 8-34).[92]

THE DONUT HOLE

Because of delays in collecting debris from the Aomon Crypt (described in Chapter 7) and the island of Runit itself (described in a subsequent section), all the contaminated debris could not be encased in slurry during the tremie operation as originally planned. The POD design provided for disposal of debris during the soil-cement operation by building dikes in which the debris would be placed and encased with contaminated slurry.

ISLAND	CURIES	SOIL (CUBIC YARDS) CRATER	DOME	TOTAL
a. Medren		110	0	110
b. Aomon	1.29	10,603	0	10,603
c. Aomon Crypt	.93	448	9,328	9,776
d. Boken	1.01	421	4,516	4,937
e. Enjebi	2.57	43,023	9,984	53,007
f. Lujor	1.70	0	14,929	14,929
g. Runit	7.22	0	10,735	10,735
h. Total	14.72	54,605	48,492	104,097

CRATER/TREMIE OPERATIONS – COMPLETED 10 FEB 79 (CUBIC YARDS):	
a. Soil removed to Runit by 10 Feb 79	58,105
b. Remaining in stockpile on 10 Feb 79	3,500
c. Placed in crater as oversize	7,109
d. Placed in crater as slurry (a-b&c)	47,496
e. Total crater volume	50,249
f. Volume filled by debris	4,500
g. Volume filled by oversize	7,109
h. Volume filled by slurry 5,520 batches @ 7CY batch	38,640
i. Soil compaction (d-h)	8,856
j. Compaction ratio (d÷h) 1.23 1	

DOME/SOIL-CEMENT OPERATIONS (CUBIC YARDS):	
a. Stockpile on 10 Feb 79	3,500
b. Soil removed to Runit after 10 Feb 79	35,257
c. Soil excised/encrypted from Runit	10,735
d. Total soil encrypted in dome (a+b+c)	49,492
e. Total dome volume	50,081
f. Volume filled by debris	1,143
g. Volume filled by soil-cement	48,938
h. Soil compaction (d-g)	554
i. Compaction ratio (d÷g) 1.01:1	
j Total soil placed in crater and dome	104,097

FIGURE 8-34. CONTAMINATED MATERIAL CLEANUP/CONTAINMENT.

As soil-cement operations began, an area approximately 100 feet in diameter was left open in the center of the mound. This area was commonly called the "Donut Hole" (Figure 8-35).

As contaminated debris was delivered to Runit, it was placed in the Donut Hole and choked in place with a four-bag (per cubic yard) mix of clean slurry. The Donut Hole remained open until mid-July 1979, when contaminated soil from Runit was used to complete the soil-cement operation so that the capping could be completed.

HOT PARTICLE DISPOSAL

There was considerable discussion regarding disposal of the more than 400 plastic bags of soil filled by the FRST and others in excising the plutonium-contaminated fragments on Runit. Mr. Roger Ray, the ERSP Manager, believed it would be better to treat these bags separately and not place them in the crater. The Director, DNA, and Commander, Field Command were willing to have the ERSP take responsibility for the bags and for their safeguarding, storage, transport, and disposal but, if this responsibility remained with DNA, they favored crater disposal.[94] The ERSP Manager responded that these particles might have transuranic concentrations in the range of one thousand to one million times the

FIGURE 8-35. DONUT HOLE.

concentrations in other soil and merited special handling. He believed they represented "high-graded" material and, once brought under control, should not again be released but should be retained in DOE-ERSP custody until completion of the Runit effort. At that time, the DOE-ERSP would propose and obtain approval of a disposal plan. He recognized that it was highly probable that some particles remained in the Fig-Quince area and could be unknowingly placed in the dome or remain unexcised, but he believed that the fragments which had been found should remain under DOE control.[95]

The JTG J-2 and DOE-ERSP technicians on the atoll reviewed data available on the fragments from the FRST survey and other files and conducted a radiological sampling of the physical material. It was determined that the total of all material collected in bags measured approximately 60 millicuries of transuranics. The fragments themselves appeared to be weathered metal, some of which had concrete or soil attached, rather than high-graded plutonium. The transuranic content of the fragments, which had been the cause of concern, was relatively low.[96] Because of these findings, the bags of material were placed in the Donut Hole and choked with concrete slurry.[97]

RUNIT DEBRIS CLEANUP

Although the EIS required disposal of all hazardous debris and crater containment of all radiologically contaminated debris, the cleanup of debris on Runit had been accomplished less rigourously than on other islands. This was not intended, or realized, by the Director, DNA or Commander, Field Command. It was apparently fostered by the concept that, since Runit would be quarantined, cleanup of debris there was a low-priority task. Too, since the debris was near the crater and transportation was not complicated, the cleanup could be set aside until the end of the soil-cement phase was near. Both of these views turned out to be ill-conceived. In reports from the atoll in September 1978, the CJTG interpreted the tasking to clean Runit soil to 160 pCi/g using available resources as applying to debris cleanup as well.[98,99] This interpretation drew a strong response from the Director, DNA to the effect that all debris on Runit must be removed. Nevertheless, Runit debris cleanup continued to be given low priority by the USAE well into 1979.

Runit debris had been surveyed initially by the FRST in July 1977. Another debris survey was conducted for the radiological characterization of Runit in December 1977. Additional surveys were made in the latter half of 1978. Some of these surveys were directed primarily toward identifying hazardous areas for radiological safety and control, rather than toward identifying the appropriate disposition of each item. During the September 1978 survey, it was estimated that there were approximately 10,000 cubic yards of debris on Runit and its associated reef areas, 4,100 of which should be disposed of in the crater.[100] A resurvey 2 months later estimated that only 2,200 cubic yards need be disposed of in the crater.[101]

Some of the higher levels of gamma contamination (maximum intensity of 25 milliroentgens per hour) were found in a twisted metal debris pile on the reef just north the old runway. Other metal located in the area of the Blackfoot GZ had gamma readings up to 17 milliroentgens per hour.[102] Debris underwater and on the reef had to be surveyed and marked several times because wave action removed both the paint and the engineer ribbon used to code its radiological condition. Efficiency of this operation could have been increased greatly if the USAE had been tasked to provide equipment to remove debris as it was being surveyed.[103] By the end of 1978, only 1,724 cubic yards of debris had been cleaned up on Runit, most of it by the WBCT or during the removal of contaminated debris from South Runit in 1977.[104]

The delays in accomplishing Runit debris cleanup had adverse effects. The landing craft which had been beached near Station 1310 during the testing period to provide shore protection were sufficiently exposed in 1977 to have permitted complete demolition and removal. However, by late 1979, due to settling and shifting sands, only portions of the superstructures were exposed, and major excavation would have been required to remove them. These landing craft were not contaminated; therefore, it was decided to remove the exposed hazards only. The most serious adverse effect of the delays, however, was that red debris continued to be located after containment operations had been completed, requiring extraordinary measures for containment. These are described in a subsequent section. In all, 4,120 cubic yards of contaminated debris and 11,482 cubic yards of noncontaminated debris were removed from Runit and its reef.

RUNIT SOIL CLEANUP

Several alternatives for cleanup of contaminated soil on Runit were considered at the 4 May 1978 Enewetak Cleanup Planning Conference including:

a. No cleanup;
b. Clean all concentrations over 160 pCi/g immediately;
c. Clean all concentrations over 160 pCi/g after all other soil cleanup was complete; and

d. Clean all concentrations over 160 pCi/g concurrently with other soil cleanup, using resources not currently employed on other tasks. The amount of resources available for Runit cleanup would increase as other tasks were completed until, eventually, all resources could be devoted to Runit cleanup.

The last alternative was adopted, and the CJTG was directed to begin cleanup of contaminated soil on Runit concurrently with other operations, using equipment available at Runit when not in use on other activities. The CJTG also was directed to segregate contaminated soil into three stockpiles on Runit according to degree of contamination. The most contaminated, principally that excised on Runit, was to be used to sustain tremie operations while disposition of that having much lower levels would be decided later.[105]

As the work was actually carried out, however, the USAE concentrated on the crater containment mission on Runit, leaving contaminated soil and debris cleanup on Runit to be accomplished later. The USAE assisted the Navy WBCT in disposal of debris removed from the waters around Runit, but because other priorities required the use of available personnel and equipment, no other effort was made to clean Runit in 1978. To sustain tremie operations, soil transported from the other islands was used in filling the crater.

The delays in soil cleanup were discussed during demobilization planning conferences in August and November 1978. Soil cleanup appeared to be the one task which could require extending the project. The Commander, Field Command noted, in a message to the Services, that the 15 April 1980 project completion date in the draft demobilization plan was based on the assumption that soil removal would be completed on schedule. He also noted that, while he intended to exert every effort to hold to the 15 April 1980 date, there was much uncertainty involved in the remaining tasks.[106] During the 1-9 August 1978 Demobilization Conference, the Services were asked to address the issue of extending the project past 15 April 1980. They responded that it was possible to extend it until 30 September 1980, since they had funded the project through the end of fiscal year 1980.[107,108]

In December 1978, the CJTG presented to the Director, DNA, and the Commander, Field Command, his evaluation of the Runit situation. South Runit met the radiological guidelines for agricultural use without soil cleanup. Soil sampling had been completed in the Fig-Quince area and indicated varied levels of contamination mixed to depths in excess of 4 feet. Soil characterization had not been completed north of the Fig-Quince area and would require 12 days' work. An estimated 28 acres in the Fig-Quince area and 2 acres in other areas needed to be cleaned. The CJTG identified the following alternative solutions:

a. Remove all soil, surface and subsurface, above 160 pCi/g of transuranics. Estimated volume was over 9,500 cubic yards.
b. Remove all surface contamination above 160 pCi/g to a maximum depth of 40 centimeters (16 inches). This would limit the worst-case volume to 62,920 cubic yards.
c. Erect a barrier at the hotline and quarantine North Runit. Permit use of South Runit.
d. Dig a wide channel near the hotline to form two islands and quarantine the northern one. Permit use of South Runit.
e. Quarantine Runit forever.

The Director, DNA requested more IMP data on South Runit before making a decision.[109,110] The matter of Runit soil cleanup, however, was to be overtaken by more pressing developments.

At the 12 February 1979 Fission Products Survey Conference, the Director, DNA reaffirmed that 15 April 1980 was an ironclad end date but that "If we try to turn away from a job half done, we will be right back out there redoing the job with more people and more cost."[111] A briefing was presented on the status of the cleanup project which indicated it might possibly be completed well before the planned end date. Cleanup and transport of contaminated material from the islands other than Runit was 3 months ahead of the revised schedule. Tremie operations were being completed 2 months ahead of the revised schedule. Less than 12,000 cubic yards of contaminated soil remained in the stockpile or to be transported from the other islands. This would sustain soil-cement operations for slightly more than 2 weeks at the planned rate of 5,000 cubic yards per week. Cleanup of Runit, based on worst case estimates of 60,000 cubic yards, could be completed in only 12 more weeks, or by the end of May 1979, permitting the crater to be capped and demobilization to be started a month early (i.e., 15 September instead of 15 October 1979). The only apparent constraint was delivery of cement to sustain the maximum rate of soil-cement containment.[112] The USAE representative at the conference confirmed that USAE could excise and contain 5,000 cubic yards of soil per week on Runit if they had the cement.

The Director, DNA decided to expedite cleanup of Runit soil and to expedite delivery of the cement. At the end of the meeting, the discussion turned to Lujor, which had been cleaned only to visitation level (160 pCi/g), not to agricultural level (80 pCi/g), the use desired by the dri-Enewetak. The Director then directed the CJTG to develop plans for two options: Cleanup of Runit to 160 pCi/g and Lujor to 80 pCi/g, or cleanup of Runit alone.

The initial response from the JTG staff and the USAE to the proposed cleanup of Lujor was pessimistic because of anticipated difficulties with Lujor; i.e., channel access, poor beach and on island trafficability, etc.[115]

However, the CJTG took the more positive position that it was possible to clean up Lujor to under 80 pCi/g and the Fig-Quince area on Runit without extending the project.[116] The CJTG proposal was modified by Field Command to consider these alternatives:

a. Clean Runit to reduce transuranic contamination to the lowest level reasonably achievable within constraints of crater capacity and time and do nothing on Lujor.
b. Clean Lujor to meet the 80 pCi/g criteria (encapsulating the soil), while accomplishing as much excision on Runit as time and resources permit (encapsulating the Runit soil).
c. Clean Lujor to meet the 80 pCi/g criteria without encapsulating all of the Lujor soil, and concurrently excise and encapsulate Runit soil as time and resources permit.

Other considerations impacted on any expedited cleanup of either Lujor or Runit. These included soil removal requirements remaining at Boken (Irene), Enjebi, and the Aomon crypt; soil transport capability; status of crater fill; cement on hand; containment rate; and projection of crater dome height.

After careful deliberation of the Field Command and JTG inputs, COL Peters (Director of Enewetak Operations) briefed the Director, DNA on the recommended options on 8 March 1979. Alternative a, clean Runit only, could be completed in the time available, would maximize crater fill, and could be initiated without any channel clearance operations and without any need to consider boat transportation capabilities. However, there would be no guarantee that the island status would change, excavation to depths of 6 feet might be required, and the EIS requirement for Lujor would not be satisfied. Alternative b allowed containment of the Aomon, Enjebi, Boken and Lujor soil within the time and crater volume available, and it would change the status of Lujor to the benefit of the people and in accord with the EIS. However, it would place great demands on equipment already overtaxed, require channel clearance and additional IMPing, place excavation and transport operations under severe time constraints, and require additional bulk-haul boat configuration to get the job done in time. Alternative c had all of the favorable aspects of alternative b, plus it would permit intensive effort on both Runit and Lujor. It was less time constrained since the soil from Lujor would not necessarily be encapsulated. It still would have the problems associated with access to Lujor, trafficability, bulk-haul boats, and overall efficiency. Since the cleanup of Runit was of less benefit to the people than the cleanup of Lujor insofar as the ultimate usage was concerned, and since either alternative could be accomplished in time to allow the crater to be capped by 15 September 1979, the Director, DNA decided to implement alternative b, with a modification. It was modified to regulate the input of

Runit soil to 1,000 cubic yards per week and not to exceed 12,000 cubic yards pending evaluation of the progress on Boken, Enjebi, Aomon and Lujor.[117] By this restriction on dome fill with the easier-to-transport Runit soil, the Director, DNA hoped to ensure that all Lujor soil would be encapsulated. On 13 March 1979, the CJTG received directions to proceed with concurrent cleanup of Lujor and Runit.[118]

As a practical matter, a limit had to be placed on the dome size to assure that it was completed in time to permit capping and the demobilization by 15 April 1980, the end date set by DNA. Field Command engineers had suggested that the POD design be followed and that the dome be extended inland as necessary to contain the additional volume required for the worst-case estimate of cleaning both Lujor and Runit. However, as a result of discussions during the 8 March 1979 briefing, the Director, DNA decided that soil-cement and capping operations would be directed toward a 25-foot dome.[119]

Upon receipt of the 13 March 1979 directions, the JTG proceeded to excise and encapsulate Runit soil at a rate which would sustain soil-cement operations while awaiting the delivery of soil from the other islands. Efforts were expanded to open a channel for boats into Lujor but the strong currents between Lujor and Aej continued to hamper the successful marriage of the LCUs with the boat ramp. However, it appeared that the LCM-8s would be successful in getting into Lujor, but with an attendant decrease in soil removal capability. By 24 March, approximately 2,400 cubic yards of Runit (Fig-Quince) soil had been contained and, with the troops on Runit accelerating the containment rate, the soil stockpile was almost depleted. The containment rate reached 4,220 cubic yards during that week, and soil was not arriving fast enough from Boken, Enjebi, Aomon and Lujor to sustain a stockpile.

The rate of containment for Runit soil caused concern at Field Command that whatever dome volume might remain for contingencies would be used for Runit soil. The fission products survey was uncovering additional subsurface contamination on Boken and Enjebi which had not been considered in selection of a dome volume. The CJTG was directed to halt, temporarily, the containment of Runit soil after 5,720 cubic yards had been excised in less than 3 weeks.

The CJTG then requested approval of a plan to maintain an effective containment rate, clean Lujor to agricultural levels, and make the most productive use of available resources to clean Runit. The plan provided for excising and containing Runit soil over 160 pCi/g at the rate necessary to sustain efficient soil-cement operations (3,000 to 5,000 cubic yards per week), while stockpiling the Lujor soil for subsequent containment or backfill of the Fig-Quince area as circumstances indicated. The suggestion was based on the fact that all of the Lujor soil was less than the 160 pCi/g level established for surface contamination on Runit.[120] The suggestion was nearly identical to the original alternative c proposed by Field Command earlier in March 1979. The suggestion was rejected again on the grounds that the EIS did not specifically authorize the spreading of low-level excised soil from one island on another island. The Commander, Field Command issued new guidance to the effect that maximum effort should be exerted to excise, transport, and encapsulate Lujor soil and to transport and encapsulate soil and debris from Enjebi and Aomon. No more soil from Runit would be encapsulated at this time. To carry out this guidance, the CJTG would be required to insure selective excision of Lujor soil and optimize usage of boats for soil transport to Runit.[121]

The Director, DNA and the Commander, Field Command anticipated that future action to reduce transuranic levels on Runit would be possible, at least to reduce the "hot spots"; i.e., the areas which indicate increased levels of activity after the first excision. The CJTG was tasked to develop a plan for the selective excision of hot spots on Runit, with the focus on the Fig-Quince area. In preparing the plan, full consideration was to be given to: impact of additional work on Runit on the soil removal effort on Lujor; availability of equipment, personnel, and time to complete the soil removal plan for the Runit hot spots; and, the impact of the plan on crater fill and crater capping operations.[122]

As a separate but related matter, the CJTG reported that excavation of the Cactus Crater lip on the island side of the containment structure would be necessary to permit adjustment in the keywall alignment and proposed that this soil be encapsulated as it was excavated. This soil was initially thought to be highly contaminated. Field Command guidance directed stockpiling of any soil from the crater lip until such time as the determination was made on the disposition of all Runit soil.[123] Actually, this crater lip soil proved, in subsequent tests, to have very low transuranic levels; i.e., 5 pCi/g.

By mid-May, Boken and Enjebi soil excavation and transport to Runit were complete. The Aomon crypt had been cleaned and backfill initiated. All Aomon debris had been hauled to Runit, and Aomon soil transport operations were underway, with 8,300 cubic yards of soil remaining to be transported. Soil excavation was almost complete on Lujor, and 4,900 cubic yards of an estimated 16,000 cubic yards of soil had been transported to Runit. Considering dome space remaining and estimated soil yet to be encapsulated, it appeared that there still would be approximately 5,600 cubic yards of space available for Runit soil when that operation was renewed.[124]

On 25-29 May 1979, the Commander, Field Command visited Enewetak to review the cleanup progress and conduct a change of command. Colonel Kenneth E. Halleran, USA, replaced Colonel Robert Bauchspies as the

Commander, JTG. MG Tate reviewed the JTG plan for the selective excision of the Runit hot spots. Recognizing that the available dome space of approximately 6,000 cubic yards would not accommodate all the contaminated soil from Fig-Quince, the JTG had developed a sequential plan for excising one-sixteenth hectare areas having transuranic readings over 160 pCi/g, working from hottest to coolest areas (highest to lowest readings). The initial excision would be limited to 2,000 cubic yards to minimize the possibility that all of the contaminated soil stockpiled at Lujor and Aomon might not be encapsulated. Dome capacity permitting, subsequent lifts would be made based on DOE re-IMPing on a one-quarter hectare grid and new areas of highest readings determined. This procedure would be continued until all one-quarter hectare areas had been reduced to less than 160 pCi/g or dome capacity no longer existed. Once encapsulation of all soil ceased and capping operations became the critical path, the USAE would place a 12-inch blanket of relatively clean soil (less than 160 pCi/g) over the Fig-Quince area.[125] This plan for selective excision of contaminated soil in the Fig-Quince area appeared to offer the best opportunity to make a substantial change in the radiological condition of Runit within the available crater dome volume, considering the potential loss of volume to other possible excision requirements on Boken and Lujor growing out of the DOE Fission Products Survey (subsurface). On 1 June 1979, the Commander, Field Command approved the JTG plan, emphasizing that completion of the soil removal and the containment operation was essential to the accomplishment of the cap completion by 15 September 1979 and subsequent demobilization on schedule.[126]

Once all Boken, Enjebi, Aomon, and Lujor soil had been encapsulated, and the Fission Products Data Base Survey had shown no further soil to be excised, the Runit excision plan was put into effect. Survey results before and after the selective lifts are shown in Figures 8-36 through 8-42. The final result, after removal of 5,015 cubic yards of soil, was a 75 percent reduction in surface contamination in the Fig-Quince area.[127] Although this was probably the most highly contaminated soil excised on the atoll, no air sampler readings exceeded the action level of 10 percent of the maximum permissible concentration (MPC), with the highest reaching 0.04 MPC. On 26 July 1979, soil cleanup operations were terminated on Runit, and final capping of the dome commenced. A final radiological characterization of the Fig-Quince area was made by DOE-ERSP, and a 12-inch blanket of clean soil was placed over the excised area. As a final check, a complete surface characterization of Runit, using the IMP, was made by DOE-ERSP in December 1979.

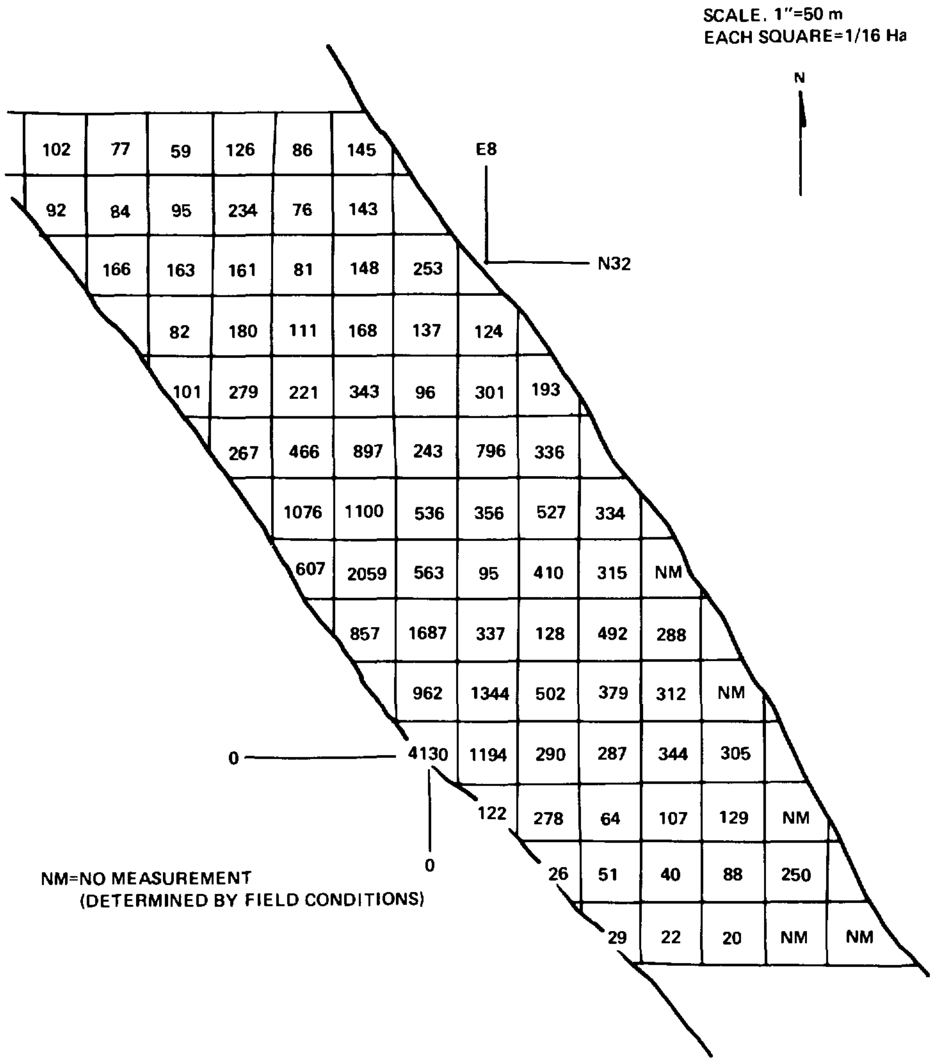


FIGURE 8-36. RUNIT FIG/QUINCE AREA PRE-LIFT TRANSURANICS.

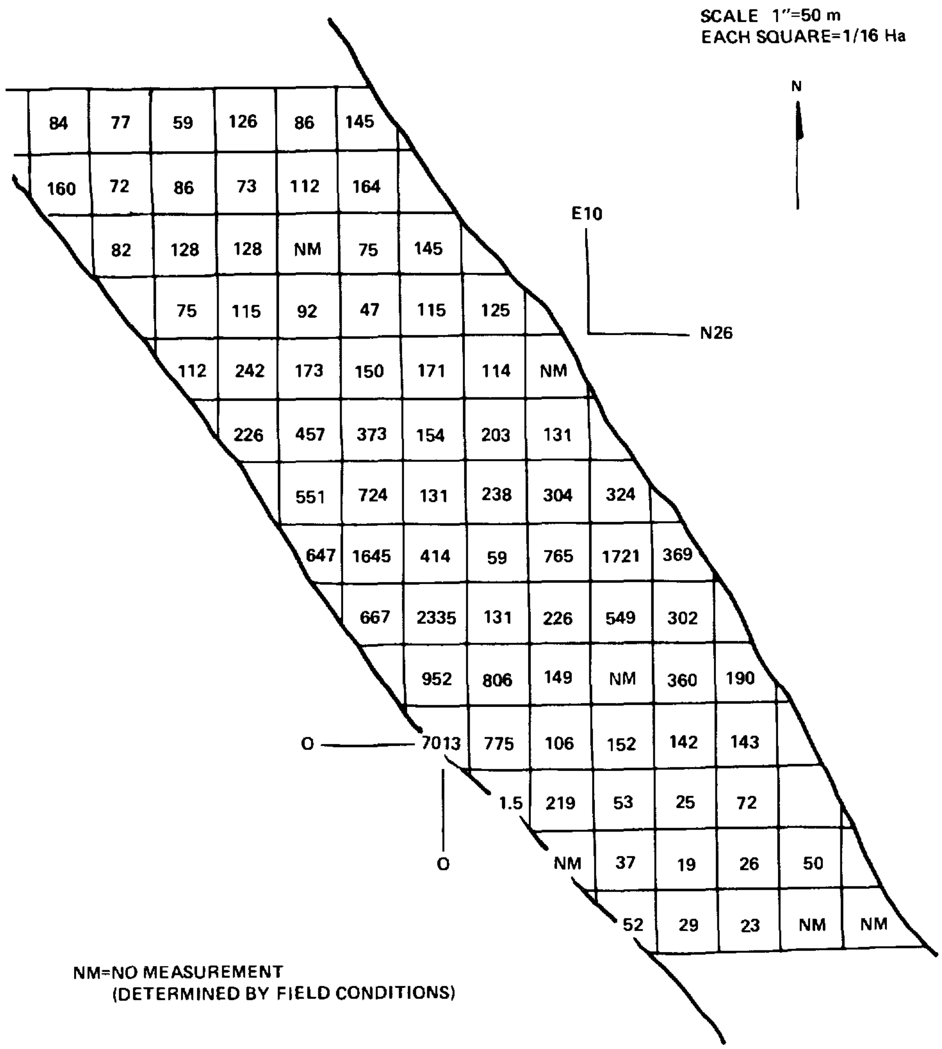


FIGURE 8-37. RUNIT FIG/QUINCE AREA POST 1ST LIFT.

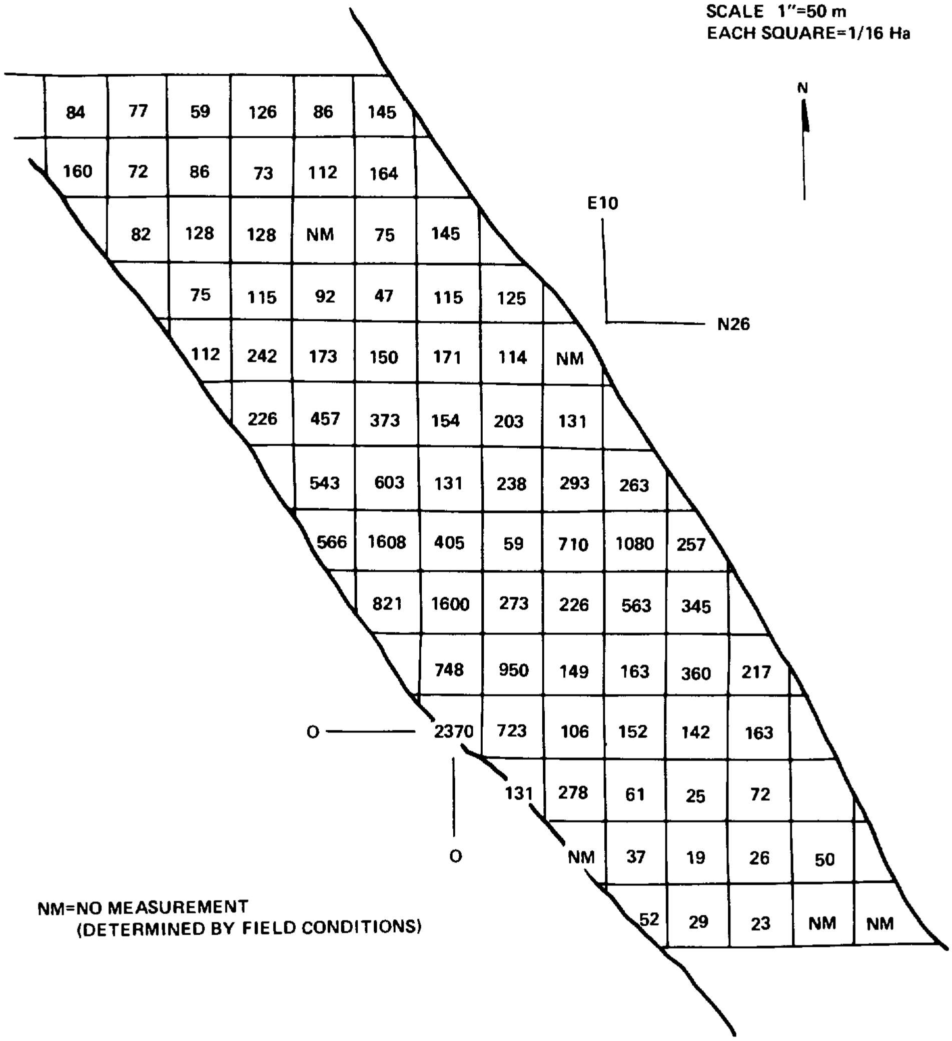


FIGURE 8-38. RUNIT FIG/QUINCE AREA POST 2ND LIFT.

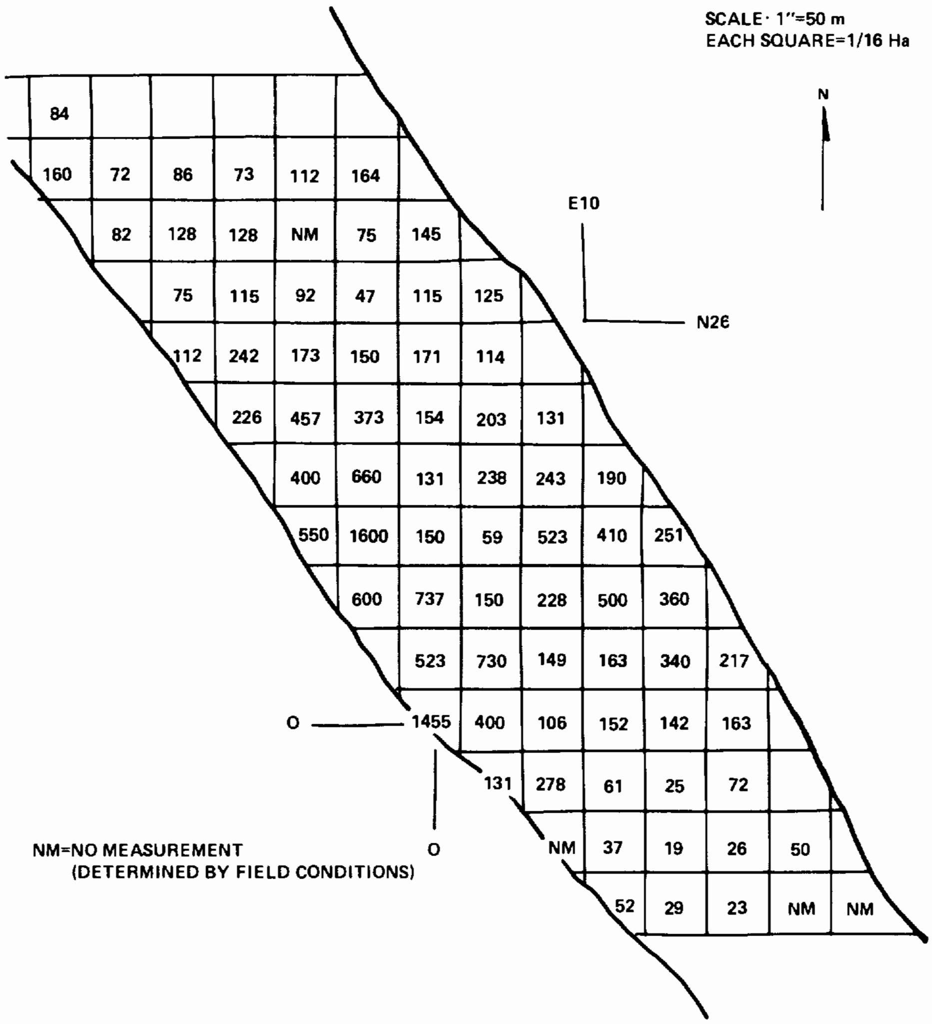


FIGURE 8-39. RUNIT FIG/QUINCE AREA POST 3RD LIFT.

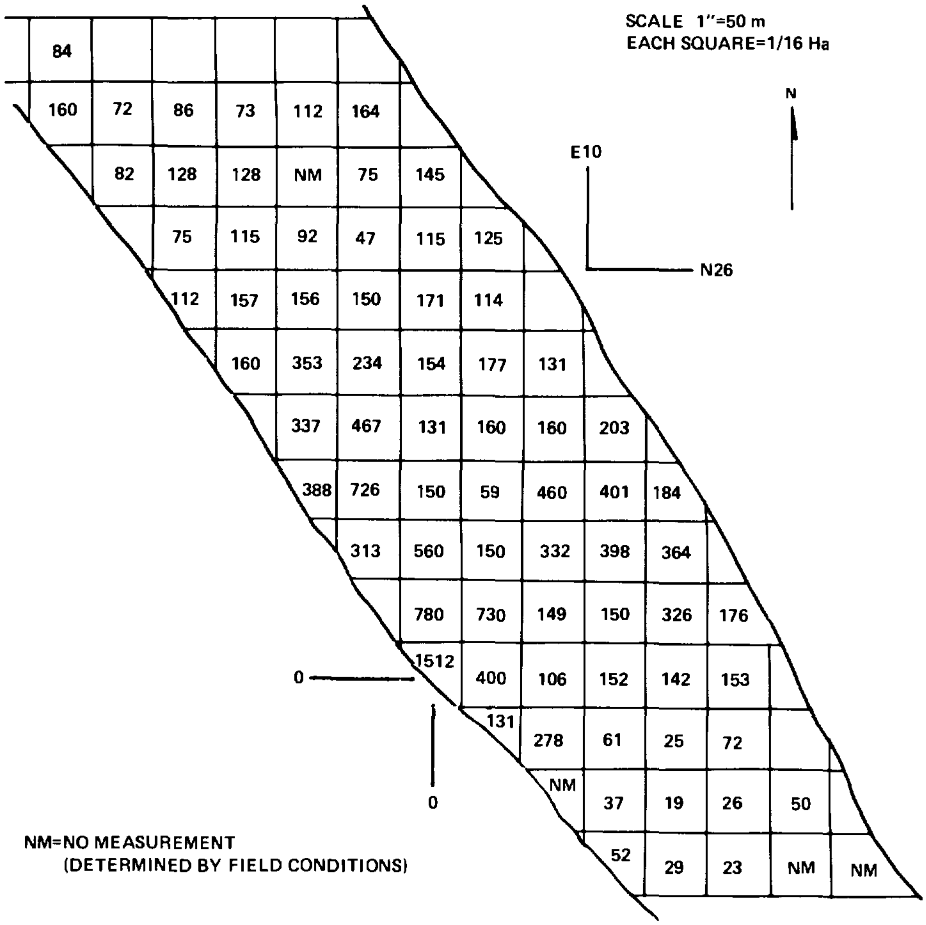


FIGURE 8-40. RUNIT FIG/QUINCE AREA POST 4TH LIFT.

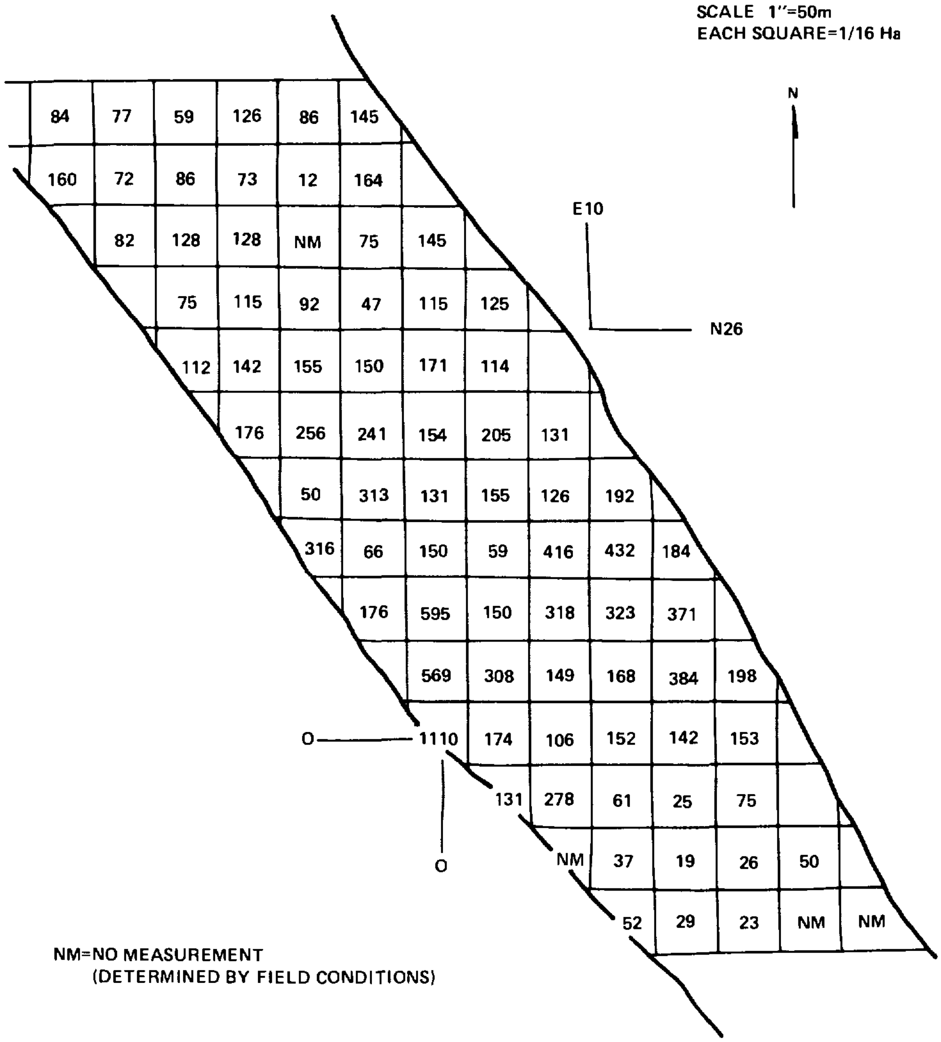


FIGURE 8-41. RUNIT FIG/QUINCE AREA POST 5TH LIFT.

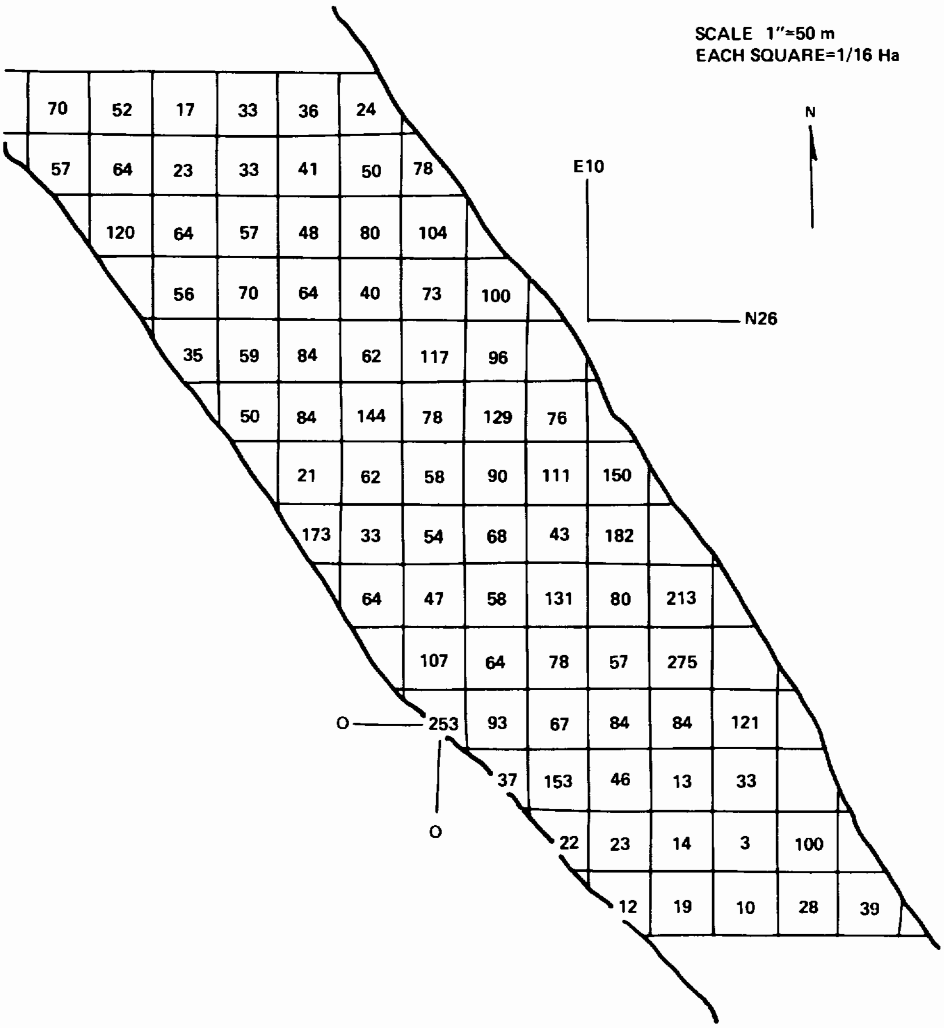


FIGURE 8-42. RUNIT FIG/QUINCE AREA POST BLANKET.

CAP CONSTRUCTION

The dome cap was designed to protect the mound of contaminated material from natural erosion by wind and water. The POD design prescribed a nonload-bearing surface of 18 inches of concrete with the same strength characteristics as the keywall. Reinforcement was not prescribed because the concrete was to be produced using salt water, which accelerates corrosion of ferrous reinforcing materials. The final design of the cap sections was left to the USAE. In keeping with good engineering practices, it was decided that each cap section should be as close to square as possible to minimize shrinkage cracking. The USAE decided to place approximately 20-by-20-foot sections in the first ring, and continue with that size until the shape of the dome dictated a reduction in size to keep the square shape of the individual sections. Each cap section was keyed to adjacent sections using forming techniques. The POD design required expansion joint material only where the first ring joined the keywall (Figure 8-43). The rings were designated by the letters "A" through "K," beginning at the keywall and extending up to the top of the dome.

The first sections of the "A" ring were placed in May 1979, before the Donut Hole was filled and before final soil-cement operations were completed (Figure 8-44). The initial 20-by-20-foot forms were fabricated on site by the USAE using heavy lumber. The forms were positioned by survey and anchored with pins driven into the soil-cement surface. Full forms were used on alternating cap sections. Intermediate sections required an end form only. The forms were 18 inches deep and contained a 4-by-4-inch tapered key (constructed using two 2-by-4-inch pieces of lumber) located from 7 to 11 inches from the bottom of the side form (Figure 8-45).

As the capping operation progressed, the use of 18-inch steel forms was recommended. These were purchased by Field Command and used through the remainder of the project. The key on the steel forms was approximately the same size as on the wooden forms, but was centered on the bottom third of the form. End forms of heavy lumber still were used in conjunction with the steel forms.

Once the forms were installed, the area within the form was brought to grade. The surface was then raked smooth and covered with polyethylene sheets to prevent absorption of water from the concrete. The forms were then lubricated to preclude their sticking to the concrete.

Concrete was placed directly from the transit-mix trucks (Figure 8-46) For rings "A" through "E," the transit-mix truck was held in place using the winch cable from a dozer. This was necessary because of the relatively steep slope of the lower dome and the deteriorating braking systems on the trucks. Spreading and consolidation of the concrete was accomplished

FIGURE 8-43. KEYWALL EXPANSION JOINT.

FIGURE 8-44. SIDE VIEW OF FORMS.

FIGURE 8-45. WOODEN CAP FORMS WITH TAPERED KEY.

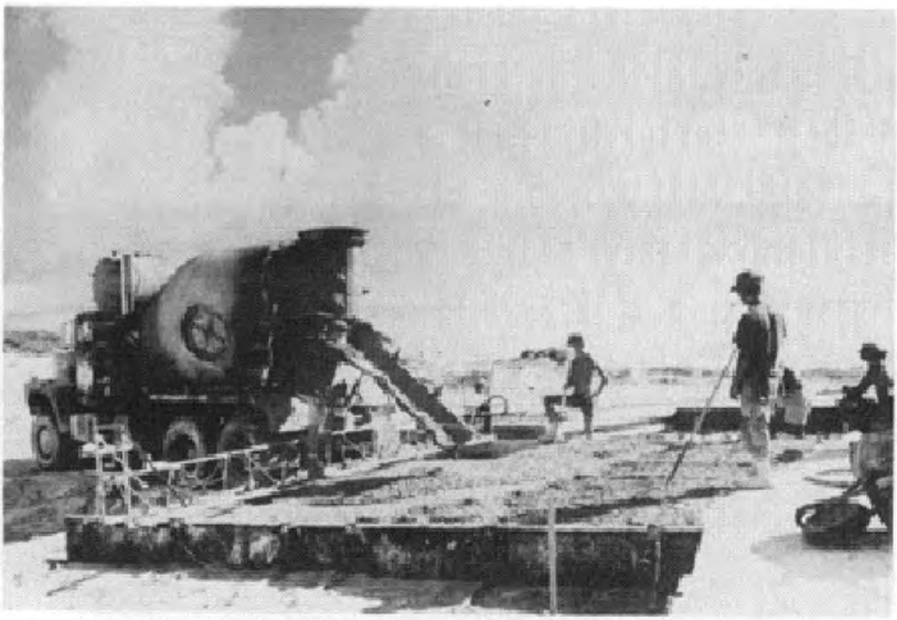


FIGURE 8-46. PLACING CEMENT IN CAP FORM.

using a standard column vibrator and vibratory power screed to dislodge entrapped air and prevent honeycombing. The power screed also provided a rough finished surface (Figure 8-47). Finishing was accomplished using a wooden screed followed by the working of the surface with a bull float. The final finish was applied using coarse brooms to provide a wearing surface (Figure 8-48). Edging trowels were used to finish the joints between adjacent sections. After the cap section was finished, curing compound was applied evenly over the entire surface.

Although soil-cement operations were finished 26 days later than scheduled, the time was made up during capping by utilizing additional manpower and equipment. The cap was finished on 6 September 1979, 9 days ahead of schedule. Over 6,000 cubic yards of concrete were used in construction of the cap itself (Figure 8-49).

Several problems arose during cap construction. While the first section was being placed, the concrete became extremely stiff and difficult to work. This was caused by the very high temperatures, which caused the concrete to hydrate much faster than normal. In order to slow down the rate of hydration, the USAE painted transit-mix truck drums white to reflect as much of the sun's radiation as possible and sprayed the aggregate and sand with water prior to mixing them with cement. The accompanying evaporation produced cooling and increased the workability of the concrete.

FIGURE 8-47. POWER SCREED.

FIGURE 8-48. BROOM-FINISHING A CAP SECTION.

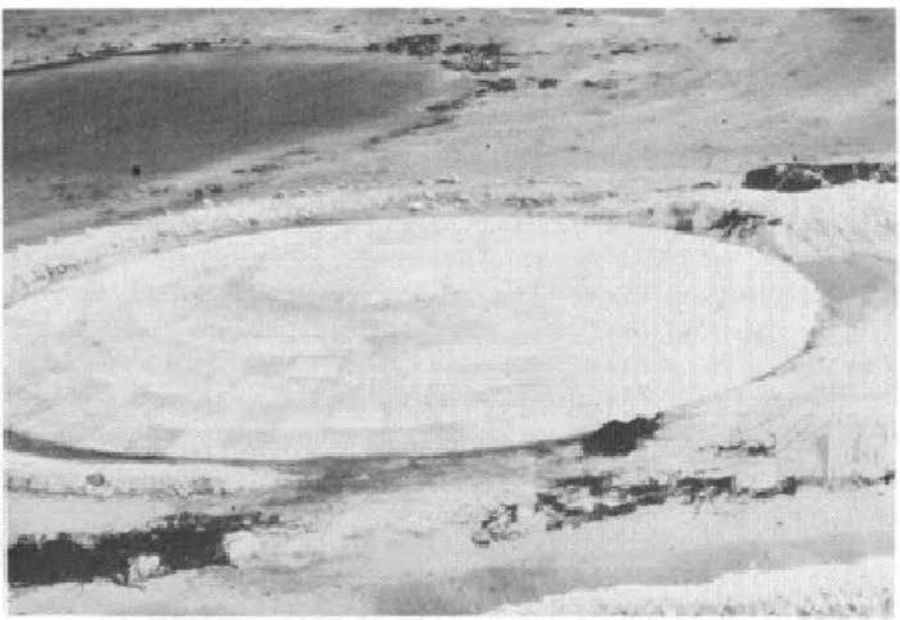


FIGURE 8-49. COMPLETED DOME CAP.

To assure that cap sections were 18 inches thick, a gauge was fabricated. It had the appearance of a huge comb with teeth 18 inches long. Projections on either end were placed atop the side forms before a section was poured and moved from one end of the section to the other. This moved the teeth across the surface to be capped so that any depressions or protrusions could be detected and corrected. After several sections had been placed, it appeared that some cap sections were turning out to be over 20 inches thick, and considerably more concrete was being used than was believed necessary. This appeared to be a result of the compaction of the disturbed soil under the tons of heavy wet concrete poured in each section which, in turn, would require more concrete to fill the form. To compensate for this effect, the teeth on the gauge were cut to 16-1/2 inches.[128] However, despite these procedures and findings, subsequent core sampling found that some sections varied, both thicker and thinner, from the specified thickness.[129]

ADDITIONAL DEBRIS CONTAINMENT

Failure to accomplish Runit debris cleanup earlier in the project began to adversely impact capping operations in August 1979. The USAE had been conducting what they believed to be the final sweeps to remove the last of the debris from the ocean reef of Runit near the Lacrosse Crater. Though this debris had been examined several months previously and found to be "yellow" (disposable by lagoon dumping), after it was removed from the water and allowed to dry, FRST screening disclosed that some of the debris was actually "red" (contaminated, requiring crater containment). It was the consensus of the USAE and the JTG that this small quantity of debris could be accommodated in the dome, despite the fact that capping operations were proceeding rapidly. Depressions were to be made in the surface of the mound to serve as dikes in which debris was to be placed and surrounded with concrete.[130] Properly executed, this would comply with the POD design. In some cases, however, debris was placed inside the cap section forms in such a manner as to extend above the surrounding soil level. Then, the concrete was placed in the cap section. Consequently, several cap sections contain pieces of contaminated metallic debris embedded in the concrete, with the result that less than 18 inches of concrete cover the debris. Inasmuch as the debris was placed in the bottom of the cap sections, it was concluded that spalling would be highly improbable. Also, since the dome was designed to contain the material and prevent erosion rather than act as a radiation shield, completely surrounding and encapsulating the material in concrete appeared to be in conformance with the intent and integrity of the structure. These conclusions were later validated by an on-site inspection by representatives of the Army Chief of Engineers, who concluded that the placement of metallic debris in some cap sections was "not detrimental to the adequacy of the concrete dome cap to provide the erosion protection intended."[131] Approximately 30-40 cubic yards of debris were contained in this manner, in and under the cap sections.

As the USAE mobilized more of its forces to complete policing of the debris on the ocean reef, the seasonal recession of the beaches revealed more and more debris, much of it proving to be red when monitored by the FRST. It was concluded from aerial and surface reconnaissance that far more red debris was being found than could be accommodated in the dome.[132,133] It was at this point that Field Command and HQ DNA first heard that red debris was actually going into the cap sections. The CJTG was directed to cease all such debris encapsulation in the cap sections. He was advised that further guidance would be provided on the method to be used for disposal.

POD was consulted and sent a representative to the atoll to study the problem. After on-site conferences with the JTG and USAE, a proposal was made to add a small extension to the containment facility on the island side (Figure 8-50).[134] This antechamber was to be constructed adjacent to the keywall with the same design specifications as the existing facility. The contaminated debris would be placed in the antechamber and choked with clean concrete slurry. An 18-inch cap would be placed on the chamber as in the dome cap construction.

The 7 September 1979 Field Command proposal to DNA was approved for execution on 17 September 1979, and the JTG tasked the USAE to construct the antechamber. Work began on 19 September on a 20-by-60-foot addition at the keywall (Figure 8-51). Aside from problems related to the water table, the work was completed without mishap. Complete sweeps of Runit and its reefs yielded approximately 120 cubic yards of contaminated debris, which were disposed of in the extension before it was sealed and capped.[135]

As the winter equinox approached, the beaches continued to recede. Two months after all capping operations were completed, more debris was exposed which, based on percentages in the previous Runit discoveries, could be expected to contain a substantial amount of contaminated material. The first indications were passed to Field Command by the JTG on 17 November 1979 in a report on seven pieces of red debris.[136] The CJTG recommended several alternative methods of disposal and requested disposition instructions. While awaiting disposition instructions, the stockpile of red debris continued to grow. By 1 December, about 4 cubic yards had accumulated. After considering proposals to seal the debris in drums and ship them to Johnston Island, leave them in place, or place

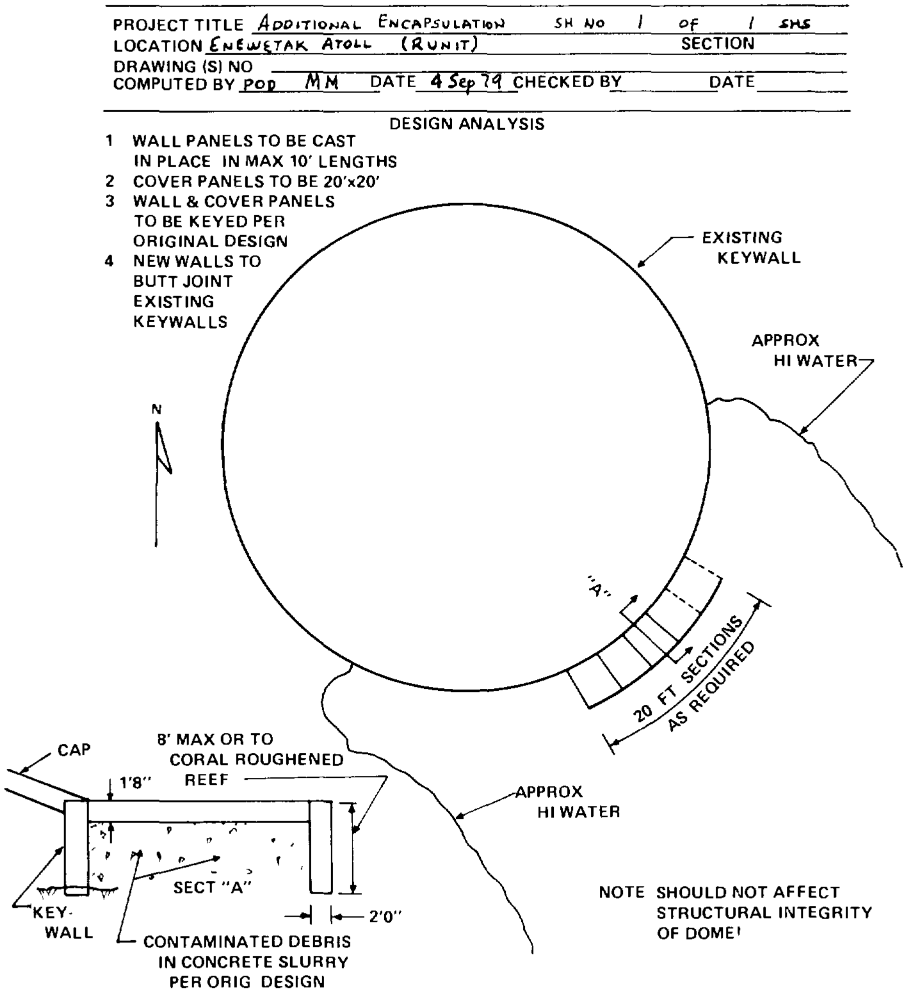


FIGURE 8-50. DESIGN FOR ANTECHAMBER.

FIGURE 8-51. CACTUS CRATER EXTENSION.

them in concrete bunkers,[137] Field Command established a disposal policy for any additional red debris on 17 December 1979.[138] Red debris was to be encapsulated in another section to be added to the lagoon side of the Cactus Crater extension. The new section would be designed to hold all red debris on hand and any additional debris that might appear through March 1980, and would be capped with an 18-inch concrete cover. Red debris would be collected and stockpiled until mid-February, at which time the USAE would construct the container and encapsulate the debris on hand. Space would be left unfilled to allow for encapsulation of any debris discovered after military forces were drawn down in February. At the end of March, just prior to project completion, the base support contractor would encapsulate any debris on hand and cap the new annex, conforming with the design and aesthetics of the previous extension. The second extension was constructed in February 1980 and consisted of approximately 13 cubic yards of space. Approximately 4 cubic yards of red debris were enclosed and slurried in place. On 31 March 1980, H&N returned to Runit, encapsulated an additional cubic yard of debris which had been collected in the interim, and capped the facility (Figure 8-52).

FIGURE 8-52. SECOND EXTENSION, CACTUS CRATER STRUCTURE.

EXCESS ATTAPULGITE DISPOSAL

As the container cap was being completed, another disposal problem became critical. Only 38 percent of the attapulgite anticipated in the design was used. This resulted in the need to dispose of over 14,000 bags which remained on the atoll. After several months of seeking local solutions, the JTG reported the excess in June 1979.[139]

Attempts were made to find other government agencies with a requirement for the attapulgite. One was located in Louisiana; however, it was determined that the cost of repackaging the bags, which had deteriorated badly at Enewetak, and shipping them to New Orleans would exceed the cost of new attapulgite. Other disposal methods, such as lagoon dumping or spreading it on the Fig-Quince area of Runit, were rejected on environmental grounds. On 13 September 1979, the JTG was authorized to seal the excess attapulgite in existing concrete bunkers on Runit. The bunkers were marked to identify permanently the material they contained.[140]

QUALITY CONTROL AND RESULTS

If there was an evident shortcoming in the construction portion of the project, it was in the quality control standards and procedures for the Cactus Crater container. Some areas of quality control were well executed. For example, directions and procedures for insuring that compression tests for concrete used in the keywall and dome were adequate, and the tests were documented. A total of 576 concrete cylinders were tested. The tests averaged 5,354 pounds psi with a high of 8,401 psi and a low of 3,298 psi, indicating a quality of concrete far exceeding the 3,000 psi design requirement. Penetrometer tests of the soil-cement reflected a bearing strength consistently in excess of the required 300 psi. On the other hand, no single individual was tasked with overall responsibility for assuring total compliance with the design specifications and adherence to the construction schedule or sequence, or for providing continuity, guidance, and supervision throughout the keywall and dome construction. DNA was designated, as the DOD Project Manager, to be the design and construction agent to supervise the execution of the project,[141] a task which normally would have fallen to the Corps of Engineers on a military construction project. In delegating responsibilities to Field Command, DNA was specific in the guidance for coordinating the preparations of plans and conducting the cleanup and assuring timely and adequate logistical support services.[142] However, there was no clear-cut delegation of the responsibility for providing professional civil engineer continuity, guidance, and expertise. Some at Field Command believed that DNA had retained this overseer responsibility. Others felt that it would be exercised through the establishment of the JTG, with its engineering section, and the designation of an engineer officer to be the JTG commander. Consequently, formal procedures for exercising this technical civil engineering responsibility were not institutionalized. When specialized technical expertise was required, the JTG generally would request assistance from POD.

As tremie operations were being completed in February 1979, HQ DNA tasked Field Command to establish a quality control program for concrete and soil-cement in order to assure the durability of the containment structure for a long period of time.[143] The CJTG reported that a concrete quality control program had been implemented in October 1978, and that concrete cylinders were being tested.[144]

In the concrete quality control program, the need to establish a system of controls during the tremie phase was not adequately highlighted. As related earlier, some oversize material and debris were pushed by bulldozer into the edge of the crater. Diver checks could not insure that these materials were fully encapsulated in slurry or that a monolithic mass resulted. Later, during soil-cement operations, contaminated soil and debris were placed in the Donut Hole without being recorded in daily inspection logs. Consequently, while indications are that the materials were encapsulated in slurry, there are no records that the procedures were checked or that managers were assured that the integrity of the containment process was being maintained.

An investigation by the Army Chief of Engineers after the dome was completed indicated that there were some deviations from the POD design and some construction deficiencies. However, according to the investigation conclusions, they did not affect the adequacy, durability, or use of the facility, and the structure was sufficiently stable to achieve the design intent.[145]

A subsequent, more thorough investigation by the National Academy of Sciences (NAS) was requested by the Director, DNA. Specifically, the NAS was asked to assess the effectiveness of the Cactus Crater structure in preventing harmful amounts of radioactivity from becoming available for internal or external human exposure and to recommend whether the assessment should be reviewed at intervals in the future.[146] Included within this assessment was an evaluation of the permanence of the structure and an assessment of the concentration of radioactive materials contained therein. In March 1980, a team from the NAS visited the atoll to conduct a series of tests to develop information with which to provide their assessment. These tests included the taking of core samples of the dome and keywall and coring in depth through the soil-cement and tremie fill of the crater and dome. Preliminary review of the core samples indicated that, while the concrete was of high quality, there were some keywall and tremie deficiencies which could affect the durability of the crater portion of the structure. On the other hand, there were no indications that the dome would not fulfill its intended purpose, and there was little reason to be concerned over the leakage of radiological materials which might result in internal or external human exposure.

FINAL QUARANTINE

Upon completion of the Runit cleanup, it was the consensus of all concerned (DNA, DOE, DOI and the Enewetak people) that Runit should remain quarantined indefinitely. There were no overt hazards, radiological or otherwise, that were known on the island or its adjoining reef, and there were no other cleanup actions that could be recommended responsibly. However, the possibility would always exist that high levels of plutonium-contaminated subsurface soil could be exposed by wave or storm action. The legal counsel for the Enewetak people, Mr. Ted

Mitchell, stated it best on several occasions—that foregoing future use of Runit Island was the people's contribution to the cleanup. In the Enewetak Return Ceremony, described in Chapter 9, Iroij Johannes Peter stated that, henceforth, the people would consider the island of Runit to be "OFF-LIMITS." Thus, although it appears that the material in the storage container does not constitute a potential hazard and that surface levels of plutonium concentrations have been reduced to prescribed standards, plutonium concentrations exceeding DOE guidelines still exist at subsurface levels, and Runit should remain quarantined.

CHAPTER 9
DEMOBILIZATION

EARLY PLANNING EFFORTS

Demobilization of manpower and materiel upon completion of the Enewetak Cleanup Project was covered by only a few procedural paragraphs in the annexes of the Field Command, DNA Operations Plan 600-77 (OPLAN 600-77). Soon after his arrival at Field Command in July 1977, BG Tate requested that detailed plans be developed for demobilization. Initial efforts to develop the plan were fairly pro forma. Outlines and skeleton drafts were prepared and dispatched for coordination and additional input but generated little interest. With more immediate problems, including the growing uncertainty as to when soil cleanup operations might begin, most Field Command and Service action officers felt it was premature to begin planning for actions at least 2 years downstream.

The work of demobilization was primarily logistics oriented: razing base camp facilities; disposing of excess materiel; and shipping personnel, equipment, and supplies to other locations. The Field Command Logistics Directorate began coordinating with its counterparts in other agencies to develop plans for accomplishing that work. Demobilization planning began by defining the condition desired at the end and identifying, in reverse chronological order, the actions necessary to achieve that end condition. On 6-7 July 1978, Field Command planners met with Mr. Charles P. Nelson, Holmes & Narver's, Inc. (H&N) manager for the Trust Territory of the Pacific Islands (TTPI) Rehabilitation Program, to identify the condition required at Enewetak after demobilization actions were complete.[1]

Mr. Nelson provided guidance for disposition of facilities at the Runit work site, Lojwa Base Camp, and Enewetak Base Camp, based on his recent meeting with the Enewetak Planning Council. Maps of Enewetak (Fred) Island were annotated to identify those facilities that would remain after demobilization. Further review indicated that these remaining facilities would be adequate to support a work force of 200 to 400 through completion of the project with only minor adjustments. Power, water, communications, billeting, medical, petroleum, oil and lubricants (POL), and boat facilities would remain essentially intact. Some changes would be required to continue laundry and food service support on a temporary basis while the permanent facilities for the functions were being dismantled.[2] With the main objective and strategy identified, development of detailed plans for deactivation of the main camp was deferred until a meeting could be scheduled with the other agencies involved.

Meanwhile, the Field Command planners were coordinating with the Defense Logistics Agency and Service action officers to develop plans for disposition and retrograde of materiel. Procedures were developed to utilize the Defense European and Pacific Redistribution Activity system for redistribution of excess property between agencies participating in the cleanup and rehabilitation effort.[3] A system was developed for reporting and compiling all necessary data on potential retrograde material so that maximum use could be made of nonreimbursable U.S. Navy sealift.[4] On 29 June 1978, the Commander, Joint Task Group (JTG) convened a meeting of representatives from all activities on the atoll to obtain their proposals and questions regarding demobilization in preparation for the first all-agency demobilization planning conference.[5]

1-9 AUGUST 1978 CONFERENCE

On 1-9 August 1978, representatives from the several agencies, commands, and contractors involved in the Enewetak Cleanup Project and Rehabilitation Program met at the atoll to develop plans for cleanup and inactivation of the base camps, for support of forces remaining during the period of demobilization, for redeployment of personnel, and for disposal or retrograde (i.e., return shipment) of materiel. Following a general discussion of goals and policy, the conferees were briefed on the results of previous planning efforts, including identification of those Enewetak Camp facilities which were to remain after demobilization. Most of the cluster of buildings around the three-story barracks were to remain, with varying degrees of modification, to form the core of the dri-Enewetak community center (Figure 9-1). They also could be used by the JTG until late in the project, then released, as required, for modification by the TTPI Rehabilitation Program contractor. There were facilities in the core for offices, billeting, medical services, communications, and recreation for most of the forces remaining through demobilization. The industrial area of shops and warehouses would be more of a problem since it would be the site for construction of several homes. Alternate facilities would have to be found for maintenance and storage activities.

After the basic strategy was outlined, the conference was divided into working groups: a communications group to plan demobilization of the primary facilities while continuing to provide minimum essential service; an engineer group to develop detailed schedules and plans for removal and modification of buildings and utilities; and a logistics group to develop plans and procedures for disposition of excess property, shipment of

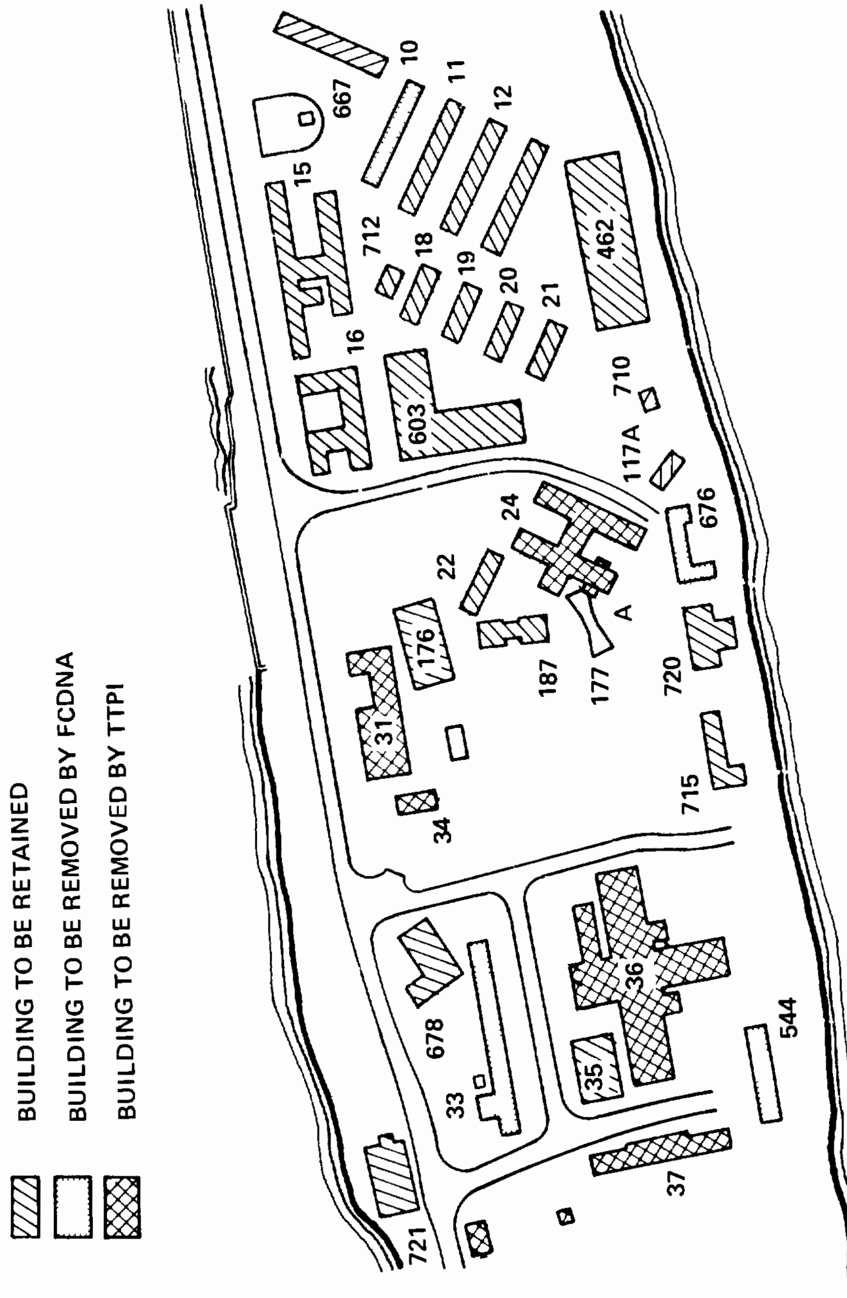


FIGURE 9-1. ENEWETAK CAMP CORE AREA CLEANUP.

personnel and materiel, phasedown of base support services, and to develop the text for the basic plan. It was decided to issue the demobilization plan as an annex to the basic cleanup project operations plan. It was designated Annex Y to OPLAN 600-77.

During the conference, it became apparent that there would be some life support and base support facilities which could not be demobilized until such time as supported forces no longer required their use and which would require time to demobilize after the last of the cleanup forces departed. For example, the billets and food service facilities, which were required to house and feed 200 troops through the night before they departed, could not be dismantled and disposed of overnight. The base support contractor, H&N-Pacific Test Division (H&N-PTD), would require time to demobilize these remaining support facilities. This effort, referred to as the contractor's "rollup," was not considered part of the cleanup project since it could not be accomplished until after the JTG departed. It was agreed that separate plans would be prepared for the rollup effort.[6]

It was decided that Lojwa Camp would be inactivated about 1 October 1979 and that all personnel, including those working on Runit, would be billeted on Enewetak. TTPI had requirements for most of the Lojwa Camp electrical distribution system, and the dri-Enewetak wanted the materials from the temporary buildings which the JTG had planned to raze and burn. It was agreed that the JTG would remove all nonexcess government property from Lojwa Camp, after which TTPI and the dri-Enewetak would complete the cleanup of the camp in exchange for the remaining building materials. Similar exchanges of cleanup work for equipment were made for the power plant and telephone exchange at Enewetak Camp.

It was decided that the Enewetak dining hall (Building 36) would be phased down incrementally as the population decreased. This would allow the rehabilitation contractor to dismantle sections of the building for materials required to complete the community center and to clear the site for a house. Industrial laundry support would be acquired from Kwajalein Missile Range beginning in November 1979 to permit removal of the Enewetak Camp laundry from the site where two houses were to be constructed.

The procedures being used by Field Command for radiological monitoring and decontamination at Johnston Atoll were adopted for all materiel shipped from Enewetak in order to insure that no contaminated items were released for uncontrolled use. Detailed procedures were developed for screening, redistribution, and disposition of property (Figure 9-2).

One of the uncertainties of planning for demobilization was the time it would take to complete soil cleanup, which had begun on Enjebi only 3

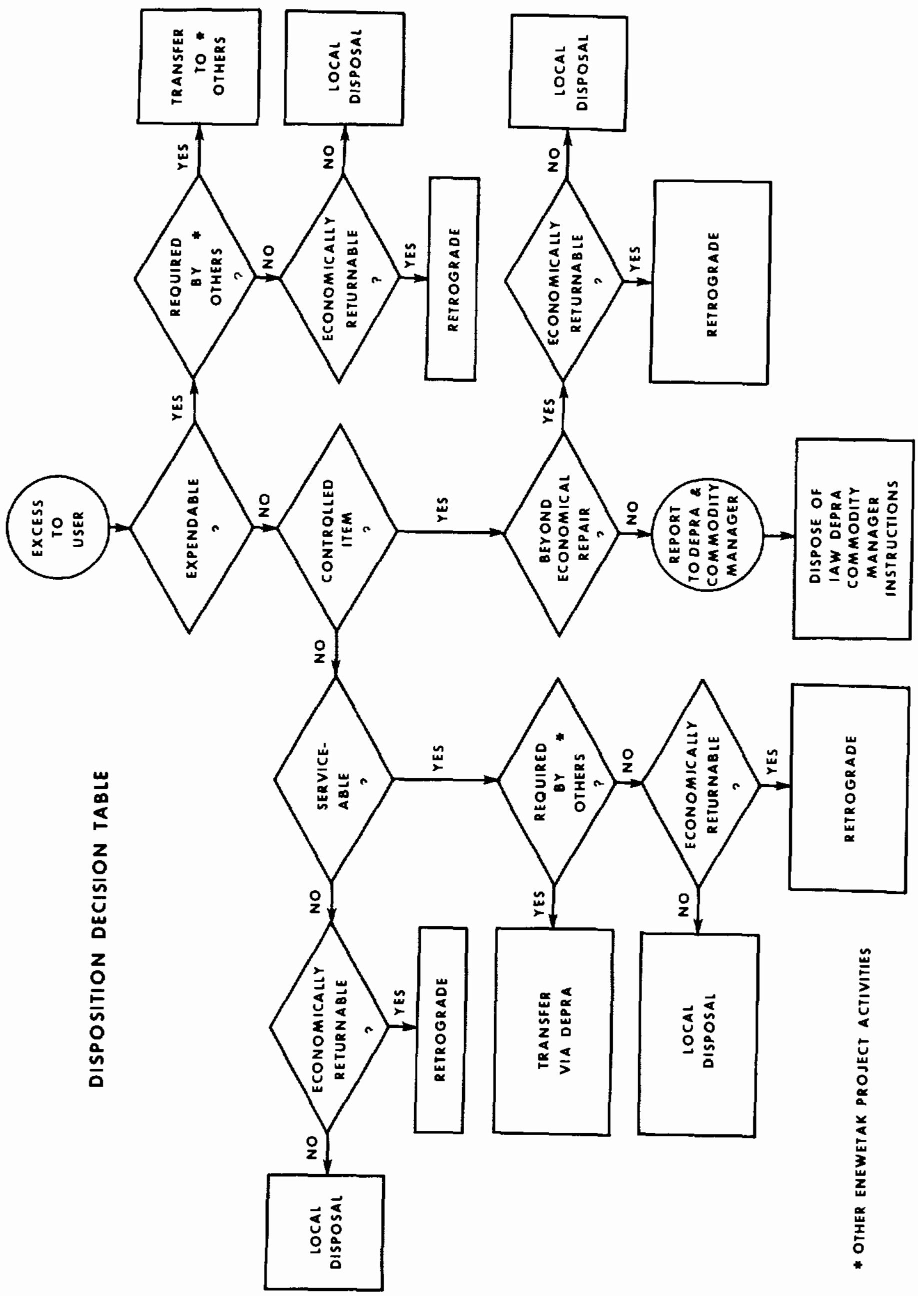


FIGURE 9-2. DISPOSITION DECISION TABLE.

weeks before the conference. The conference representatives were asked for comments on the impact of extending the project and on how far in advance would they require notification that it would be extended.[7] The Department of Energy (DOE) and H&N-PTD advised that there would be no adverse impact. The Services advised that there would be minimal impact in extending the project to as late as 30 September 1980 since they were funded for project support through Fiscal Year 1980 (FY 80). The organizations which an extension would have adversely affected were TTPI and their prime rehabilitation contractor, H&N. If the construction contract with American International Constructors, Inc. (AIC) could not be completed on Enewetak Island because it was impeded by unfinished cleanup work, AIC could insist on an expensive extension to their contract. It also was anticipated that Rehabilitation Program funds would be depleted by April 1980.[8]

Although there were a few technical problems remaining to be solved, the only issue not resolved at the conference was when to terminate helicopter support. The Army believed it could be eliminated as soon as cleanup work was complete on the islands other than Enewetak The Defense Nuclear Agency (DNA) desired to retain some helicopters for search and rescue and medical evacuation (MEDEVAC) support right up until the last Department of Defense (DOD) personnel departed the atoll. This issue was deferred for resolution at the next planning conference. The August 1978 conference achieved much more than expected, producing a complete draft demobilization annex in less than 6 days. A briefing on results of the conference was presented at Headquarters, Pacific Air Forces on 14 August 1978 for interested officials from the Hawaii area.[9]

14-15 NOVEMBER 1978 CONFERENCE

The second all-agency demobilization conference was held in Albuquerque on 14 November 1978 to resolve the remaining issues and to finalize the demobilization annex. It was agreed that the Army LARCs and two helicopters could be retrograded on the September 1979 sealift. Two helicopters would be retained until the end of the project.

The financial appendix to Annex Y was completely rewritten to identify exactly which demobilization costs would be financed by Military Construction (MILCON) funds. It appeared that MILCON funds probably would not cover all demobilization costs; however, the Service representatives advised that their FY 80 budgets probably were adequate to finance those costs not covered by MILCON funds. It was agreed that any major increases in project costs due to increased workload or new tasks would require a conference of all participants to determine how to finance them.[10]

Requirements for support of the contractor's rollup operations also were discussed at the conference. It was agreed that the Military Airlift Command (MAC) would continue to provide channel airlift support as long as it was required by Field Command. U.S. Air Force representatives also agreed to provide communications equipment until the end of rollup operations if the Mid-Pacific Research Laboratory (MPRL) communications equipment proved to be inadequate. At least one LCM-8 landing craft and one YC barge would be required and manned by H&N-PTD during rollup to dispose of scrap from dismantling the remaining life-support systems and buildings. It was agreed that these craft could be retrograded on the summer 1980 Navy opportune sealift if they were still serviceable.[11]

Based on the conference, Annex Y was finalized and published on 18 December 1978. A revision was issued four months later to reflect changes in manning and cleanup operation schedules resulting from addition of the Fission Products Data Base survey and cleanup of Lujor for agricultural use.

RETROGRADE PLANNING

The vast majority of equipment to be retrograded from Enewetak was owned by the Army. In March 1979, the project officer for Headquarters, U.S. Army Material Development and Readiness Command (DARCOM), Mr. Ralph B. Lehman, scheduled a series of conferences in San Francisco and San Diego, California, to coordinate equipment retrograde actions with transportation and supply agencies.

At the San Francisco conference on 12-14 March 1979, policy, procedures, and schedules were developed to identify and inspect material for retrograde prior to each Navy sealift (Figure 9-3). Seventy days prior to each Navy task group arrival at Enewetak, Army depot technicians would inspect equipment at Enewetak that would be available for retrograde on that convoy. Concurrently, Field Command would conduct a joint survey by representatives of Government activities in the Pacific area, including the Defense Property Disposal Region-Pacific (DPDR-PAC), Wake Island, Johnston Island, Kwajalein Missile Range, and the TTPI. They would inspect potential excess and arrange for its transfer or disposal as appropriate. The Army depot inspectors were authorized to make on-site decisions on Army-managed items to be retrograded or disposed of as salvage or excess. Procedures were coordinated with Military Traffic Management Command representatives to arrange for transportation and routings from the Naval Supply Center in San Diego, where the ships would be offloaded and the cargo forwarded to final destinations.[12]

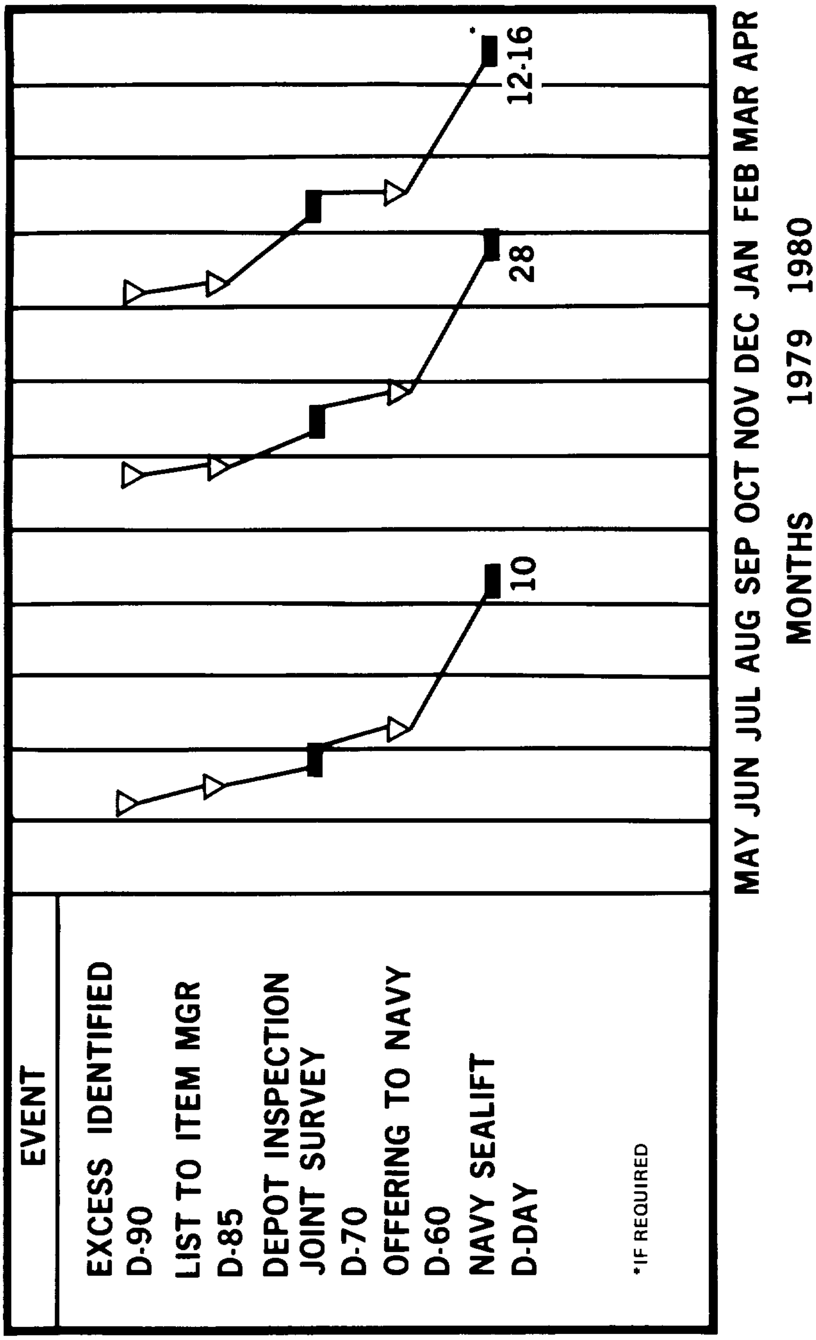


FIGURE 9-3. NAVY SEALIFT SEQUENCE OF EVENTS.

At the San Diego conference on 14-15 March 1979, arrangements were made with the Naval Supply Center to provide port handling services to augment ships' crews in offloading retrograde from the Navy ships and to provide freight forwarding services. It was agreed that United States Army Western Command (WESTCOM) would deploy equipment operators via the Navy ships to drive the equipment off the ships at San Diego. The Commander, Naval Forces, U.S. Pacific Fleet (COMNAVSURFPAC) representatives at the conference advised that their sealift support for the Enewetak Cleanup Project was considered a COMNAVSURFPAC mission rather than an opportune sealift and that the sealift scheduled for April 1980 would be a dedicated sealift with enough capacity to remove all remaining retrograde.[13]

DEMOBILIZATION BEGINS

Within 2 weeks after the retrograde planning conferences, the first significant demobilization sealift was accomplished. On 26 March 1979, an Amphibious Squadron (PHIBRON) returning to the United States after a Western Pacific tour of duty, met with the westbound squadron which was to relieve it in the Enewetak lagoon. This rendevous, called a PHIBRON turnover, involved 13 ships. The cargo planning officer for the convoy, Captain Terrance Labar, USMC, had arrived by aircraft 6 days earlier to work with the JTG Logistics Officer, J-4, Lieutenant Colonel James H. Rogers, USA, and the H&N Supply Officer, Mr. Jack Livingston, in planning the loading operation. This on-site planning preceded each Navy sealift of retrograde material and was essential to assure safe, efficient loading of the Navy vessels. The cargo planning officer knew exactly what space was available for loading on which ships and any height or load limits. Enewetak logistics personnel provided the dimensions, cube, and weight for each piece of cargo to be loaded. Based on this information, the loading sequence and location for each item could be preplanned.

Several lessons were learned on the March 1979 sealift. An attempt was made to begin loading cargo before offloading was complete. Facilities and manpower on Enewetak could not support simultaneous operations, requiring some lighters to circle in the lagoon until they could be offloaded. Since they were unfamiliar with JTG decontamination and certification procedures, one ship's crew felt it necessary to remonitor each item before it was loaded aboard the ship. A total of 531 measurement tons (M/T = 40 cubic feet), weighing 83 long tons, was retrograded on this convoy.[14,15]

JUNE 1979 JOINT SURVEY

On 19-22 June 1979, 9 months before the project was due to end, representatives of various agencies conducted the first joint survey of equipment and supplies which would become available for redistribution as they became excess to Enewetak Cleanup Project requirements. Agencies represented included HQDNA, DARCOM, DPDR-PAC, the Department of Agriculture (USDA), WESTCOM, COMNAVSURFPAC, Kwajalein Missile Range, TTPI, the Government of the Marshall Islands (GMI), Field Command, and the JTG. The survey was conducted in conjunction with an inspection by depot technicians of 80 Army items scheduled for retrograde in September 1979. Based on their deteriorated condition, 60 items, including dump trucks, tractors, and construction equipment, were identified for local disposal. Other items surveyed included excess and salvage material from the Enewetak Consolidated Supply Account; recreational club equipment at Lojwa Camp; and commercial laundry and food service equipment which would become excess as the base camps were inactivated. Requirements for these items were submitted to the JTG J-4 by the participating agencies. It was discovered later that the nomenclatures on the requests were difficult to identify with specific items being offered. This problem was solved on subsequent surveys by using JTG-prepared listings to request excess.[16]

Representatives of the GMI identified a considerable amount of excess construction material which was urgently required at Kwajalein Atoll and Majuro Atoll to repair essential public utilities. When the dri-Enewetak learned that actions were being taken to transfer property to other atolls in the Marshall Islands, they were quite concerned. They did not understand the policy that U.S. Government excess must be used on U.S. Covernment-funded programs such as those in the TTPI and believed that all excess should be left for the dri-Enewetak to use or market. Transfer of excess to GMI was delayed for several months while TTPI representatives worked with the people's attorneys to resolve the matter. Arrangements were made whereby the GMI furnished some sealift for the dri-Enewetak between Enewetak and Ujelang in exchange for dri-Enewetak agreement that some excess could be used on other atolls.[17]

To expedite screening and disposition of surplus and salvage items, the DPDR-PAC representative, Mr. George Fisher, developed simplified evaluation and reporting procedures. His personal efforts greatly facilitated prompt, effective redistribution and disposal of the Enewetak project excess. Simplified procedures also were approved by HQ DARCOM for disposition of U.S. Army excess through local Enewetak channels.[18]

The USDA representative was briefed by MPRL officials concerning biota found at Enewetak and by JTG officials on the inspection and cleaning procedures used on retrograde shipments. He reported that these measures were more than adequate to assure that Enewetak shipments would have no problem passing USDA inspections at U.S. ports of entry.[19]

During the period 22-28 June 1979, the USS ALAMO provided wet-well repair service to the U.S. Navy Element (USNE) craft at Enewetak. In addition, the ship loaded 2,894 measurement tons of retrograde cargo for Pearl Harbor and 1,585 measurement tons for San Diego, including a disabled Army LARC-LX. The disabled craft was towed by another LARC-LX from the beach at Enewetak to the USS ALAMO during the hours of darkness without incident.[20,21] Personnel from the U.S. Army Element (USAE), USNE, and H&N-PTD worked well into the night to complete loading of retrograde aboard the ship.

MONITORING AND DECONTAMINATING RETROGRADE

One of the primary concerns of radiological control was to assure that contaminated equipment was not removed from a radiologically controlled island to an uncontrolled island within the atoll. Before equipment was removed from a controlled island, it was monitored by the Field Radiation Support Team (FRST) and, if necessary, decontaminated before being released. The release of an item was logged in the FRST Team Chief's report for the island. This procedure also was used for retrograde of equipment from controlled islands during most of the project.

Prior to monitoring, all equipment had to be cleaned by the owning or using activity to remove accumulated mud, grease, oil, concrete, or other foreign matter that potentially could trap contamination or could interfere with monitoring. To determine fixed contamination, the equipment was monitored with portable field instruments for alpha, beta, and gamma activity. The amount of removable contamination was determined by using paper swipes to wipe an area of 100 square centimeters. Then, the swipes were analyzed for alpha and beta activity either in the FRST laboratory or in the J-2 office.[22]

The areas to be monitored and/or swiped were selected as those locations most likely to contain or entrap contamination, such as radiators, floor boards, air cleaners, and wheel wells of vehicles. Contamination limits for release of equipment to clean areas were based on draft American National Standards Institute Standard Number N328-1976 as amended by DOE-NV. Limits were as follows:

Alpha: 1000 dpm/100 square centimeters fixed or 20 dpm/100 square centimeters removable.

Beta:	5000 dpm/100 square centimeters fixed or 200 dpm/100 square centimeters removable.
Gamma:	15 μR/hr fixed.

As the project drew to a close, the emphasis shifted to preparing equipment for retrograde from the atoll. FCRR Standing Operating Procedure 608-14, Radiological Certification of Enewetak Atoll Retrograde Equipment, 18 March 1979, was published to provide a more elaborate system of record keeping and certification for all equipment.

All equipment identified as having been on a radiologically controlled island at any time during the cleanup project had to be certified as noncontaminated by the Radiation Protection Officer (RPO) or his alternate prior to its release for unrestricted use off the atoll. Equipment which was on a radiologically controlled island was monitored and certified as it was removed from the island. Since all of this equipment had to pass Runit en route to Enewetak, Runit was established as the central cleaning point for retrograde. Steam cleaners were borrowed from the base support contractor until the USAE's own high-pressure solvent cleaners were delivered. After they arrived, the solvent cleaners were used until they succumbed to the harsh climatic conditions and long hours of operation. A high-pressure air/salt water system using an air compressor and a venturi nozzle was fabricated by the USAE and used most effectively for the remainder of the cleaning operation on Runit.[23]

To minimize transportation of equipment within the atoll, a second cleaning area was established on Enewetak Island for equipment used there. Before a piece of equipment was cleaned, it was monitored by instruments and released to the wash rack. If any possibility of contamination was found during the initial monitoring, the equipment was returned to Runit (Yvonne) for decontamination. Only one such piece of equipment was sent to Runit with any measurable contamination, although below the limits for retrograde. Although most of this equipment was noncontaminated, it was cleaned to remove grease, dirt, and other foreign matter to allow a higher degree of confidence in the measurements.

Since another air compressor was not available, a fire truck was pressed into service to provide a high-pressure stream of salt water for the Enewetak facility. This method also proved to be quite successful, allowing the cleaning and certification of much equipment to be accomplished in a relatively short period of time. Items which could not be decontaminated were disposed of as contaminated debris. Prior to release of an item of equipment for unrestricted use off the atoll, the JTG RPO or his alternate reviewed the results of the monitoring and swiping to insure that the readings were all within the established limits. The RPO or alternate then signed a prepared statement which identified the equipment and certified that it could be released for unrestricted use. The original certificate was kept by the JTG Radiation Control Division, while two copies were provided to the using or owning activity. Shipping documents accompanying retrograde equipment which had been used in controlled areas were annotated to reflect that the equipment had been certified for unrestricted use off the atoll.[24]

As retrograde cleaning got underway, the basic philosophy developed within the JTG J-2 and FRST was that, not only did the equipment have to be radiologically clean, but it also had to look clean to a casual observer. From this philosophy, very stringent standards of physical cleanliness developed and prevailed throughout the processing of retrograde. Meeting these standards was a major challenge for the various owners and operators of equipment. Meeting the cleaning standards required much dirty, grimy, greasy, unpleasant work, sometimes in cramped, hot spaces under vehicles or inside engine compartments of boats. The lesson that vehicles and equipment could be cleaned to the exacting standards required had to be learned, in turn, by each of the major organizations which had equipment to be retrograded.

As each organization went through the learning process on cleaning, there were complaints that the standards were too strict, unnecessary, and impossible to meet. In some cases, differences of opinion between FRST and the individuals doing the cleaning led to heated discussions over the standards and procedures, and the adversary relationship that developed caused some morale problems. As the success of the retrograde cleaning became more apparent, many of the difficulties were overcome, only to reappear as a new organization started cleaning their equipment for retrograde.

The 8th Radiation Safety Audit and Inspection Team inspectors recommended that the equipment which had never been on radiologically controlled islands be certified in some manner. It was decided that the owners of such equipment could certify that their items had never been on a controlled island.

SEPTEMBER 1979 SEALIFT

On 3-4 September 1979, the USS FORT FISHER called at Enewetak to pick up retrograde cargo. Army depot inspectors had determined that over half of the items originally scheduled for retrograde in September were not economically repairable. A total of 4,065 measurement tons was shipped via the FORT FISHER. There were 345 measurement tons for Johnston Atoll, 1,685 for Pearl Harbor including two helicopters, and 2,035 for San Diego including two Army LARCs. The Johnston Atoll cargo included sheet pile salvaged from the Aomon Crypt project to repair seawalls at Johnston Atoll and two IMPs to be used in a planned radiological survey of Johnston Atoll.[25,26]

SEPTEMBER 1979 QUARTERLY REVIEW

On 11-18 September 1979, a quarterly review of cleanup and rehabilitation work was conducted, including a walk-through of representative islands by the Enewetak Planning Council, Field Command, TTPI, Micronesian Legal Services Corporation (MLSC), H&N and AIC representatives. Several demobilization issues were resolved including a decision by the council that the hangar should be removed. Since it had been severely damaged by tropical storms, the building now represented a potential hazard. Concepts for a ceremony to mark the return of the atoll to the people also were discussed with the Council. This quarterly review was typical of many which were held with the dri-Enewetak, affording their representatives the opportunity to be actively involved in the total planning process for the project. These sessions also enabled the dri-Enewetak to review the work progress and to submit modifications to the lists of facilities to be razed based on current condition, newly recognized needs of the people, and potential salvage value. Their modifications were presented to the JTG and rehabilitation project contractors in the form of resolutions, which bore the approval of the Enewetak Planning Council.

On 18 September 1979, the Deputy Director, DNA visited the atoll to review demobilization plans and progress. A Columbia Broadcasting System crew also visited the atoll during the quarterly review to videotape a program on the Enewetak Cleanup Project,[27] which was to be later broadcast nationwide on the "60 Minutes" program. This crew also traveled to Ujelang Atoll for the Dose Assessment Conference described in the next chapter.

DOE-ERSP DEMOBILIZATION

As the island radiological surveys were completed, DOE-Enewetak Radiological Support Project (DOE-ERSP) personnel strength at Enewetak was steadily reduced until the end of September 1979 when the last member departed. Two IMPs were retrograded on 4 September 1979. The third was retained for the final IMPing of Runit between 24 October and 14 December 1979 by temporary duty ERSP personnel. The radiological laboratory was deactivated on 12 September 1979. Samples collected after that time were sent to Eberline Instrument Corporation in Albuquerque for analysis.[28,29]

LOJWA (URSULA) ISLAND CLEANUP

The demobilization phase of the project schedule began on 15 October 1979. Two of the major tasks to be completed were the final dismantling of the forward base camp at Lojwa and the main base camp at Enewetak. Lojwa consists of 40 acres and it had been used as a base camp to support preparations for nuclear tests in the vicinity. Vegetation was dense in the central portion of the island, nearly covering the concrete slabs which remained after the test period. The Engineering Study identified 90 Master Index items and 170 cubic yards of noncontaminated debris for cleanup action. In addition, most of the base camp facilities constructed during mobilization were to be removed during the demobilization phase. Lojwa was to be used by the people for commercial agriculture.[30,31]

On 13-14 October 1979, all personnel stationed at Lojwa Camp were relocated to Enewetak Camp except for a small contingent from Company A, USAE. The contingent, assisted by a DARCOM technician, removed the four 500 KW generators and associated switch gear from the Lojwa power plant and placed them on semitrailers for transport to Enewetak by LCU. Upon completion of this task, this contingent relocated to Enewetak on 20 October 1979. The remaining tasks on Lojwa and Runit were supported from Enewetak Camp. JTG forces dismantled and removed from Lojwa that material and equipment scheduled for retrograde and disposed of the resulting scrap residue. Serviceable excess quarters furnishings were shipped to Medren for storage for the dri-Enewetak. Upon completion of these actions and DOE certification of the island, Lojwa Camp facilities reverted to the TTPI in accordance with the United States use agreement for final disposition under the TTPI Rehabilitation Program.[32,33]

Contractor personnel removed utility poles, transformers, and other equipment required for government programs elsewhere in the TTPI. On 12 October 1979, 44 dri-Enewetak workers arrived from Ujelang Atoll. Under TTPI management, they dismantled 52 temporary buildings and salvaged the reusable materials. The USNE made 14 LCU trips to transport 393 bundles of the material to Medren for subsequent delivery to Ujelang Atoll. Ten buildings and five concrete slabs were left in place at the request of the dri-Enewetak Planning Council.[34] H&N-PTD completed the removal and disposed of the remaining building slabs and, in early April 1980, accomplished the final cleanup of scrap and debris from Lojwa.

A total of 1,302 cubic yards of debris was removed from the island to dump site Bravo, and 813 cubic yards of concrete rubble were placed as shore protection. DOE-ERSP soil survey of Lojwa indicated that surface contamination was less than that required for Condition C, qualifying the island for residential use without soil cleanup.

RUNIT (YVONNE) WORK SITE CLEANUP

Removal of the temporary buildings at the Runit work site began in early October 1979.[35] Concurrently, the FRST and USAE were monitoring and decontaminating equipment from the northern islands, including Runit, for return to Enewetak Camp. Some items, such as the transit-mix trucks, could not be adequately cleaned and monitored. They were badly deteriorated and beyond economical repair. They were disposed of as yellow debris rather than risk release of contaminated items for uncontrolled use. Although hot line facilities were removed in mid-November 1979, Runit continued to be treated as a controlled island.[36]

Final cleanup of the Runit work site, originally scheduled for completion in mid-October, was delayed by the need to construct additional containers adjacent to the Cactus Crater containment structure for disposal of red debris discovered on the island and reef after the dome had been capped. The task was completed the last week of December 1979.[37]

NOVEMBER 1979 JOINT SURVEY

The second joint equipment survey was conducted on 6-9 November 1979 following an inspection by Army depot technicians. The technicians classified all of the remaining major items of Army equipment in preparation for demobilization of the USAE. Only 41 of 224 major items were determined to be economically returnable to the Army supply system. The remaining items were either being phased out of the Army system, beyond economical repair, or not worth the cost of retrograde. Of these, 150 items were offered for redistribution during the November 1979 joint equipment survey along with several hundred other items of minor equipment and supplies which were salvage or excess to the requirements of the other cleanup project participants.[38]

Navy inspectors initially determined that eight of the watercraft were sufficiently serviceable to warrant consideration for return after the project. Further analysis at COMNAVSURFPAC eliminated seven of those, leaving only one YC barge to be returned at the end of the rollup effort. The remaining watercraft were transferred to Field Command for local disposal or redistribution to other Pacific area activities. The only major items identified by the Air Force for retrograde were the communications equipment, two POL trucks, and the aircraft loading equipment.[39]

During the joint survey, decisions were made for disposition of most of the materiel which would be remaining at the end of the project. Jointly funded recreation equipment was to be distributed among the Services for use at other military reservations. Much of the equipment purchased for the base camps by Field Command was to be shipped to Johnston Atoll to replace unserviceable and obsolete items there. A water distillation unit, generator, and several trailers were identified for use in expanding the MPRL and making it self-sufficient, since it would remain in service on the atoll. Much of the medical, food service, laundry, and other institutional equipment was identified for transfer to other United States-funded programs at Kwajalein Missile Range, Majuro Atoll, and other locations in the TTPI. Innumerable items of furniture and supplies which could be used by the dri-Enewetak were to be stored in buildings or open storage areas designated by the Municipal Council. By the end of the joint survey, it appeared that almost all of the equipment to be returned to the military services could be retrograded, if it was not required for cleanup of the Enewetak base camp, on the January sealift.[40]

ENEWETAK (FRED) ISLAND CLEANUP

Enewetak is the largest island in the atoll. It consists of 322 acres and was the DOD support base during the nuclear test period. The Engineering Study identified 310 Master Index items and 27,513 cubic yards of noncontaminated debris for disposal. Enewetak was scheduled to be used as a residence by the dri-Enewetak.[41,42]

Efforts to clean up Enewetak Island began in March 1976, when base camp facilities were prepared to support a steady increase in population, and continued through the Mobilization Phase (Chapter 3). Approximately 22,000 cubic yards of commercial scrap was removed from the island by the salvage contractor in 1978. Almost 5,000 man-hours of cleanup work on the island were accomplished by TTPI's rehabilitation contractor in exchange for rehabilitation work accomplished by the JTG on the northern islands.[43] JTG element efforts to remove debris from

Enewetak and the adjacent reef were accelerated in June 1979 as northern island cleanup operations were ending.

Two suggestions by H&N-PTD were implemented to improve debris disposal procedures. First, a dozer was placed on the BC barge and debris was loaded around it. At the dump site, the dozer would push the debris overboard. It could push up to 500 cubic yards of material overboard in less than 30 minutes compared to 1-1/2 days required for a crane to offload the barge. Next, to reduce barge loading time and offset a shortage of operational dump trucks, dump truck beds were salvaged from uneconomically repairable 20-ton trucks and placed on flatbed trailers to be loaded with debris. Cranes lifted the loaded dump beds and deposited the debris directly on the barge.[44]

In August 1979, a USAE 12-1/2-ton crane with clamshell was positioned on two connected USNE floating causeway sections to assist the Water Beach Cleanup Team in recovering debris from shallow water. Debris was picked up with the crane and loaded on the causeways for transport to the dump site. The crane-causeway combination could deliver 300 to 500 cubic yards of debris per trip to the dump site. It replaced the hazardous and less efficient system of dragging debris ashore, trucking it to the cargo pier, and barging it to the dump site.[45]

Numerous concrete slabs and all of the aircraft aprons were removed well ahead of schedule to permit early planting of coconut trees. On 27 October 1979, the JTG Command Group, plus the J-1 and J-3 offices, were moved from Building 15 to trailers on the fringe of the core area to permit conversion of Building 15 to a dri-Enewetak Council Hall. The Base Exchange was moved to three trailers near Building 462. On 24 December 1979, the J-2 and J-4 offices were moved to the trailer complex so that Building 16 could be rehabilitated.[46]

With the end of the project in sight, the troops were accomplishing the final camp cleanup much more quickly than anticipated. In mid-October 1979, the Commander, JTG was informed by the element commanders that all remaining USAE and USNE tasks would be completed on or about 15 December 1979 (Figure 9-4). These tasks, scheduled for completion on 1 April 1980, would be complete 3-1/2 months early. The element commanders therefore recommended major reductions in strength on 19 December 1979, leaving only those personnel necessary to accomplish the 29 January 1980 retrograde sealift and contingency missions, such as Explosive Ordnance Disposal and equipment maintenance. The cleanup project would essentially be completed on 15 February 1980 rather than 15 April 1980.

The Commander, Field Command, Brigadier General John H. Mitchell, was briefed on the proposed new demobilization schedule during his 6-8 November 1979 visit to the atoll. The work remaining to be accomplished

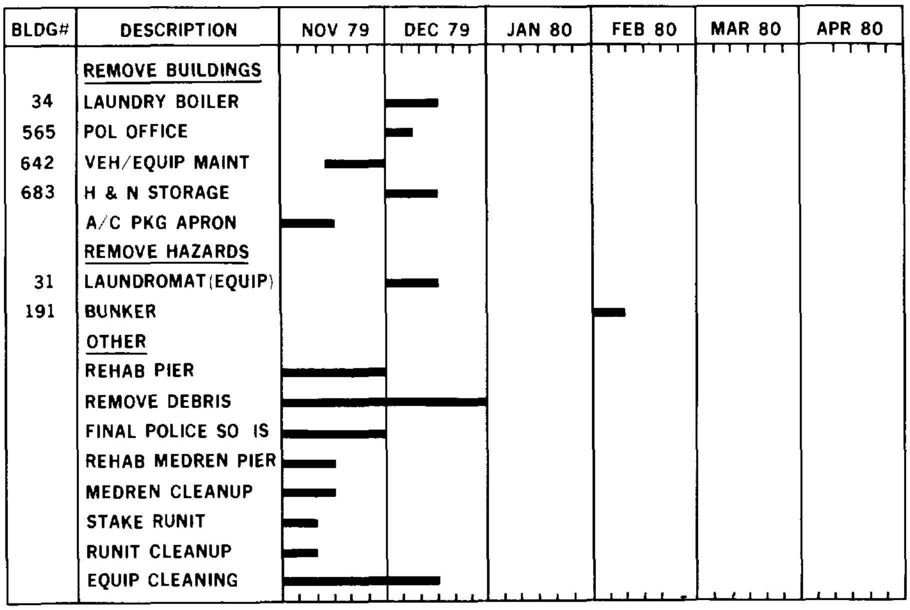


FIGURE 9-4 ARMY TASKS (ANNEX Y).

was reviewed in detail. Several tasks were identified which could be accomplished by the USAE rather than by one of the contractors. In keeping with the intent of Congress to minimize costs by using troop labor, these tasks were reassigned to the USAE (Figure 9-5).

One major unfinished task was the removal of the hangar, Building 118, which had been damaged by typhoons and now constituted a potential hazard. It was agreed that H&N-PTD would dismantle the highest portion of the building, which required skills not available in the USAE, while the USAE would complete the dismantling and removal of the hangar. The work began on 19 November 1979 and, by the end of the week, 95 percent of the aluminum sheeting had been removed and stockpiled for use by the dri-Enewetak.[47] By 15 December 1979, in a period of 4 weeks, the huge hangar had been completely dismantled, the metal stockpiled or disposed of in the lagoon, and the concrete pad ripped up and used as beach and shoreline protection. That same week, the last one of the fuel storage tanks which were not to remain for the people also was removed.[48]

On 10 December 1979, an all-agency conference was held in Albuquerque to revise demobilization plans based on the accelerated progress being made by the JTG. Several issues with the potential to impact on the momentum of the demobilization effort were discussed. A major tropical storm could strike in the closing days and cause damage

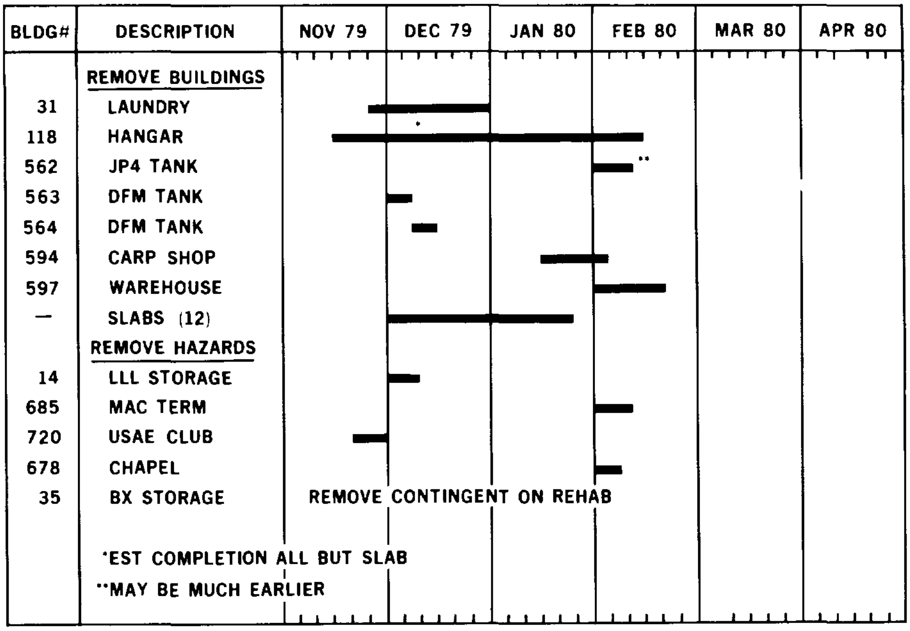


FIGURE 9-5. ARMY TASKS ADDED. 7 NOV 1979.

beyond the capability of the remaining work force to clean up. Early deployment of JTG manpower and resources might adversely impact DNA's obligation to support the rehabilitation program and to assure the completion of all cleanup tasks, including those for which TTPI had assumed responsibility from the JTG. A recently discovered error in the soil survey analysis might require additional soil cleanup on the northern islands. Additionally, DNA was especially interested in retaining two helicopters for search and rescue and MEDEVAC missions during tree-planting operations on the northern islands and for support of additional red debris containment operations on Runit if necessary.

The conferees agreed that the two helicopters would remain until after the 8-9 April 1980 return ceremony; that the Military Services cleanup effort would officially end 29 February 1980; that the contractor's rollup would begin 1 March 1980; and that, should the correction of DOE's soil survey data or the ongoing investigations of crater containment require it, cleanup forces would return on a TDY basis.[49] Annex Y was subsequently revised to reflect the acceleration of demobilization actions.

The acceleration of the demobilization effort by the JTG was particularly beneficial in terms of insuring project completion by 15 April 1980. During the demobilization planning in early 1979, it became clear that a contractor rollup period would require about 45 days after the departure of all DOD forces. Thus, with a planned cleanup completion and a departure of DOD forces on 15 April 1980, rollup was not scheduled for completion until about 30 May 1980. The Director, DNA had hoped that all project activities, including rollup, would be completed by 15 April 1980. With the acceleration of the withdrawal of the DOD forces and the start of the contractor's rollup activities on 1 March 1980, most of the rollup activities would be moved forward to the period before 15 April 1980, thus meeting the commitment to complete all project activities by 15 April 1980 more fully.

Meanwhile, work at the atoll progressed rapidly. The troop-operated laundry was closed, and the building was removed to permit construction of homes on the site. The FRST trailer was moved to the core area, and the remaining radiological support trailers were relocated for other uses. By the end of December 1979, over half of the cleanup forces had departed, decreasing the island population from 947 before Lojwa Camp was closed in October to 425 on 31 December 1979.

On 6 January 1980, the sixth and last fatality during the project occurred. Specialist Four Leo E. Morris, of Headquarters and Headquarters Company, 84th Engineer Battalion, was discovered lying in his bed, apparently unconscious. Resuscitative efforts by the doctor from the Enewetak Medical Clinic failed to revive him and he was pronounced dead from apparent aspiration of the lungs on his own vomitus, and then suffocation. Specialist Morris' remains were flown to Hickam AFB, Hawaii, later in the day, and memorial services were held at the Enewetak Base Chapel.

Later in January 1980, the Air Force Communications Service (AFCS) deployed an AN/TRS-94 satellite communications van to Enewetak to permit the existing system to be demobilized. Two AN/TRC-96 vans also were deployed, but neither could be made operational with the teletypewriter equipment. The satellite system provided a far more reliable and better quality of communications than the installed system which was used during most of the project.[50]

The final Navy sealift of the Enewetak Cleanup Project was loaded during the PHIBRON turnover of 25-29 January 1980. A total of 4,387 measurement tons of cargo was retrograded to Johnston Atoll, Pearl Harbor and San Diego on the USS THOMASTON and USS JUNEAU. Despite adverse weather conditions, the loading was completed on schedule through the superb efforts of the USNE, USAE, H&N-PTD, USMC combat cargo officers, and PHIBRON personnel.[51]

ENEWETAK ATOLL SEISMIC INVESTIGATION (EASI)

Analysis of the Pacific Cratering Experiment (PACE) and the Exploratory Program on Eniwetok (EXPOE) results in June 1977 indicated a need for additional crater investigations to develop a comparison between airblast and crater-related kill/damage probabilities against hard targets. Since the backbone of the empirical data base craters were those in the Pacific and included Mike, Koa, and Oak Craters at Enewetak, it was important to determine the credibility and relevancy of those craters as a data base. Following a period of technical review, it was decided at DNA in October 1979 that additional crater investigations would be undertaken. Despite the fact that demobilization of the cleanup force was already underway, the presence of substantial resources on the atoll in support of the cleanup requirement provided an excellent opportunity to conduct the additional investigations at minimal cost.

The concept for the test required the deployment of an overwater/overland seismic telemetry system to study crater formation, refraction, compaction, and profiles. The technical investigation and the operation of the telemetry system were contracted to Fairfield Industries, Inc. The test direction, operational aspects, and support responsibilities were assigned to Field Command. Dr. Byron Ristvet, of the Test Directorate, Field Command, was assigned as the Technical Director and was assisted by Captain Robert Couch, USAF, Air Force Weapons Laboratory, Kirtland AFB, the Deputy Technical Director.

With the demobilization effort in an accelerated state, the remoteness of the EASI operational area; i.e., northern islands from Enjebi west and south beyond Bokoluo to the Oak Crater, the safety and well-being of the project personnel were paramount. Potential hazards to the EASI operation were great. Isolation of the EASI team, austere support in the northern islands, limited communications, hazards of operations at the northern and western reefs, adverse weather and the possibility of typhoons, harsh climate, environmental and health hazards, and other potential dangers emphasized the high-risk nature of the project and mandated detailed planning and coordination with the JTG. Additionally, the difference in risk between operations at the Mike and Koa Craters, near Enjebi, and those at Oak Crater, remotely located on the western reef, prompted an operational decision that initial operations would be conducted at the Mike and Koa Craters and, after experience was gained there, Field Command would decide whether or not any operations at Oak Crater would be attempted.[52]

After discussions with the project participants and the JTG, Field Command recommended to DNA that a small base camp be established on Enjebi to support the project. Basing on Enjebi would permit more effective operations in terms of time available for the survey and minimize wear and tear on boats, fuel consumption, and interference with final cleanup, demobilization and rehabilitation tasks. The support requirements included: dedicated boat support (LCM-8, two whalers) for a 45-day period; billeting and messing support; generators; fuel supply; intra-atoll communications; minor welding and carpentry support; emergency medical support; and evacuation provisions in a contingency situation. The survey was scheduled for the period 12 January 1980 to 26 February 1980. A mobile trailer was moved from Enewetak Island to Enjebi to provide billeting and shower facilities for the 15 participants who would camp there. One trailer was already permanently installed at Enjebi to support the tree nursery. Portable, tactical radios were assigned to the team to provide communications support from the base survey vessel, the LCM-8, to the whalers and to the base camp on Enjebi, as well as to provide 24-hour communications from Enjebi to the Enewetak Island base camp radio control station. Emergency MEDEVAC support was provided by the helicopters attached to the JTG and H&N provided personnel for messing support and to operate the boats. Food resupply runs were established to insure a supply of fresh food was available at Enjebi. Prior to the arrival of the technical survey crew, a 48-hour test of the communications system was performed and constant communications were maintained throughout the period.

On 11 January 1980, a C-141 MAC special mission flight took off from Ellington AFB, Texas, for Honolulu with the survey equipment, contractor personnel, and Field Command representatives. On 13 January, the flight departed Honolulu for Enewetak. On arrival, all of the personnel participating in the project were briefed by JTG representatives on the environment, safety considerations, communications systems, area of operations, MEDEVAC provisions, weather and tides, occupational and health hazards, and recreational activities. After equipment preparations, the survey team joined with the H&N personnel and moved to the northern camp at Enjebi on 17 January 1980.

By 4 February, EASI survey operations were complete at the Mike and Koa Craters and, based on operational experience, Field Command authorized the conduct of overwater multipak and refraction surveys at the Oak Crater.[53] Despite some periods of high winds and heavy wave action during which operations were suspended, the measurements at Oak Crater were completed on 21 February 1980, 3 days ahead of the planned completion date. The navigation stations and towers which had been emplaced to support the various surveys were demobilized and, on 22 February, the base camp at Enjebi was vacated. All contractor-supplied equipment was packed and crated and, on 26 February, the EASI participants departed Enewetak by C-141 for Honolulu and subsequent return to Houston, Texas.

Even though cleanup demobilization efforts accelerated greatly during the January-February time frame and, in fact, all military personnel were scheduled to depart by 28 February 1980, the EASI project was supported and completed successfully with no adverse impact on the completion of the cleanup project. While analysis of the technical data obtained during the survey is ongoing, preliminary indications are that the data is of high quality and that the accomplishment of the EASI project has provided significant contributions to the understanding of cratering mechanics and effects.

COMPLETION OF CLEANUP OPERATIONS

On 5-8 February 1980, the final quarterly review was conducted with the dri-Enewetak municipal and planning councils, the Chief Secretary of the GMI, Field Command and TTPI representatives to assure that all remaining cleanup work was identified prior to departure of the Military Service elements.[54] The review found that all remaining work had been scheduled and was being accomplished well ahead of schedule. Army and Navy elements were reduced to the minimum essential to complete their remaining cleanup tasks.

The watercraft which had been declared unserviceable by all concerned were disposed of by the USNE prior to their departure. The week of 10 February 1980, four landing craft and three miscellaneous craft were sunk at dump site Alpha. Prior to their departure, the USAE policed all beaches and cleaned out the burn dump at Enewetak Camp.

A trailer chassis was discovered on Ribewon (James) Island in early February 1980. The last LARC had been retrograded on the January sealift, and the island was unapproachable by landing craft. Two men were airlifted to the island by helicopter to burn the tires and cut the chassis into pieces which could be lifted by helicopter. The residue was dumped at site Alpha by helicopter.[55]

On 15 February 1980, H&N-PTD assumed responsibility for POL and airfield operations from the Air Force teams. On 27 February 1980, the remaining military service cleanup forces, with the exception of those required to support rehabilitation and rollup operations, redeployed from Enewetak Atoll. In the 27 months since the Cleanup Phase began, they had accomplished the hazardous cleanup plus a considerable amount of work identified as cosmetic cleanup. The cleanup had been accomplished 1-1/2 months earlier than anticipated in OPLAN 600-77, despite typhoons, organizational difficulties, logistics problems, and other delays.

In accomplishing the cleanup of Enewetak Island, the JTG disposed of a total of 132,780 cubic yards of hazardous and obstructive debris.This total includes 22,000 cubic yards which were removed by a scrap contractor and 49,340 cubic yards which were used as shoreline protection.

ROLLUP BEGINS

The departure of the Service elements reduced the Enewetak Camp population to approximately 250, including 37 military, 99 base support contractor, and 98 rehabilitation contractor personnel, and permitted H&N-PTD to begin the final rollup of base support and life support facilities. On 28-29 February 1980, HQ JTG offices were relocated from the trailers to the three-story barracks, Building 462. The three office trailers, plus three latrine trailers and eight billet trailers, were burned and the residue dumped at site Alpha.

The first day of March was the first official day of rollup, and austerity became the watchword. The tactical switchboard and field telephones went into operation. On 6 March 1980, the Tradewinds Club (Building 721) was converted to a temporary messing facility and the dining hall (Building 36) was removed. Building 24, which had served as an officers quarters and Army element headquarters, was vacated and dismantled to provide materials for the rehabilitation effort. H&N-PTD maintenance and warehouse functions were relocated to Building 679, which the dri-Enewetak had selected to remain. The former shop and storage facilities were razed to permit construction of homes.[56]

On 15 March, as scheduled, the power and water distillation plants were shut down. From this point on, all electric power was generated by mobile generators located near the billeting, office, and other work facilities requiring power. Two distillation units were installed on a covered slab, and fresh water production continued on a smaller scale.

Rollup continued at a rapid pace through March 1980 with the removal and disposal of buildings, slabs, power poles, and equipment, and with an ever decreasing work force requiring fewer and fewer facilities. The one remaining constraint was the need to retain sufficient facilities for temporary support of over 500 dri-Enewetak and 65 other visitors expected to attend the Enewetak Return Ceremony on 8 April 1980, described in the next chapter.

Rollup activities increased rapidly after the return ceremony. On 10 April 1980, the U.S. Air Force satellite communications team and equipment redeployed from Enewetak. The Army Aviation Detachment prepared the two helicopters and other equipment for retrograde and, on 11 April 1980, departed with the helicopters for Hickam AFB via MAC channel airlift. On 11 April 1980, a team from TTPI arrived at Enewetak to dismantle the telephone exchange. The same day, the AFCS team began preparing the remaining Air Force communications equipment for shipment or local disposal. On-atoll communications capability was reduced to hand-held radios and off-atoll capability was limited to that provided by the MPRL and MARS stations.

Holmes & Narver contracted with Sause Brothers for a joint-venture (TTPI-GMI-DOE-DNA) tug with two barges to sealift contractor and excess material from Enewetak. The tug Awa arrived at the atoll on 23 April 1980 towing the barges Skiponan and Alsea. The Skiponan was loaded with 3,916 measurement tons of cargo destined for Kwajalein and Majuro Atolls. It was towed from Enewetak on 26 April 1980, and work began on loading the second barge with cargo destined for Honolulu and Seattle.

Teams from the GMI and American Samoa repaired the two remaining LCUs and loaded them with additional excess property which had been transferred to their agencies. H&N-PTD disposed of three landing craft and one YC barge which were beyond economical repair. Another landing craft was transferred to TTPI on an "as-is/where-is" basis, while two were retained in DOE custody to support ongoing U.S. Government programs at Enewetak.

Meanwhile, H&N-PTD continued cleanup and disposal of the remaining base camp facilities. Trailers not required by other agencies were burned and the residue disposed of at dump site Alpha. Hazards were removed from buildings to be retained by the dri-Enewetak. Life support was reduced to the minimum essential as facilities were inactivated or removed.

On 6 May 1980, the tug and barge Skiponan returned from Majuro Atoll and were loaded with cargo for Johnston Atoll and Honolulu. On 10 May 1980, loading was completed and the tug and barges departed Enewetak. On 13 May 1980, the final 45 personnel of the rollup forces departed Enewetak Atoll, 36 months after the initial elements arrived on atoll to mobilize for the Enewetak Cleanup Project.[57]

FINANCIAL MANAGEMENT SUMMARY

While earlier chapters of this documentary have dealt with the requests, approval, and broad allocation of funds to support the radiological cleanup of Enewetak Atoll, this section deals with procedures, key decisions, and lessons learned in the funding aspects of resource management.

When the project working groups were established at Field Command in preparation for the development of the CONPLAN and OPLAN, one of those established was the comptroller working group. It was chaired by the Financial Management Division Chief at Field Command, Mrs. Gloria Kriegshauser, and included representatives from each Service, Forces Command, U.S. Army Support Command, Hawaii, DOE-NV, and H&N-PTD. This group allocated and controlled the use of all Service, MILCON, and Field Command O&M funds in support of the cleanup project. They were responsible for major decisions on which funds would be used for what items, with full consideration for maintaining the intent of the Military Appropriation Act. Where funding shortfalls became evident, the comptroller working group was responsible for resolving the shortfalls along the lines of three basic options: (1) expend MILCON funds; (2) spend Field Command O&M funds; or (3) contact the various Services for funding assistance.

Though each agency managed its own manpower and financial resources, H&N-PTD established a centralized accounting system for the Enewetak base camp support and provided identification codes within the system for each Service. The Services provided funds to H&N for financing unique procurement, jointly-funded procurement, and cost transfers such as were necessary for fuel and subsistence. MILCON funds were utilized for pipelines and inventories of food and fuel. The Services were billed based on issues and the issue slips were used to accomplish a monthly cost transfer from MILCON to Service funds. A standard reporting system for all costs by all agencies was incorporated into Annex R of OPLAN 600-77 to provide the Project Manager and involved agencies with an up-to-date status of overall project costs. The centralized accounting and reporting systems proved to be highly effective in retaining true accountability when the Services, other Government agencies, or their contractors drew support from the inventories.

In the financial preplanning for the project, three areas bear mention. First, no consideration was given to costs accruing as a result of the effects of a natural disaster, despite the fact that tropical storms and typhoons are common occurrences in the Enewetak area. Approximately $591.3 thousand were absorbed in MILCON funds to remedy or ameliorate the effects of Typhoons Mary, Rita, and Alice and Tropical Storm Nadine. Second, the idea of using a commercial scrap contractor to remove noncontaminated materials seemed to be a beneficial and feasible option in the planning stages. However, the addition of another contractor on the island, the contractor demands on equipment and support from the cleanup and base camp support elements, and the procedures and mechanisms for financial reimbursement by the contractor for outside support created numerous, serious, time-consuming problems. Finally, the availability of Navy opportune sealift produced savings of a magnitude that such arrangements should certainly be considered for any future operation of this type. The Navy's flexibility in scheduling and enthusiastic support of supply and maintenance needs of the on-atoll forces deserves utmost credit. In both the Mobilization Phase and the Demobilization Phase, the use of Navy ships to deliver materials needed to establish the base camps to support the cleanup and to return equipment and material from the atoll on the completion of cleanup negated the requirements for expensive, commercial tug and barge lash-ups to clear the atoll.

When control of Enewetak Atoll was transferred to DNA in January 1974, a small contingent of base support personnel was in residence there. In Fiscal Year 1976, the base contractor force was enlarged in preparation for the radiological cleanup. To house, feed, and maintain the initial cleanup forces, Field Command O&M funds were used to enlarge the existing facilities. The O&M activity costs incurred during this expansion project, less the cost of special projects, were used as the base level for continued O&M support of Enewetak during the cleanup. Costs over this base level for operating the camp with the increased personnel for the cleanup on board were charged to MILCON.

During the 3 years of the radiological cleanup project, over 8,000 people were assigned to work on the atoll at one time or another. The total costs for the radiological cleanup project were $86,778,800, which included:

DNA Military Construction	$18,177,400
DNA Operations and Maintenance	19,692,000
Army	33,797,500
Navy	7,863,800
Air Force	3,877,100
Department of Energy	3,371,000

In addition to the cleanup costs, the Department of the Interior spent over $14 million on the Enewetak Rehabilitation Program which is discussed in Chapter 10.

Section 3 of Appendix B contains a detailed breakout of the expenditures from the $20 million MILCON appropriation, a breakout of the O&M expenditures for rehabilitating the base camp at Enewetak in preparation for the cleanup, and a summary of the O&M expenditures for the project by fiscal year.

CHAPTER 10

THE ENEWETAK REHABILITATION PROGRAM 1972 - 1980

BASIC CONCEPTS: 1972 - 1973

The 1972 decision to return Enewetak Atoll to the dri-Enewetak required that the islands be made habitable as well as safe for future use by the people. At the same time that the Defense Nuclear Agency (DNA) was tasked to make the islands safe, the Department of the Interior (DOI) was assigned the responsibility of making them habitable by constructing village communities and by planting commercial and subsistence crops.[1] Basic concepts for the Enewetak Cleanup Project and the Enewetak Rehabilitation Program were developed concurrently. Mr. John DeYoung and Mr. Harry Brown, of DOI's Office of Territorial Affairs, worked closely with Headquarters, DNA in coordinating the initial planning and funding efforts at the Washington level. Responsibility for detailed planning and accomplishment of the Rehabilitation Program was delegated by DOI to the Trust Territory of the Pacific Islands (TTPI) which, in turn, assigned the responsibility to its District Administrator for the Marshall Islands (DISTADMI), Mr. Oscar DeBrum.

On 2-3 May 1973, Mr. DeBrum hosted a conference at Majuro, M.I., of dri-Enewetak and U.S. Government agency representatives to discuss basic concepts for the rehabilitation and resettlement of Enewetak Atoll. It was agreed that TTPI would develop a Master Plan for the program based on the anticipated results of the cleanup project and on the desires of the dri-Enewetak.[2] On 13 June 1973, TTPI engaged Holmes & Narver, Inc. (H&N), which had accomplished the Enewetak Atoll engineering survey for DNA, to prepare the Master Plan under the direction of the Marshall Islands District Planner, Mr. Dennis P. McBreen.[3] H&N assigned Mr. Charles P. Nelson to serve as its Program Manager, under the direction of Mr. Earl P. Gilmore, Executive Vice President. Mr. Carlton Hawpe, a Majuro architect who knew the Marshallese language and people, provided architectural and consultant services under subcontract to H&N.

In July 1973, Mr. Hawpe, accompanied by other agency representatives, met with the dri-Enewetak on Ujelang Atoll to develop the basic concepts for the future Enewetak Atoll communities. To facilitate orderly planning of both the cleanup project and the rehabilitation program, it was proposed at the Majuro conference that the people elect a Planning Council. This proposal was not supported by many of the dri-Enewetak who feared that a Planning Council would usurp some of the powers of the Municipal Council.

The dri-Enewetak had established the elected Municipal Council and Magistrate form of government in 1968 to assume most of the powers which the hereditary iroijs (chiefs or kings) had exercised under the former system. Within the confines of Ujelang Atoll, many of the feudalistic distinctions between the dri-Enewetak and the dri-Enjebi clans were disappearing, and a united community with a representative form of government was emerging. However, the promised return to Enewetak Atoll and hereditary land holdings was reviving the old feudal elements and the powers of the iroijs. Both they and the Municipal Council members viewed the Planning Council proposal with some skepticism.

After lengthy explanations by the Americans and lengthy discussions among the people, it was agreed that a five-member Planning Council would be selected from the population at large to serve under the Municipal Council in an advisory capacity on cleanup and rehabilitation matters only. The Planning Council was elected by secret ballot and held its first meeting on 24 July 1973. The membership subsequently was increased to six.[4,5]

The Planning Council tried to develop a two-community concept which would retain the traditional dri-Enjebi/dri-Enewetak divisions of land. It was assumed that Enjebi (Janet) Island would be cleaned to radiologically acceptable levels for residential use. Therefore, they selected Enjebi, Japtan (David), and Medren (Elmer) Islands for the primary residential areas, leaving Enewetak (Fred) Island to be used as an airport and commercial/industrial area. Later, when it appeared that fission product levels on Enjebi would preclude its residential use for a number of years and that outside interest in Enewetak Island would be limited, the two-community concept was abandoned. The people agreed that both the dri-Enewetak and the dri-Enjebi would share the islands of Enewetak, Medren and Japtan as permanent residential sites.[6]

During the July 1973 meetings, the people identified the following islands for intensive agricultural use and some full-time residential use: Ananij (Bruce), Aej (Olive), Lujor (Pearl), Aomon (Sally), Bijire (Tilda), Lojwa (Ursula), Alembel (Vera), and Runit (Yvonne). The remaining islands were to be visited occasionally for food gathering or picnicking.

A survey was conducted to determine each family's housing needs and preferences using six scale models fabricated by Mr. Hawpe's company. Two of these models are illustrated in Figures 10-1 and 10-2. Maps showing the land parcel (wato) boundaries on Enewetak, Medren, and Enjebi were reviewed and corrected by members of the council and others who claimed a special knowledge of these matters. The information obtained in these meetings was incorporated into the first draft Master Plan.

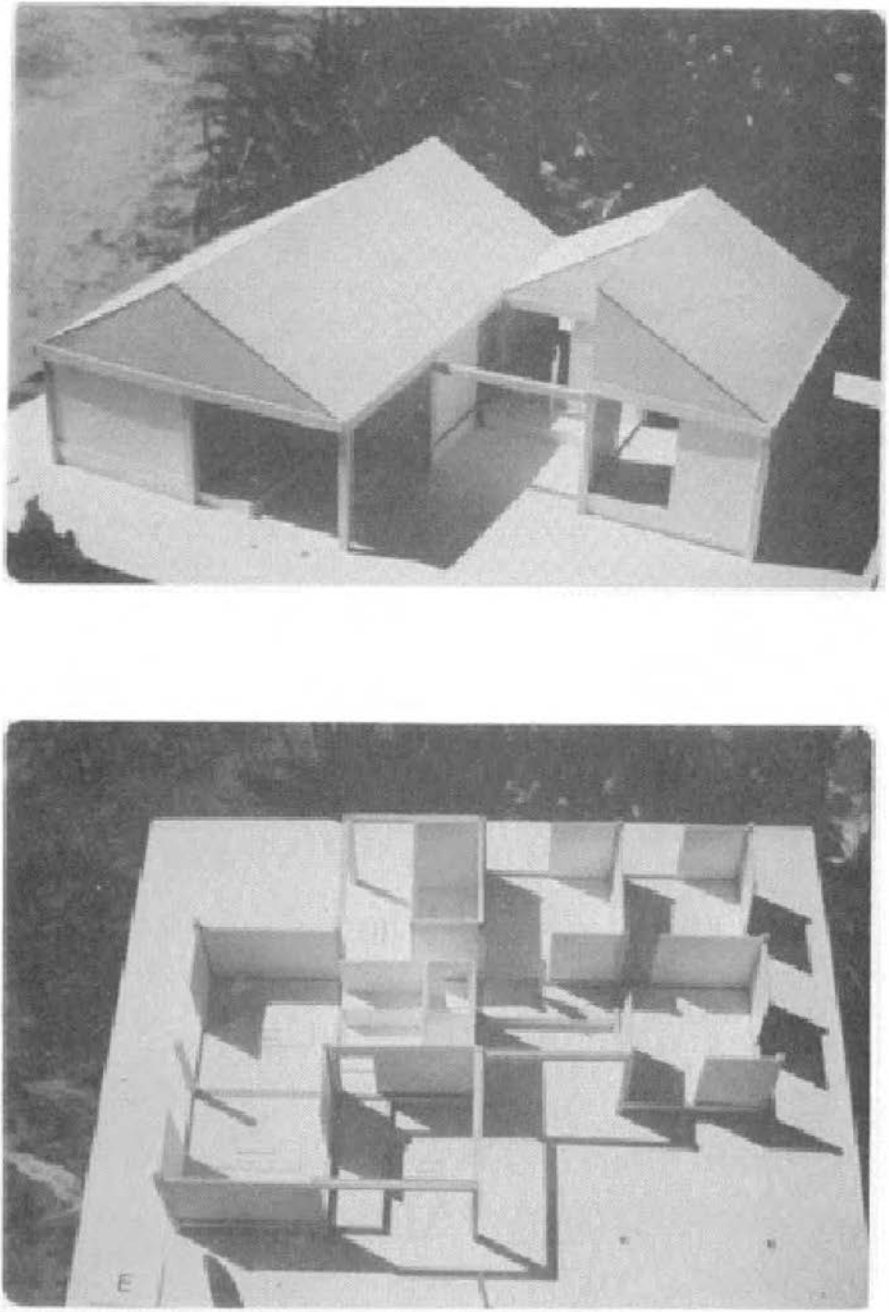


FIGURE 10-1. SINGLE STORY HOUSE, MODEL "E."

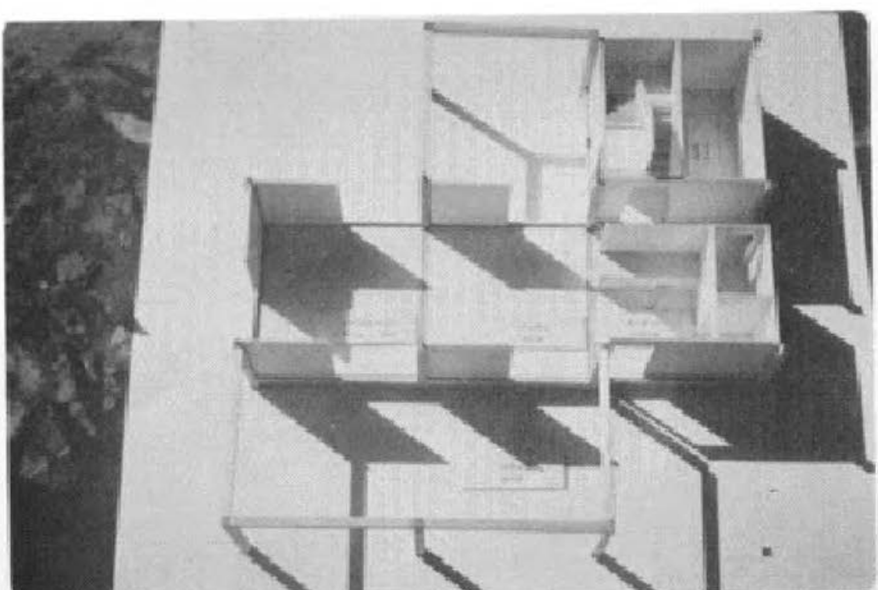


FIGURE 10-2. TWO STORY HOUSE, MODEL, "B."

ENEWETAK ATOLL MASTER PLAN: 1973 - 1975

The draft Master Plan was issued in November 1973. Final results of the Enewetak Radiological Survey, the Atomic Energy Commission (AEC) Task Group Report and the Draft Environmental Impact Statement, as well as further coordination with the dri-Enewetak and TTPI officials, required changes to be made in the Master Plan.[7,8] Enjebi was changed from residential to agricultural use, to be planted at a later date. Runit was changed from agricultural use after the cleanup to "quarantined indefinitely."[9]

The final Master Plan, issued on 31 March 1975, was based on adoption of the Environmental Impact Statement (EIS) Case 3 and the following recommendations for resettlement and habitation which were presented to the dri-Enewetak by government officials during a conference at the atoll in September 1974:[10]

a. Enjebi cannot be made radiologically safe for habitation for approximately 30 years.
b. Although coconuts may be grown on Enjebi, pandanus, breadfruit, and other plants used as food sources could be unsafe for consumption if grown on that island.
c. Permanent habitation would be confined to the southern sector of the atoll, Jinedrol (Alvin) through Kidrenen (Keith).
d. Runit would be quarantined to all inhabitants for an indefinite period.
e. Coconuts may be grown on the southern islands, Jinedrol through Kidrenen, and in the north on Enjebi through Billae (Wilma).
f. Pandanus, breadfruit, and other edible plants would be grown only in the southern section (Jinedrol-Kidrenen).
g. Domestic meat would be raised on islands in the southern section only (Jinedrol-Kidrenen).
h. Coconut crabs would be taken from islands in the southern sector only (Jinedrol-Kidrenen).
i. There would be no restrictions on travel within the atoll, except to Runit (for the duration of the quarantine).
j. Lagoon fishing and wild bird and bird egg gathering would be unrestricted, except for Runit.

The dri-Enewetak accepted these recommendations and, by December 1974, had reallocated the land on the three southern residential islands to accommodate both the dri-Enewetak and dri-Enjebi families.[11] The final Master Plan reflected the revised land assignments for Enewetak (Figure 10-3), Medren (Figure 10-4), and Japtan (Figure 10-5).

According to the revised Master Plan, houses would be arranged in clusters around a common courtyard on each extended family's wato (Figure 10-6). The courtyard would serve as a focal point for social

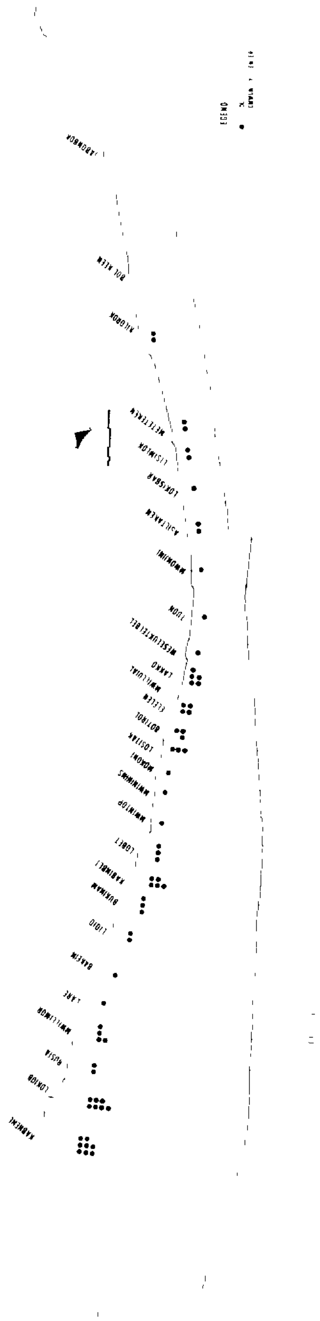


FIGURE 10-3. LAND TENURE PLAN - ENEWETAK ISLAND.

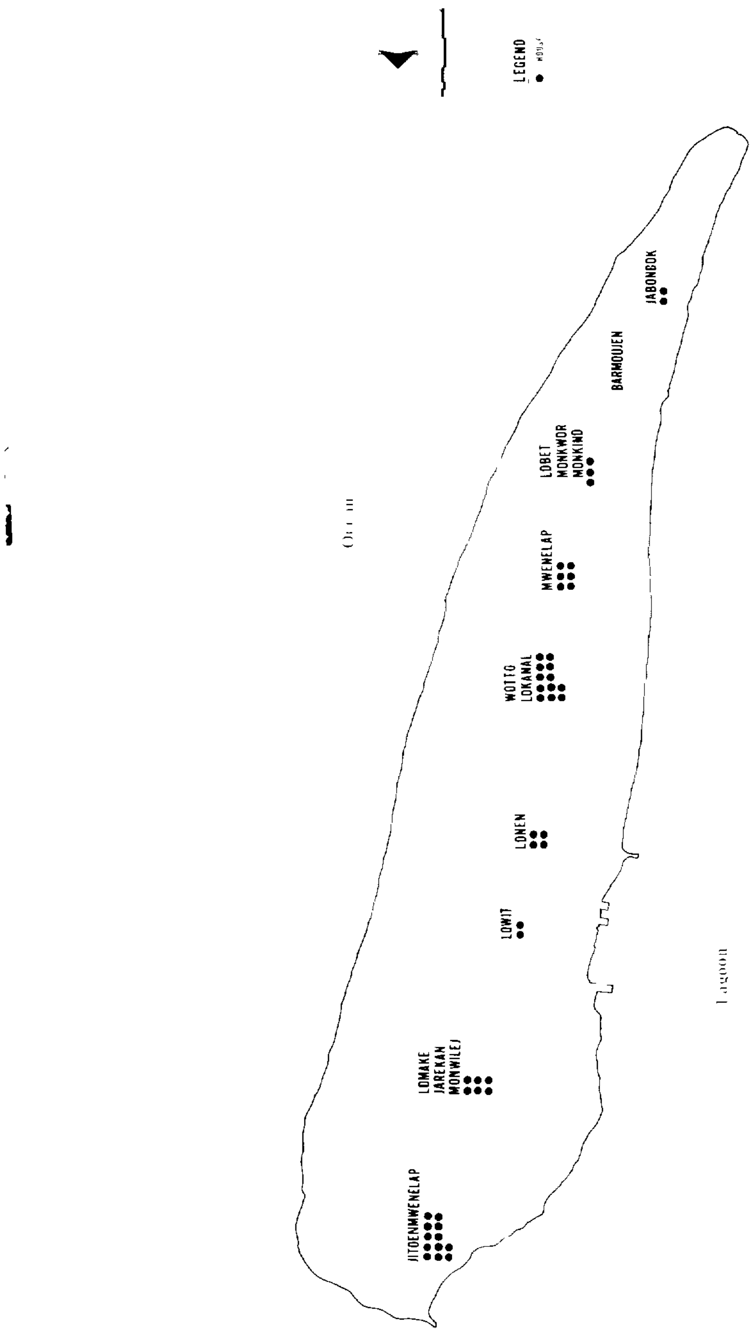


FIGURE 10-4 LAND TENURE PLAN - MEDREN ISLAND.

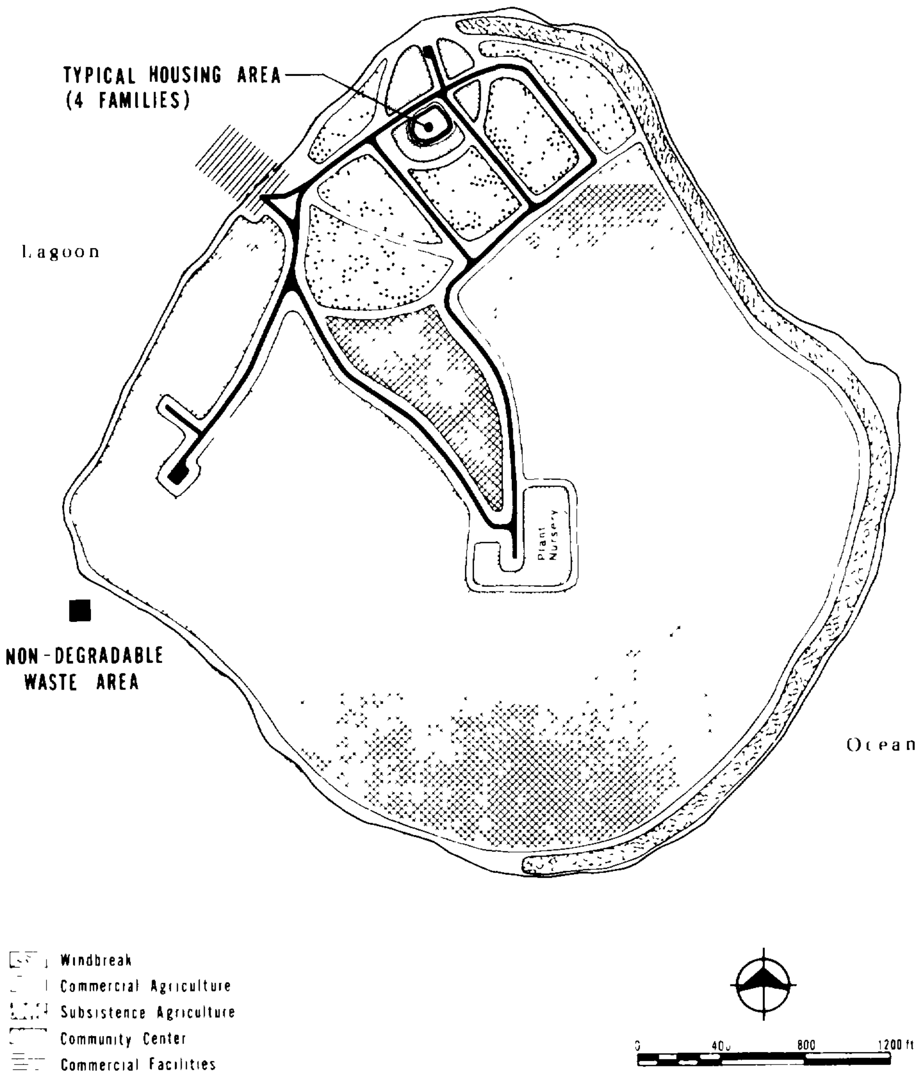


FIGURE 10-5. PERMANENT LAND USE PLAN FOR JAPTAN ISLAND

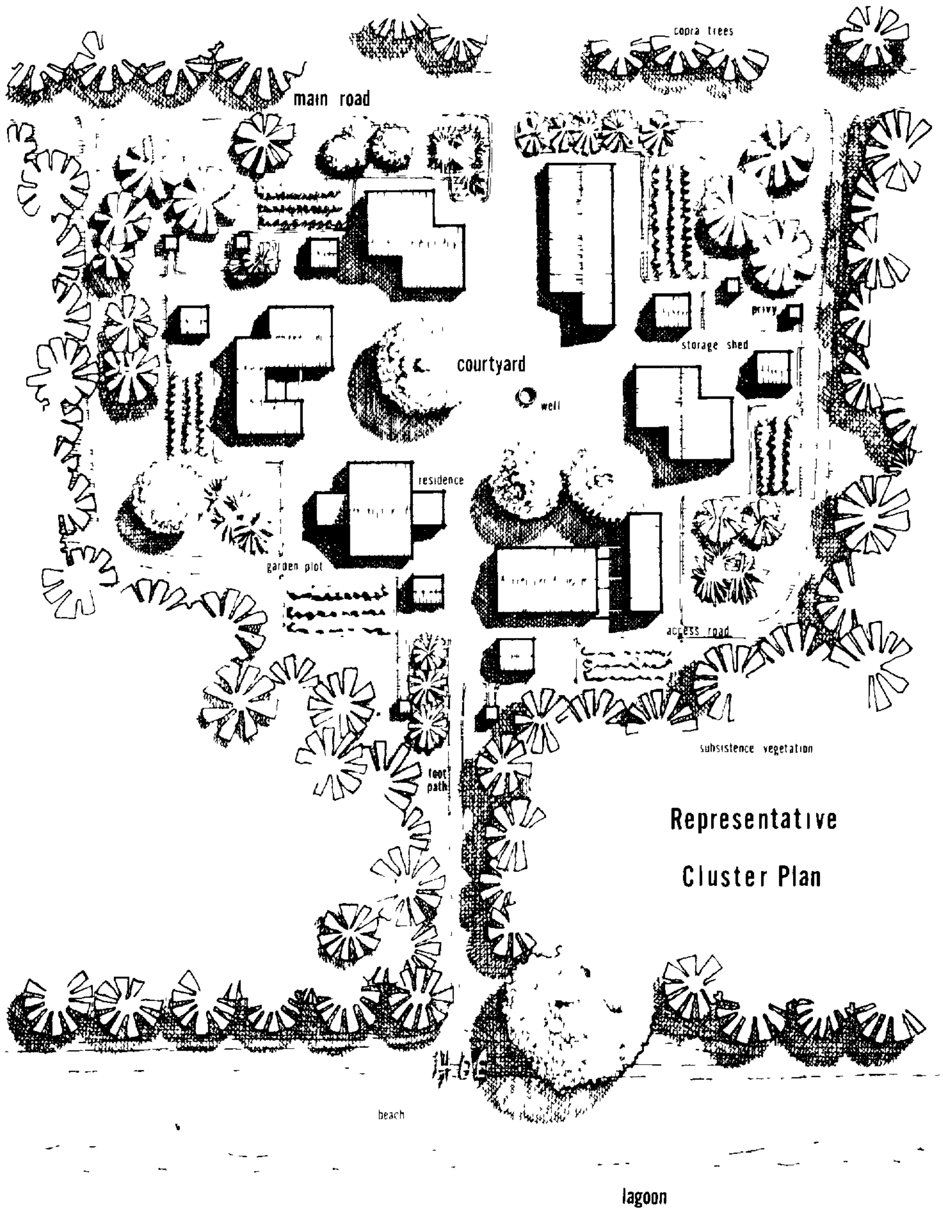


FIGURE 10-6. HOUSE CLUSTER.

functions where children could play, gossip could be exchanged, and birthday parties held (Figure 10-7). The number of houses in the clusters would vary, as would the number of clusters in a wato, depending on the size of the extended family. The clusters would be situated along the shoreline of the island, just off the main roads which parallel the beaches. Garden vegetables would be grown in and around the clusters, while privies (benjos) and animal pens were to be located around the peripheries.[12]

The new houses would be a departure from traditional Marshallese residences where separate buildings were used for cooking, sleeping, and washing. In the traditional pattern, the space between these structures, which was usually sheltered by shade trees, became the living area. Roofs and walls served only as protection from intruders and the elements. Since they were constructed of wood with thatch or sheet metal roofs, they provided little security during severe storms.[13] The new houses would be of reinforced concrete and would incorporate all the living activities, except the toilet or benjo, under one roof, to provide the residents better protection from the elements as well as from unwanted visitors. The standard room size would be 12 feet by 12 feet, while gross square feet per house would vary from 1,138 to 1,600. A typical floor plan and elevation are at Figure 10-8. Each house would have a 3,780-gallon cistern, in which rain from the roof would be collected, and a supplemental 3,200-gallon cistern to assure an adequate water supply during dry spells. The cooking area would include built-in sink, countertop, and storage shelf, plus a screened pantry for food storage. Plumbing fixtures in the house would be limited to a kitchen sink, a lavatory and shower head in the shower room, and a utility sink on the washing porch.[14]

Community centers were planned for Enewetak and Medren. The centers included: a four-classroom school; a two-bed dispensary with adjoining health aide quarters; a cooperative store; a council house containing the magistrate's office, radio transceiver equipment, a weather office, and a meeting hall; an open-sided recreation building; an open nursery; several storage sheds; and a play field. Community center facilities were to be constructed utilizing existing metal buildings to the extent possible by using some in place, relocating others, and dismantling still others for parts.

Rainwater from community building roof catchments would be stored in large cisterns to provide a reserve water supply. Rainwater trapped in underground "lens" would provide another source of fresh or brackish water on many of the islands. The lens would be tapped with shallow wells to provide water for washing clothes and, when rainwater supplies were low, for washing, cooking and, if necessary, drinking. Other community utilities would include septic tank leaching fields located near the beach,

FIGURE 10-7. RESIDENTIAL COURTYARD.

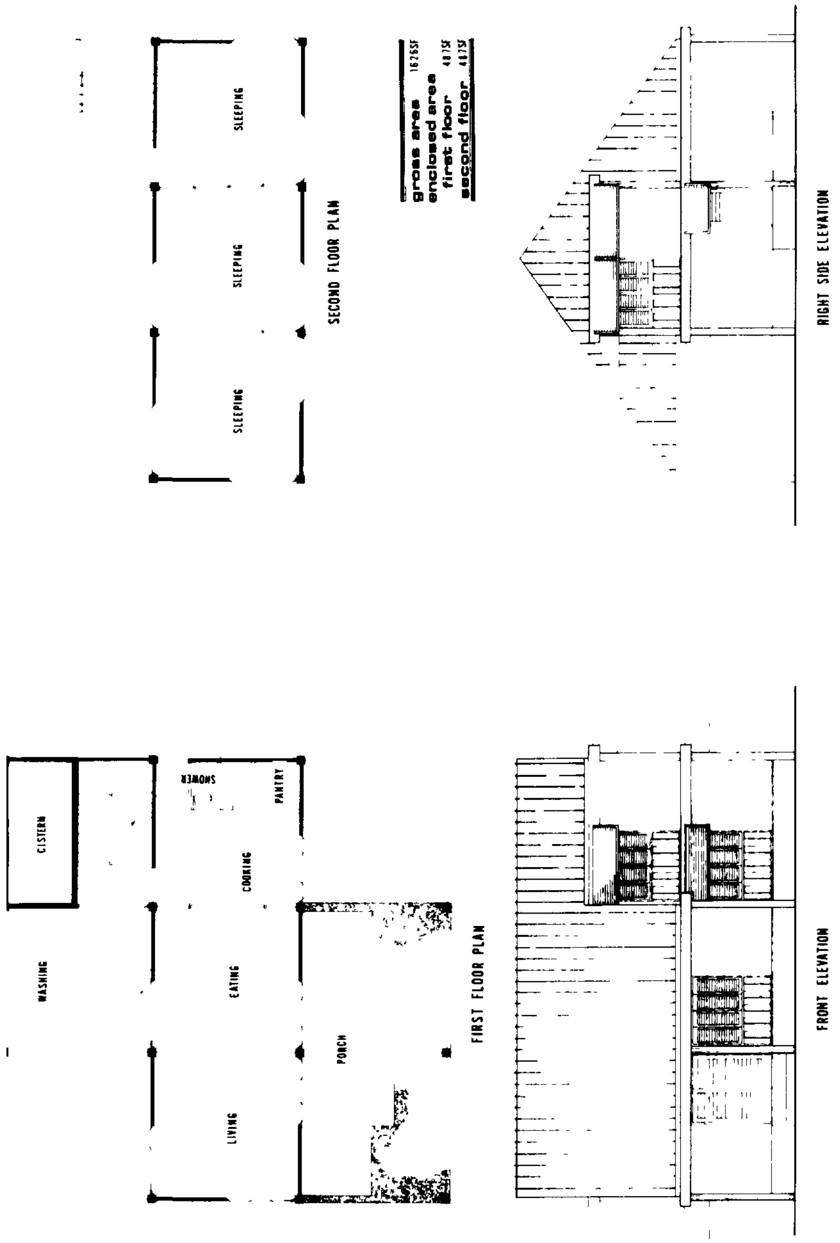


FIGURE 10-8. PLAN AND ELEVATION FOR HOUSE, MODEL "B."

away from the homes and lens wells, and central disposal pits for non-biodegradable waste. Electric power requirements would be limited to the radio transceiver and low-level lighting in the school, recreation building, dispensary, cooperative store, and council house. A 2-kilowatt generator appeared adequate for each community's electrical needs.[15]

Subsequent actions by the Enewetak Planning Council and by the various government agencies involved in the restoration of Enewetak resulted in many minor changes to the rehabilitation program as it appeared in the March 1975 Master Plan. The basic concepts of the plan remained valid, however, and it proved invaluable in supporting DOI's requests to Congress for authorization and funding of the Enewetak Rehabilitation Program.

OTHER PLANS AND PREPARATIONS: 1974 - 1978

During the early planning stages, when it was assumed that the cleanup of Enewetak would be accomplished by contractor forces engaged and supervised by the U.S. Army Corps of Engineers' Pacific Ocean Division (POD), it was proposed that the same POD contractor accomplish the construction for the Rehabilitation Program.[16,17] This would have minimized mobilization, logistics, and demobilization costs and would have provided for a more integrated, efficient restoration effort. The Congressional proposal in 1975 to use military troop labor and equipment for the cleanup project raised the issues of whether the POD and the military resources would be used to accomplish some of the Rehabilitation Program work as well.[18] It was decided that H&N, acting as DOI's and TTPI's agent, would develop, advertise, award, and administer a contract for the construction and agricultural development work and would negotiate with Field Command for joint use of military resources to reduce overall costs to the Government.[19] While efforts proceeded to identify possible efficiencies and savings, no firm commitments could be made until Field Command was formally provided funds and military resources for the Cleanup Project.[20,21,22,23]

On 18 August 1976, shortly after Cleanup Project funds were appropriated, Mr. Gilmore and Mr. Nelson, of H&N, visited Field Command to coordinate plans for support and accomplishment of the rehabilitation program. It was agreed that existing support facilities at the main base on Enewetak Camp, such as the dining hall, base exchange, and utilities, would be expanded at TTPI's expense to support TTPI contractor personnel. It also was agreed that TTPI would provide intra-atoll transportation for Rehabilitation Program personnel, and intra-atoll transportation of their equipment and cargo would be provided by DOD on a reimburseable basis. H&N estimated that it would have cost $2.5 million to lease and man an intra-atoll cargo vessel, a cost not warranted by TTPI's limited requirements if DOD transportation would be available.[24]

Funding for initial financing of the Rehabilitation Program was omitted in error from the regular Fiscal Year (FY) 1977 DOI appropriation. DOI requested $4 million in supplemental funding. If the Office of Management and Budget concurred, DOI planned to reprogram other funds, pending approval of the supplemental appropriation, so that the Rehabilitation Program could begin concurrently with the Cleanup Project. It was estimated that deferral of the program funding to FY 1978 would result in increased support costs of $5.2 million and would complicate and extend both the cleanup and rehabilitation efforts. If FY 1977 funds were available, TTPI planned to begin mobilizing in November 1976 and to begin work in June 1977.[25] The supplemental request was not approved, however. The Rehabilitation Program was funded at $12.4 million in DOI's appropriation for FY 1978. Since scrap removal operations were still ongoing on the residential islands, the impact of late funding on the Rehabilitation Program was minimized.[26]

Meanwhile, H&N proceeded to develop the rehabilitation contract specifications based on meetings with the Enewetak Planning Council and Field Command at the atoll in September 1976, with concerned government agencies at Majuro in November 1976, and with military service representatives at the Operations Plan (OPLAN) development conferences in February and March 1977. Soon after funds for the program had been appropriated, TTPI, Field Command, and H&N representatives met to finalize agreements for support of the construction contractors and to coordinate ongoing cleanup and rehabilitation activities.[27] In November 1977, the rehabilitation contract was advertised for bid, and H&N engineers began to survey and lay out nursery sites on Medren and Enewetak Islands.

In January 1978, the contract for rehabilitation program construction was awarded to American International Constructors, Inc., Pacific (AIC), of Seattle, Washington. Over the next 4 months, several shiploads of construction equipment and materials were received and stockpiled on the atoll. H&N survey crews continued work, but were hampered by indecision and frequent changes of mind on the part of the dri-Enewetak. The Planning Council, the two iroijs, the members of the Municipal Council, and several respected elders (alabs) spent over 6 weeks at the atoll discussing and deliberating the division of land on Medren and Japtan, the location of community center facilities, and the siting of houses. On 29 March 1978, the Municipal Council of Enewetak signed a resolution which, although subsequently changed many times, provided enough information for H&N to complete the initial survey and begin siting houses, nurseries, and plantations.[28,29]

The May 1978 resolution requested relocation of the Enewetak Community Center to the vicinity of Buildings 15 and 16, removal of 20 buildings and slabs previously designated to remain, and retention of all slabs within 100 feet of the lagoon. It requested that portable benjos of the pit privy type be substituted for the concrete benjos with septic tanks, since there would be no provisions for maintaining septic tank systems following resettlement. The council also requested that aluminum-clad buildings be dismantled carefully by cleanup forces to conserve the aluminum sheeting for the dri-Enewetak.[30]

While the dri-Enewetak were deliberating, site preparation work was underway. Asphalt taxiways and concrete slabs were removed, and the residue was stockpiled for placement at the ends of the islands to protect the shorelines. The aggregate and sand bases of the taxiways were stockpiled for use in subsequent concrete construction. Work proceeded on rebuilding the main pier at Medren, on water catchment systems, and on quarrying and crushing rock to be used in construction of the houses.[31]

CONSTRUCTION: 1978 - 1980

Construction of seven model homes on Enewetak Island began on 19 July 1978.[32] Two weeks later, members of the Planning Council returned for more deliberations on land boundaries,[33] and a formal groundbreaking ceremony was conducted by the two iroijs, the council members, and the Joint Task Group Commander (Figure 10-9).

The houses constructed by AIC-Pacific at Enewetak Atoll are modular reinforced concrete structures, fabricated at the home site using the W-panel system. The panel is a welded steel wire three-dimensional frame, 4 feet by 8 feet by 2 inches thick (Figure 10-10). The center of the panel has a 1-inch-thick plastic foam core, with the wire framework exposed approximately one-half inch from each face of the core. The panels are cut, set in place and wired together by hand. Adjoining foam edges are sealed with a bead of mastic. The structure is then coated with a 1-inch-thick layer of Portland cement plaster on both sides, using spray guns or hand trowels. This coating completes the composite of reinforcing wire, foam core, and cement plaster.[34] Roofs were constructed using the same procedure, providing sufficient insulation to preclude the need for additional ceilings. Figures 10-11 through 10-18 illustrate the basic construction of these houses.

Painting, plumbing, and the installation of louvered doors and windows were accomplished to complete the houses. Figures 10-19 through 10-21 depict some of the completed houses. A total of 116 houses were constructed on Enewetak, Medren, and Japtan between 19 July 1978 and

FIGURE 10-9 GROUND BREAKING CEREMONY FOR RESIDENCES.

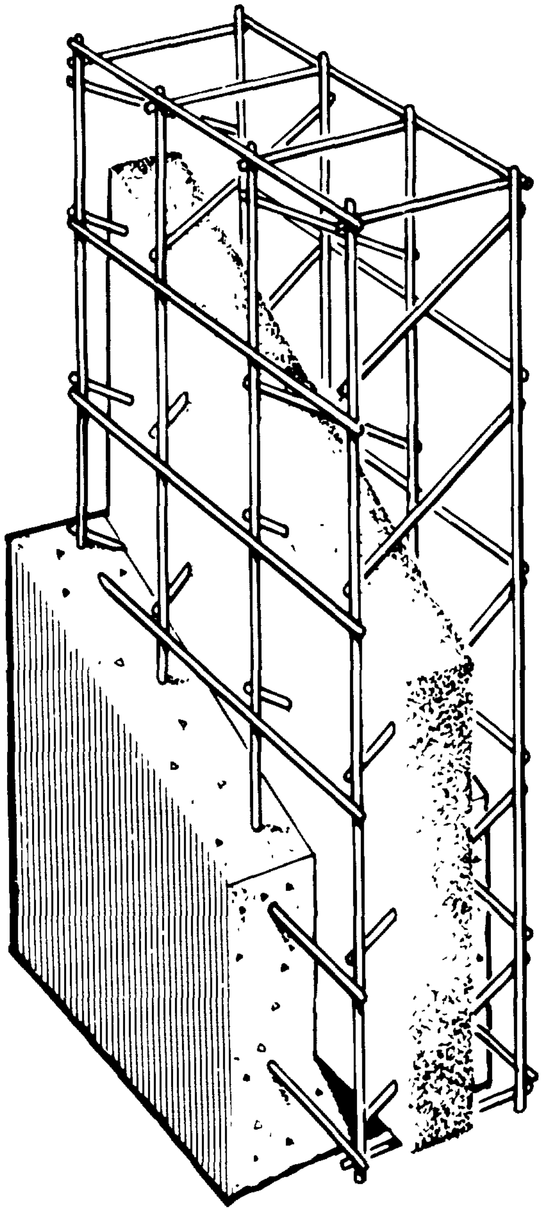


FIGURE 10-10. DETAIL OF W-PANEL CONSTRUCTION.

FIGURE 10-11. STARTING HOUSE CONSTRUCTION.

FIGURE 10-12. PLACING CONCRETE FOR HOUSE FOOTINGS.

FIGURE 10-13. IROIJ ABRAHAM AND ARCHITECT HAWPE DISCUSS WALL PANEL INSTALLATION.

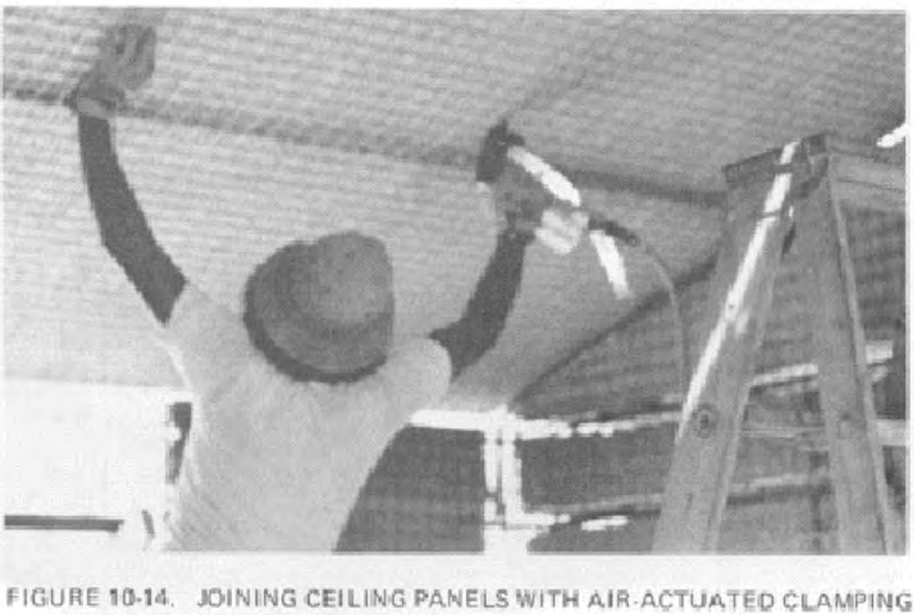


FIGURE 10-14. JOINING CEILING PANELS WITH AIR-ACTUATED CLAMPING DEVICE.

FIGURE 10-15. HOUSE NEARING COMPLETION WITH W-PANELING INSTALLED.

FIGURE 10-16. APPLYING CEMENT PLASTER.

FIGURE 10-17. PNEUMATIC APPLICATION OF CEMENT PLASTER TO A ROOF.

FIGURE 10-18. PAINTING THE ROOF.

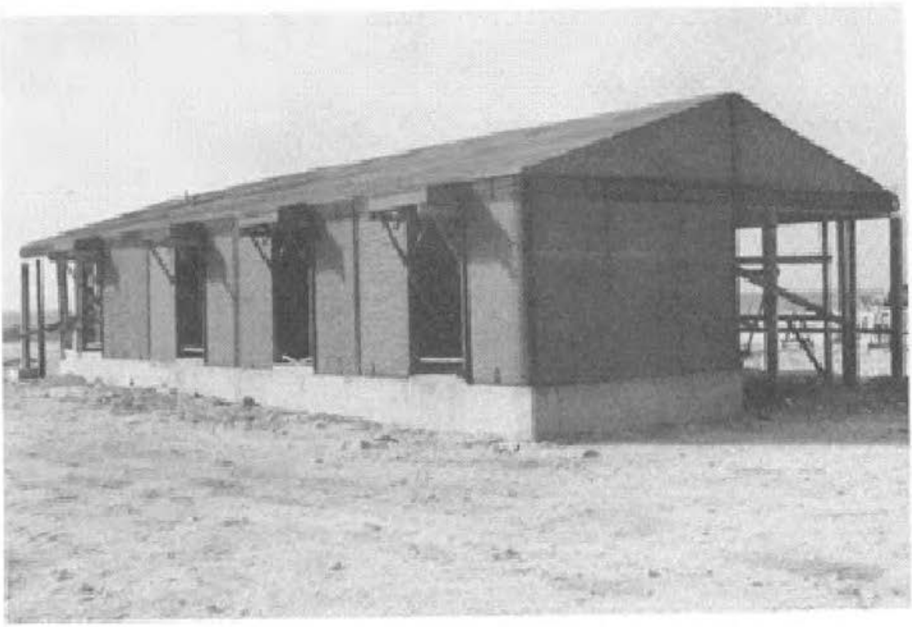


FIGURE 10-19. SINGLE STORY HOUSE.

FIGURE 10-20. TWO-STORY HOUSE.

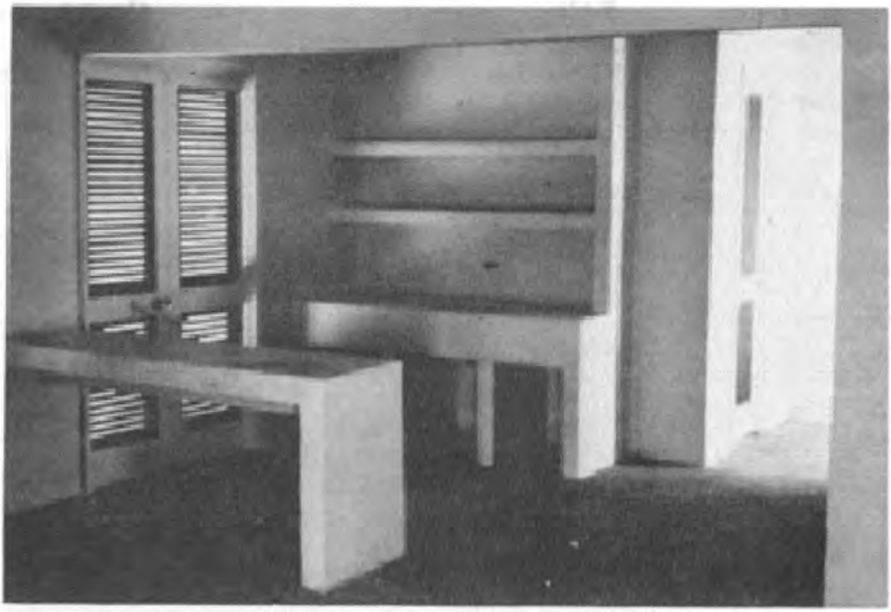


FIGURE 10-21. KITCHEN AREA.

19 March 1980. Location, types, and construction dates are shown in Figure 10-22.

The churches, council halls, and other community-center buildings were constructed using existing aluminum buildings to minimize costs. Converting air-conditioned offices, barracks, and shop buildings to breeze-cooled chapels and classrooms required highly imaginative designs and use of materials.

Construction of the community center on Medren began in mid-January 1979. With the island cleared and deserted, except for the construction crews and a few troops who were removing hazards remaining after completion of salvage contractor operations, construction proceeded smoothly. On the other hand, construction on Enewetak Island was constrained by the use of that island as a very active base camp until well into February 1980. Many of the buildings which were to be remodeled could not be vacated until late in the Enewetak Cleanup Project.

The Joint Task Group headquarters building was converted into the Council Hall, while the Base Exchange was remodeled into a school house. One of the barracks was stripped, cut free from its slab, picked up by hand and turned 90 degrees, placed on concrete pilasters, and converted into the Enewetak community church. Some of the remodeled community buildings are depicted in Figures 10-23 through 10-26.

LOCATION	HOUSE MODEL A	B	C	D	E	F	TOTAL	START DATE	COMPLETION DATE
Enewetak Island	25	19	12	2	9	9	76	7-19-78	3-19-80
Medren Island	7	4	10	3	2	6	32	11-78	11-27-79
Japtan Island	-	3	2	1	-	2	8	3-79	12-05-79
TOTAL	32	26	24	6	11	17	116		

FIGURE 10-22. RESIDENTIAL CONSTRUCTION ON ENEWETAK ATOLL.

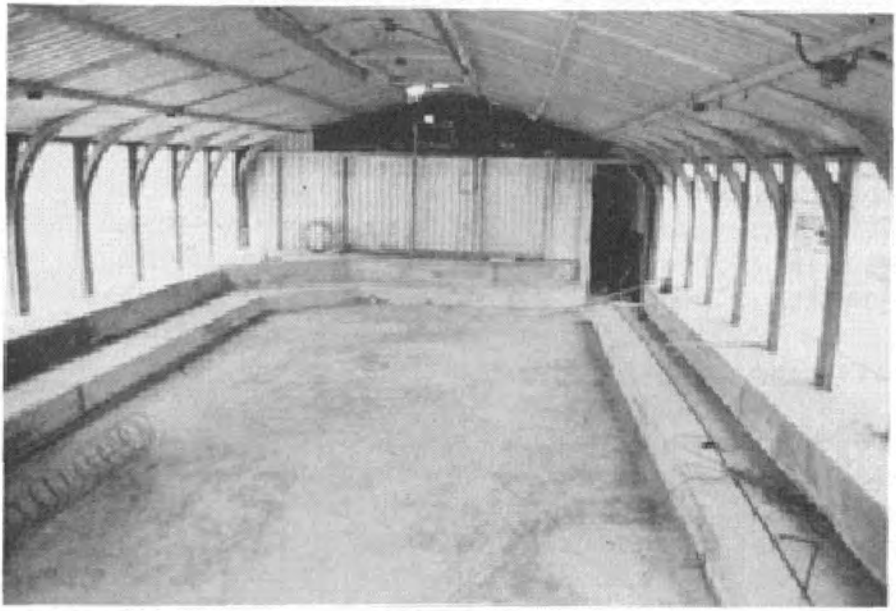


FIGURE 10-23. ENEWETAK ISLAND COUNCIL HALL.

FIGURE 10-24. MEDREN ISLAND COUNCIL HALL.

FIGURE 10-25. CHURCH ON ENEWETAK ISLAND.

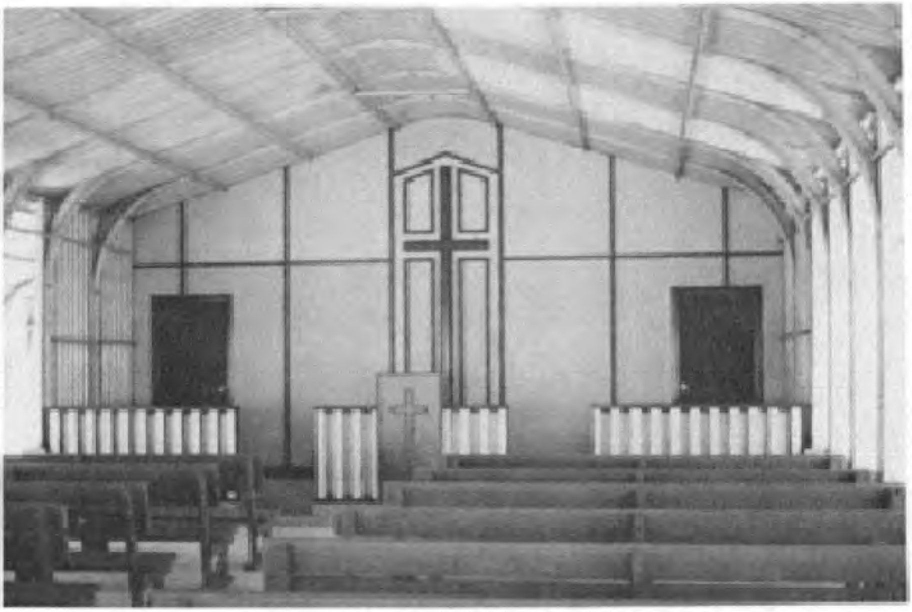


FIGURE 10-26. INTERIOR OF CHURCH ON ENEWETAK ISLAND.

One of the major rehabilitation efforts was reconstruction of the deep-water pier at Medren (Figure 10-27). Piers at Japtan (Figure 10-28) and Enewetak (Figure 10-29) were repaired for use during the Cleanup Project. In addition, the Joint Task Group forces, as part of the cleanup effort, converted a sunken barge off Enewetak and a dilapidated pier at Medren into usable fishing and small boat jetties (Figures 10-30 and 10-31).

AGRICULTURAL DEVELOPMENT PLANS: 1973 - 1975

Military and scientific activities between 1940 and 1977 destroyed almost all of the coconuts, pandanus, and other edible vegetation on Enewetak Atoll. In their place were asphalt taxiways, concrete slabs, and the ubiquitous but inedible Messerschmidea and Scaevola plants. To provide a viable, self-sustaining ecology for the dri-Enewetak, it was necessary to reestablish the groves of coconut trees and the other edible, native plants. Basic concepts for agricultural development of the atoll were included in the Enewetak Atoll Master Plan based on accepted agricultural practices, predicted diet patterns, and the desires of the dri-Enewetak.[35]

The March 1975 Master Plan provided for replanting ten islands as part of the Rehabilitation Program, with four other islands to be replanted by

FIGURE 10-27. DEEPWATER PIER ON MEDREN, UNDER CONSTRUCTION.

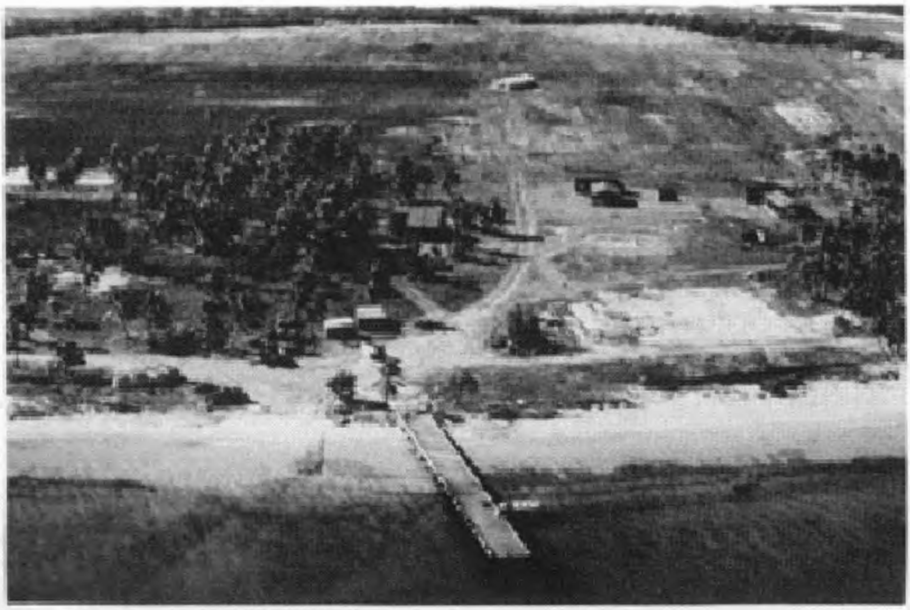


FIGURE 10-28. PERSONNEL PIER ON JAPTAN.

FIGURE 10-29. ENEWETAK PERSONNEL PIER.

FIGURE 10-30. ENEWETAK BARGE JETTY.

FIGURE 10-31. MEDREN JETTY.

the people later, after relatively low concentrations of strontium-90 and cesium-137 decayed to acceptable levels (see Figure 10-32). This complied with the desires of the dri-Enewetak for agricultural development with two exceptions: Enjebi could not be planted until its strontium and cesium levels were lowered; and Runit could not be planted until its plutonium concentrations were reduced. Subsequent events at Bikini Atoll caused a reevaluation of the plans to replant the islands north of Ananij, while agricultural development proceeded on the southern islands.

SOUTHERN ISLANDS AGRICULTURE: 1978 - 1980

Subsistence crops were to be planted on Ananij and the three residence islands of Enewetak, Medren, and Japtan.[36] There were four basic food plants. The coconut palm (cocos nucifera) is not only the primary food source, but it also is used for timber, cordage, thatching, firewood, matting, fiber, handicrafts, and medicine. The dried meat of the nut, called copra, is sold for subsequent processing into a variety of products, including shredded coconut and nondairy coffee creamers. The dwarf coconut palm (locally called Ni Karu) is grown essentially for drinking and cooking. The breadfruit (artocarpus incisa) provides a major source of carbohydrates and is usually cooked or preserved before eating. The

ISLAND	TOTAL ACRES	AGRICULTURAL ACRES	REMARKS
Japtan (David)	79	63	Commercial coconuts (copra),
Medren (Elmer)	220	193	dwarf coconuts, breadfruit,
Enewetak (Fred)	322	166	& pandanus
	621	422	
Ananij (Bruce)	25	13	
Aej (Olive)	40	20	
Lujor (Pearl)	54	38	
Aomon (Sally)	99	65	Commercial coconuts (copra),
Bijile (Tilda)	52	34	breadfruit & pandanus
Lojwa (Ursula)	40	25	
Alembel (Vera)	38	23	
	348	226	
Kidrinen (Lucy)*	24	13	
Mijikadred (Kate)*	16	12	Commercial coconuts (copra)
Bokenelab (Mary)*	12	6	only
Elle (Nancy)*	11	5	
	63	36	
TOTAL	1,032	684	

*Islands to be planted at a later date by the Enewetak people.

FIGURE 10-32. ISLANDS CONSIDERED SUITABLE FOR AGRICULTURE.

pandanus (pandanus tectorius) is grown for its edible fruit, which provides sugars and starches as well as vitamin C. Pandanus leaves also are used for thatching, matting, and fiber.[37] Minor crops, to be planted by the rehabilitation contractor or the people, included papaya, banana, and lime.

In May 1978, work began on the three residence islands to prepare plant nurseries for seed coconuts and other developing plants. Coconuts which had sprouted and cuttings of pandanus were imported from Ujelang Atoll and nurtured in the nurseries until they were sufficiently developed for transplanting in permanent locations (Figure 10-33). The first shipment of 13,000 coconut seedlings arrived at Enewetak in mid-September 1978.[38] Breadfruit roots are more delicate and must be transported and retransplanted with the earth in which they are grown (Figure 10-34). Over 1,000 boxes were fabricated by AIC-Pacific and shipped to Ujelang for use in growing, shipping, and transporting breadfruit. Additional breadfruit and other plants were donated by the Government of the Marshall Islands (GMI) and were flown in from Majuro.[39]

Fertilizer, in the form of copra pellets, was added to the young plants in the nurseries. Screens, fabricated from plywood and W-panels, protected the coconut and pandanus seedlings in the nurseries from the ever-present trade winds until they were ready to be transplanted. Breadfruit plants were placed at their permanent locations in three-sided, thatch-covered

FIGURE 10-33. YOUNG COCONUT TREES IN NURSERY.

FIGURE 10-34. BREADFRUIT PLANT IN NURSERY.

boxes to provide them with shade and protection from the wind (Figure 10-35).[40] Coconuts and pandanus were transplanted in the open in areas prepared by rototilling copra pellets into the soil (Figure 10-36).[41]

Transplanting of coconut and pandanus seedlings on the four southern islands began in early June 1979[42] and continued into late March 1980.[43] The planting program encountered the common agricultural problems of heat, drought, and insects. In August 1979, heavy infestations of army worms appeared in the plantations on Japtan and Ananij. An entomologist summoned from Kwajalein Atoll recommended continued use of malathion spray which proved effective in protecting the plants.[44]

NORTHERN ISLAND PLANTING RECOMMENDATION: 1978

The discovery in early 1978 that the Bikinians were experiencing unexpectedly high intakes of strontium and cesium from eating locally grown coconuts and other foods was disturbing to the agencies involved in the Enewetak Rehabilitation Program. The levels were attributable to the Bikinians drinking and eating more coconut than predicted in the diet on which the Bikini Atoll cleanup and resettlement was based. The Enewetak cleanup and rehabilitation plans were based on the same diet assumptions and on planting coconuts on six northern islands where fission products also were found in measurable concentrations. The Bikini experience cast a shadow of doubt on the Enewetak diet model, predicted exposure levels, and island use plans.

The matter was discussed during the 4 May 1978 conference at DNA Headquarters and was examined in a study by Field Command.[45] The AEC Task Group Report in 1974 had indicated that coconuts could be grown on the six northern islands, assuming that any plutonium concentrations over 400 pico curies per gram (pCi/g) would have been removed.[46] Based on this radiological assessment, the Enewetak Master Plan and the EIS prescribed that these islands would be cleaned and rehabilitated for agricultural use. Cleanup of fission products on any island was excluded in the EIS, as this would require excessive soil removal. After the Bikini experience, it appeared that the Department of Energy (DOE) might not recommend planting the six islands until fission product levels had been reduced by natural decay or as a by-product of transuranic cleanup. This development created problems for H&N, whose fixed-price contract with AIC-Pacific included planting the six northern islands. Any substantial delays would be costly, expecially if they required remobilization of a logistics base. To resolve this question, H&N formally requested, on 4 August 1978, DOE's recommendations on planting these islands.[47]

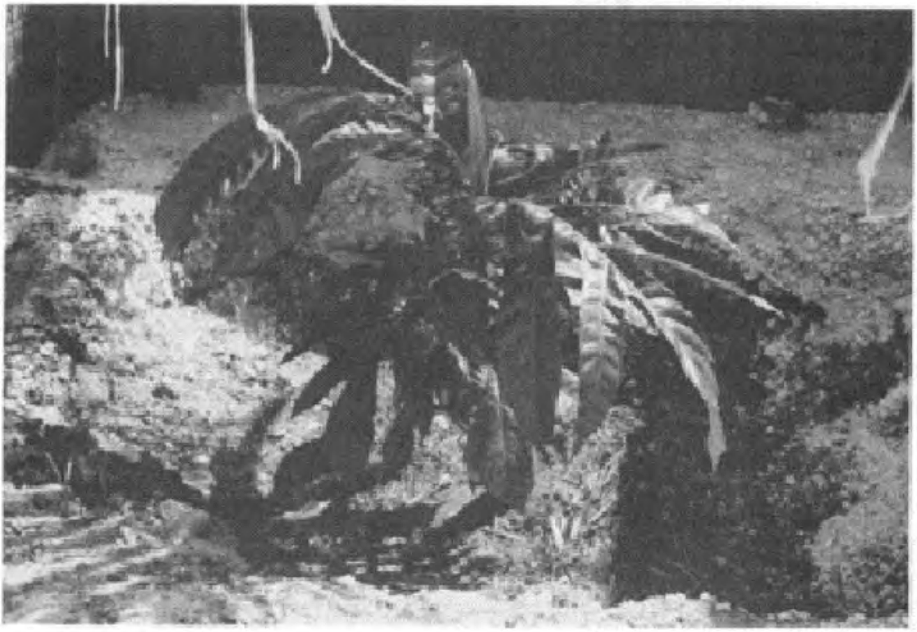


FIGURE 10-35. BREADFRUIT PLANT IN SHELTER.

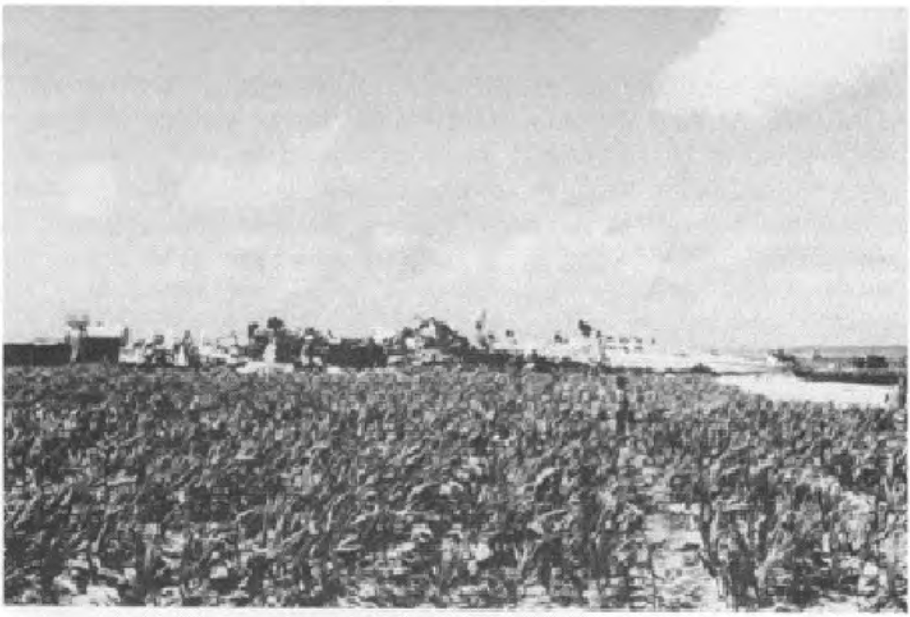


FIGURE 10-36. ROWS OF COCONUT SEEDLINGS.

The possibility of a delay in planting also was of concern to DNA. The cleanup was scheduled to be completed in 1979, and all DOD forces—on which DOI depended for all life support services on the atoll—were scheduled to be demobilized and off the atoll by 15 April 1980. If the delays in DOE decision-making or in planting prevented completion of rehabilitation before this date, either the DOI portion of the project would have to be extended, at additional expense, or this particular portion of the project would have to be cancelled. Either of these outcomes would affect the dri-Enewetak adversely and would reflect adversely upon the U.S. Government's fulfillment of its commitment. Thus, DNA was determined that DOE and DOI resolve the issue expeditiously, taking all factors in account.

On 20 September 1978, VADM Monroe, Director, DNA, telephoned Dr. Liverman, DOE's Deputy Assistant Secretary for Environment, to express concern that further delays in resolving the matter could result in increased costs to the government. In this conversation and in one the following day with Mr. Deal, of HQ DOE, VADM Monroe was assured that DOE would expedite action on the matter.[48,49] On 29 September 1978, DOE formally recommended that no coconuts be planted on the northern islands during the next planting season (May-December 1979).[50]

COCONUT PLANTING STUDY

Meanwhile, anticipating an adverse recommendation from DOE, VADM Monroe had directed Field Command to conduct a study of coconut planting alternatives.[51] A team headed by Field Command's Colonel John Hemler, USA, began working with an H&N team headed by Mr. Charles Nelson to identify coconut planting requirements and alternatives. On 25 October 1978, H&N received formal direction from TTPI to prepare alternate plans for planting coconut trees at Enewetak Atoll.[52]

A joint Field Command-H&N report, "Examination of Alternatives for Coconut Agricultural Islands at Enewetak/Ujelang Atolls," was issued on 20 November 1978. It provided a detailed analysis of pertinent factors, including natural decay of radioactivity, population trends, predicted diet, and coconut crop forecasts.[53]

The study indicated that, while strontium and cesium levels on some of the six islands (e.g., Alembel, Lojwa) would diminish within 8 years to levels commonly found in the continental United States (CONUS), it would take over 135 years for others (e.g., Aej, Lujor) to reach those levels. Over 155 years would be required to reach CONUS levels on islands where the original AEC Task Group report recommended planting be deferred; e.g., Enjebi, Mijikadrek (Kate), Elle (Nancy).[54] Coconuts grown on these islands earlier than that could be expected to contain strontium and cesium levels approaching those recently found on Bikini. While use of CONUS levels as a standard provided a yardstick, the technique was open to speculation since levels considerably higher than these might prove to be acceptable. Also, as noted in Figure 10-32, coconuts grown on these six northern islands were not intended for consumption.

Population estimates for the study were taken from the Enewetak Master Plan which assumed a 5 percent annual increase, resulting in a total dri-Enewetak population of 818 in 1985 when trees planted in 1979 would be fully mature and bearing coconuts.[55] The study assumed that 700 of the people (86 percent) would reside on Enewetak Atoll and would consume eight coconuts per person per day under normal conditions; i.e., normal rainfall and delivery of imported food by field trip ships.[56] This rate represented a compromise between that used in the Bikini and Enewetak resettlement plans (four to five per person per day) and that observed at Ujelang during National Science Foundation-funded research in 1976-1978 (eight to ten per person per day). Under drought and/or starvation conditions, such as had occurred at Bikini, coconut consumption could increase to 40 to 60 per person per day.[57] To provide an average of eight coconuts per day for 700 persons, it was estimated that between 20,440 and 40,880 trees would be required.[58]

Four alternatives for planting trees were considered in the study:[59]

a. Plant in accordance with the Master Plan and EIS, i.e.: DOI plant the four southern and six northern islands now and plant Enjebi later; the dri-Enewetak would plant the other four northern islands later when fission product levels permitted. While this alternative complied with the Master Plan and the EIS, it was contrary to DOE's latest recommendation to defer the planting season, and it could possibly result in contaminated coconuts which could neither be eaten nor sold on the world market.
b. DOI plant the four southern islands now and, when fission product concentrations have decayed to acceptable levels, plant the six northern islands plus Enjebi. This would comply with DOE recommendations but would deviate from the Master Plant and EIS time-table for planting the six northern islands.
c. DOI plant only the four southern islands. This would comply with DOE recommendations but deviate from the Master Plan and the EIS regarding the six northern islands and Enjebi.
d. Plant in accordance with the Master Plan and EIS but plant Enjebi now rather than wait for fission product levels to decay. This would be contrary to the DOE recommendations, the Master Plan, and the EIS, and would run the risk of producing an unusable crop.

Alternatives a and d were intended to accomplish as much planting for the dri-Enewetak as possible during the Rehabilitation Program. Adoption of either alternative would create no immediate or near-term radiation hazard because the trees would bear no coconuts until about 1985. By that time, fission product levels in the soil and nuts might be insignificant. Also, it was likely that scientific knowledge concerning fission product uptake and body burden accumulation through diet will have advanced to provide new techniques to minimize dose or exposure. Alternatives b and c were intended to comply with DOE recommendations and minimize the chances of uncontrolled use of possibly contaminated coconuts during droughts and delays in food ship deliveries at Enewetak.

No coconuts from any of the northern islands were to be used for food or drink under any of the alternatives. Only coconuts from the southern islands were to be consumed. It appeared that there would be a shortage of "clean" southern island trees under any of the alternatives.[60] Three "variations" were proposed to alleviate the shortage:

a. Plant the southwest islands of Ikuren (Glen), Mut (Henry), Boken (Irwin), Ribewon (James), and Kidrenen. Plantations had existed on these islands previous to World War II, and it was estimated that they could accommodate 4,608 trees planted on 30-foot centers. This variation would have eliminated the remaining wild habitat on the atoll and would have been difficult and costly ($0.5 million) to implement because of restricted boat access to these islands.[61]
b. Improve Ujelang coconut availability by planting 11,900 additional trees there, improving the Ujelang pier, and improving sealift capability between Ujelang and Enewetak. This variation would have cost almost $1.5 million in additional funds.[62] In effect, it constituted a Ujelang Atoll Rehabilitation Program which would have been difficult to justify if all the dri-Enewetak were returning to Enewetak, as planned.
c. Remove 3,600 feet of the Enewetak runway (leaving 4,500 feet to accommodate aircraft up to the size of a Boeing 727) and plant an additional 720 trees. This variation would have been difficult to schedule and implement since the full runway was required by the C-141 cargo aircraft which supported the rehabilitation program. Its potential cost/benefit ratio was very unfavorable.[63]

The study concluded that optimum subsistence coconut productions on the four southern islands could be achieved by planting 20,880 standard trees on 30-foot centers rather than on 26-foot centers as proposed in the Master Plan.[64] (The planting of 930 dwarf coconut trees prescribed by the Master Plan and the plantation contract was somehow overlooked in the study.) A total of 21,810 trees would supply 8 coconuts per day for approximately 600 people. Any additional requirements for subsistence coconuts would have to be satisfied by adopting one of the variations.

The study made no specific recommendations on planting, but recommended that:

- DOE aggressively pursue radiological assessments of the northern islands to obtain improved risk assessment calculations and to establish criteria for suburanic acceptability in subsistance/commercial crops.
- DOI/DOD/DOE/TTPI collectively evaluate the alternatives and variations presented and determine their acceptability as soon as possible.
- The Enewetak people be directly involved in the evaluation of these alternatives and variations.
- H&N-Orange continue to refine the time schedules and costs involved in the implementation of various alternatives and variations.

Since none of the coconuts from the six northern islands in question was to be used for food, the islands would be planted only to provide a cash crop, copra. The cost programmed by DOI for planting the six islands was $865,000.[65] According to the study, the 10,272 trees which could be planted on these islands could produce $41,088 per year gross income (less than 5 percent per annum return on investment) assuming the copra was uncontaminated or that the United States would reimburse for contaminated copra.[66]

Copies of the study were forwarded to 29 addressees, including DOE and Mr. T. R. Mitchell, the dri-Enewetak's legal counsel. DOE responded that only the four southeastern islands should be planted by the U.S. Government in the foreseeable future (Alternative c) due to the presence of fission products on the northern islands. Mr. Joe Deal, of DOE HQ, requested that the other alternatives not be presented to the dri-Enewetak until after the radiological impacts had been discussed by DOE, DNA, and TTPI representatives together with Mr. Mitchell, to develop a mutually agreeable government position.[67] Mr. Mitchell, VADM Monroe, and MG Cody, the Deputy Director, DNA, insisted that all the alternatives and their radiological impacts be discussed with the dri-Enewetak at a forthcoming conference called by the TTPI for that purpose. In the opinion of the Director, DNA, it was of paramount importance that the dri-Enewetak be consulted fully on all aspects of the issue, for their inputs to decisions were essentials which no other participant could provide.[68,69]

1978 PLANTING CONFERENCE

On 30 November 1978, U.S. Government and dri-Enewetak representatives met at the atoll to confer on coconut planting alternatives. The dri-Enewetak were represented by the two iroijs, six Planning Council members, 16 Municipal Council members, 11 alabs, and their attorney, Mr. Mitchell. The first session was disrupted when the dri-Enewetak were informed by ERSP that it now appeared that the Joint Task Group would be able to clean Enjebi to residential levels of transuranics (40 pCi/g). This appeared to change the entire purpose of the conference so far as the dri-Enewetak were concerned. They immediately began asking questions about the safety of living on Enjebi as soon as cleanup was complete. At their request, a tour of the southwest islands was cancelled so that they might tour Enjebi instead. While the dri-Enewetak spent the next day touring the northern islands, Mr. Mitchell was meeting with the U.S. Government representatives to discuss coconut planting.[70]

The DOE representative, Mr. Deal, described the Bikini problem with fission products, emphasizing that DOE did not want a similar problem at Enewetak. He was advised that the Bikini report would be available for review in January or February 1979 but that detailed current data on Enewetak was not available to determine the potential hazards of residence or planting on the northern islands. It would require several months to conduct a fission products survey to provide complete data for such determinations. Meanwhile, based on data from the 1972 survey, DOE had recommended against planting those islands in the near future. Mr. Deal did not wish to discuss the possibility with the dri-Enewetak.[71] After much further discussion, he was persuaded to attempt to explain to the people those factors which should be considered in any planting decision for the northern islands, such as life-style and potential health hazards.[72]

On the following day, the conferees met again to allow Mr. Deal to explain the radiological factors involved in planting the northern islands. The people's questions, however, pertained almost entirely to the hazards of living on the northern islands. He reminded them that all the data calculations and dose estimates that had been presented to them in September 1974 showed that living on Enjebi would subject them to dose rates exceeding the U.S. Federal standards. It was at this point that the dri-Enewetak requested that a fission products survey be made and the results be presented to them by 1 June 1979.[73] Follow-on actions to bring the fission products data base survey in the northern islands to reality are described in Chapter 7.

NORTHERN ISLAND PLANTING DECISION: 1979

The results of the new fission products survey of the northern islands were made available in July 1979. The survey results were incorporated by Lawrence Livermore Laboratory into a preliminary dose reassessment, which also incorporated current transuranic data and the results of a recent diet survey conducted at Ujelang Atoll by Micronesian Legal Services Corporation.[74] The new diet survey indicated that only one half of a coconut per person per day would be consumed, which was only 7 to 12 percent of what previous studies had indicated.[75] Results of the preliminary reassessment were forwarded to DOE and DOI. On 13 September 1979, Mr. J. A. Joseph, Under Secretary of DOI, notified VADM Monroe that, after considering all the factors involved, DOI had decided that planting of the six northern islands should proceed in accordance with the approved Master Plan.[76]

On 21 September 1979, DOI directed H&N to proceed with the planting of the northern islands. Site preparation work began on Aomon the second week of October 1979 and on Bijire and Alembel the following week.[77,78] Planting of all six islands was completed by the end of February 1980. A summary of the entire planting program is at Figure 10-37.

In summary, the concern over fission product levels in northern island soil had delayed the planting about 1 year, and planting was completed at the last possible moment. That it was completed at all can be attributed to: (1) the constant pressure to reach a decision applied upon all organizations by DNA, often on a weekly or even daily basis over a year; and (2) the dedication and flexibility of H&N, which modified its planting plans almost weekly to accommodate whatever decision was made, whenever it was made.

DOSE ASSESSMENTS

The preliminary reassessment report prepared by Lawrence Livermore Laboratory in the summer of 1979 was used to develop a briefing pamphlet for the dri-Enewetak on the radiological condition of the atoll as of mid-1979. The pamphlet, entitled "Ailin In Enewetak Rainin" (The Enewetak Atoll Today), was prepared with Marshallese and English texts. It contained simplified explanations of radioactivity, its presence at the atoll, and its effects on human beings. Fourteen living/island-use patterns were described and illustrated together with predicted dose rates for each. The pamphlet did not constitute the final DOE dose assessment promised to Congress and DOI. It contained no recommendations for rehabilitation, and it clearly indicated that the data and dose estimates were still being studied and were subject to revision and refinement.[79]

Mr. Mitchell felt that the pamphlet, which he reviewed in draft form, was insufficient for decision-making by the dri-Enewetak. He engaged several eminent scientists as consultants to review the data and provide independent technical advice on predicted doses.

	COCONUTS			DWARF COCONUTS			BREADFRUIT			PANDANUS			
ISLAND	PLTD	REQ	COMP DATE	PLTD	REQ	COMP DATE	PLTD	REQ	COMP DATE	PLTD	REQ	COMP DATE	DATE ACCEPTED
Enewetak	5,482	7,968	03/21/80	456	450	01/08/80	375	300	03/12/80	905	450	09/24/79	03/22/80
Medren	11,572	9,264	10/01/79	181	180	10/24/79	132	120	11/18/79	242	180	09/15/79	11/21/79
Japtan	2,589	3,024	08/06/79	303	300	08/09/79	116	100	08/09/79	325	300	09/19/79	11/21/79
Ananij	720	624	07/21/79	0	0	-	30	25	09/10/79	158	158	07/21/79	11/21/79
Lujor	1,898	1,824	01/16/80	0	0	-	0	0	-	0	0	-	01/18/80
Aej	1,385	1,344	02/28/80	0	0	-	0	0	-	0	0	-	03/15/80
Aomon	3,409	3,168	11/10/79	0	0	-	0	0	-	0	0	-	11/20/79
Bijire	1,543	1,632	11/03/79	0	0	-	0	0	-	0	0	-	11/20/79
Lojwa	1,305	1,200	02/28/80	0	0	-	0	0	-	0	0	-	03/15/80
Alembel	1,150	1,104	11/10/79	0	0	-	0	0	-	0	0	-	11/21/79
TOTALS	31,053	31,152		940	930		653	545		1,630	1,088		

FIGURE 10-37. AGRICULTURE PLANTING PROGRAM - ENEWETAK ATOLL.

On 19 September 1979, Mr. Mitchell and his consultants, several U.S. government agency representatives, and dri-Enewetak officials travelled to Ujelang Atoll to present the dose assessment briefings. The proceedings were video-taped by a crew from Columbia Broadcasting System's "60 Minutes" program.

The Chief Secretary of the GMI, Mr. Oscar DeBrum, opened the meeting by reading a letter from the President of the Marshall Islands, Amata Kabua, to the dri-Enewetak officials and people. It advised that their national government could not bless or participate in any decision on their return to Enewetak "without being absolutely certain of all aspects of the lingering danger of residual radiation in Enewetak." He warned of the apparent dangers of living on the atoll and of the differences in prewar and present lifestyles which could be expected. He recognized that the decisions properly could be made only by the dri-Enewetak, and he expressed the willingness of the GMI to share in their problems and to assist in any way possible.[80]

After remarks by DOI and DOE representatives, Ms. Alice Buck, a distinguished translator from Kwajalein Atoll, read and explained the briefing pamphlet to the people in Marshallese. The government representatives then attempted to answer qeustions by the dri-Enewetak, whose initial response was generally negative. Regrettably, the pamphlet displayed its statistics on the effects of radiation in terms of tens of thousands of people rather than in terms of the few hundred dri-Enewetak. It tended to exaggerate those effects in the minds of the people, and its technical nature was confusing to them. Mr. Mitchell took over the questioning in terms which the dri-Enewetak could comprehend. Their response became visibly more optimistic.

Mr. Mitchell and his advisors then met separately with the Municipal Council. Following this meeting, the Council passed a resolution stating that the dri-Enjebi must return to live on the island of Enjebi and imploring the United States Government to concur in this decision and to provide all necessary assistance to enable the dri-Enjebi to return to their traditional homeland.[81]

Following the dose assessment conference, Mr. Mitchell's consultants issued their own assessment entitled "Assessment of Radiation Health Effects of the Resettlement of Enewetak Atoll." In this report, it was deemed entirely possible that this radiation exposure, including immediate Enjebi residence, would never result in even a single case of disease among the returning population or their descendants.[82] The report strongly supported the return of the dri-Enewetak to their homeland, which already had begun with the establishment of the Japtan settlement in March 1977.

THE JAPTAN SETTLEMENT

When it was announced, in April 1972, that the United States would relinquish Enewetak Atoll to the dri-Enewetak, many of them wanted to return to the atoll immediately. During their visit to the atoll the following month, however, it became obvious that much work was required before the residence islands could support any significant population. Their leaders proposed that an advance party of approximately 50 people move from Ujelang to Japtan, the former home of Iroij Johannes Peter. They would live in the existing buildings and prepare additional temporary quarters so that most of the population of Ujelang could live on Japtan until the U.S. Government could provide permanent housing. This idea evolved over the next few years into the concept of a settlement on Japtan of approximately 50 people who would assist, consult, and advise the cleanup and rehabilitation forces in their efforts. The concept was proposed to the U.S. Government officials at every opportunity [83,84,85]

At the 7 September 1974 conference at the atoll, it was agreed that some 50 dri-Enewetak, including Planning Council members, could return from Ujelang and live on Japtan, contingent on Congress approving and funding the cleanup project. This number was considered about the maximum that the island could sustain. To promote the safety of the early returnees during cleanup operations, the following conditions were established:[86]

a. No visits would be permitted on the northern islands, from Runit to Biken.
b. Scrap collection and stockpiling would be undertaken only with approval of the TTPI District Administrator's representative (DISTADREP).
c. Visits to Enewetak Island must be coordinated between the DISTADREP and the site manager of Enewetak Base.
d. Visits to other southern islands would not be made without specific prior approval of the DISTADREP and, then, only in accordance with his instructions.

These restrictions were promptly adopted by the Council of Enewetak in an ordinance which made violations punishable by $100 fines.[87] They also were incorporated into an agreement between DNA and DOI in which DOI was made responsible for assuring the provision of all necessary subsistence and support for the Japtan settlement and for law enforcement among the returnees, including their compliance with pertinent DNA regulations.[88] This agreement was implemented by a Field Command-TTPI agreement which detailed the on-atoll responsibilities for support and law enforcement.[89] The Marshall Islands District developed a plan for preparing temporary quarters and other life support facilities on Japtan; for educational, medical, and communications services; and for resupply by TTPI field ships.[90]

It soon became apparent that values and priorities in the Marshall Islands were quite different from those with which most U.S. Government officials were familiar. The Marshall Islands Public Works employees who arrived to prepare the Japtan facilities appeared ill-equipped. In fact, they intended to borrow most of the equipment and material from the Enewetak base support contractor. When the base support contractor had to furnish labor as well in order to complete the Japtan facilities before the early returnees, news teams, and U.S. Government officials arrived, the assistance was given and accepted as a normal, expected arrangement. The fine line between DOI and DOD responsibilities under the agreements faded as the work of supporting the Japtan settlement proceeded.

The first returnees, led by Chief Johannes Peter, arrived on the TTPI field ship "Militobi" on 15 March 1977 (Figure 10-38). There were 56 people in the party including Planning Council members, the DISTADREP, the school teacher, and their families. Following the arrival day ceremonies described earlier,[91] they set up housekeeping in the refurbished shops and office buildings on Japtan (Figures 10-39 and 10-40) Lieutenant Colonel John R Sitten, Jr., USA, the first Joint Task Group officer to arrive at Enewetak, established friendly relations with the returnees while acting as atoll commander. He remained their primary point of contact when he reverted to his permanent assignment as Logistics Officer. Since most of the Japtan settlement's tangible problems were logistical, the succeeding Logistics Officers also acted as Civil Affairs Officers.

The dri-Enewetak, like most Marshallese, are a practical people. After centuries of living as foragers and fishermen whose lives depend on the vagaries of Nature, they had learned to adjust to periods of plenty and of famine. The Japtan settlement, adjacent to an American base with most of the American consumer products and comforts, obviously offered an opportunity for a more plentiful life for the dri-Enewetak than was available on Ujelang. It did not approach the magnitude of the similar Marshallese settlement on Ebeye Island at Kwajalein Missile Range, but the material attractions of life at Japtan were considerable. On neighboring Enewetak Island, there was sweet distilled water, a bountiful food supply in the base warehouses, a nightly movie, and a base exchange full of consumer goods. On the other hand, Ujelang had been the home of the dri-Enewetak for 30 years, and many of the people felt displaced and homesick on Japtan. After the first 6 months, the concept of the Japtan settlement changed.[92,93]

In September 1977, the DISTADREP, Ismael John, and Magistrate, Hertes John, surprised LTC Sitten and the other government officials with

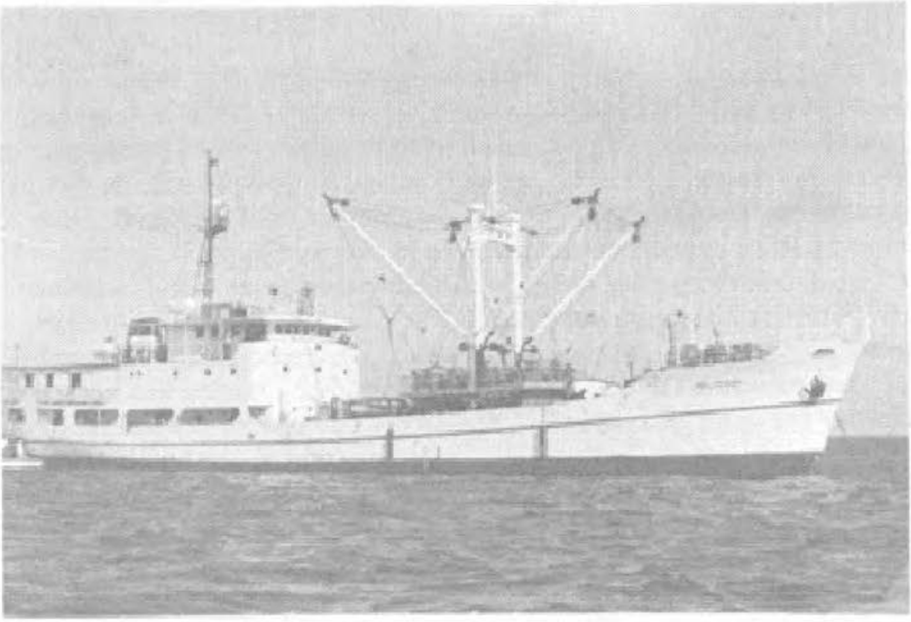


FIGURE 10-38. EARLY RETURN SHIP "MILITOBI."

FIGURE 10-39. SECTION OF JAPTAN USED FOR EARLY RETURN RESIDENCES.

FIGURE 10-40. CONVERTED APARTMENT BUILDING ON JAPTAN ISLAND.

the announcement that the dri-Enewetak planned an exchange of families between Ujelang and Japtan. Of the original party, only Iroij Johannes Peter would remain. Even his wife, Bila, wanted to return to Ujelang. All of the Planning Council members were leaving, and any future decisions by them would be made on Ujelang or on short visits to Enewetak. (This made little practical difference, since the Planning Council had no real power without the concurrence of the Municipal Council and the Iroijs.) The dri-Enewetak indicated that they were not dissatisfied with conditions on Japtan but had always planned to exchange the Japtan population at 6-month intervals.[94,95]

The first exchange increased the population on Japtan to 88 instead of the agreed 50. This severely strained the available housing, sanitation facilities, and water supply on Japtan. Colds and influenza became widespread, affecting 75 percent of the people, and one baby born on the island died within 3 days. Because of the long journey, strange surroundings, sickness, and lack of breadfruit and pandanus to vary their diet, the new families were not as happy with the Japtan settlement as the first group had been.[96] The new school teacher, who had made excellent progress instructing 20 students, became dissatisfied with the DISTADREP's support and conditions on Japtan and returned to Ujelang after 1 month.[97] The Japtan settlement area was strewn with waste and garbage, and the water cisterns were unsanitary. The disease, unsanitary conditions, and lack of DOI/TTPI support at Japtan distressed LTC Sitten, and he initiated action to improve the situation.[98] With the assistance of the Joint Task Group, conditions and morale on Japtan gradually improved. The entire Japtan population celebrated Christmas 1977 in the Enewetak Base dining hall with a traditional turkey dinner paid for by donations from the cleanup and rehabilitation forces.[99]

As time passed, changes occurred in the Japtan settlement and its relations with forces at Enewetak Camp. A variety of cultures were represented on the atoll, especially within the American military and contractor forces. There were the Marshallese, some employed by the contractors, with their casual customs; there were American contractor employees who spent their lives in remote assignments; there were Filipinos seeking better wages than were available at home and who were subject to removal for the slightest wrongdoing; there were "island boys" from Hawaii and other parts of the Pacific; there were the "boys from the block" who grew up in the slums and carried their personal lifestyles into the military; and there were the professional military, responsible for order and discipline in a disorderly part of the world. Considering the potential for cultural shock, the additional problems the Japtan settlement caused were not as serious as could be expected.

The Japtan men used discarded plywood, none of it marine-grade, to construct small boats, and they obtained at least one small aluminum boat from a mail order company. Powered by outboard motors obtained from various sources, these craft became known as the "Japtan Navy." They were used for fishing the southeastern waters of the lagoon and several miles out into the ocean and for travel to the other islands. Despite the agreements, keeping the dri-Enewetak on Japtan became an impossible task. One could wade the reef from Japtan to well past Runit at low tide, and the Joint Task Group was not manned or authorized to enforce the municipal council's ordinance prohibiting unauthorized travel off Japtan. Field Command efforts to have TTPI provide an effective resident representative to enforce the ordinances and regulations were fruitless.[100]

The increased mobility and natural gregariousness of the dri-Enewetak led to broader social and commercial contacts between the Marshallese and other people working at the Enewetak Camp. The husbands of some Japtan women worked for contractors on Enewetak. Inter-island visits became more and more frequent. Liquor and beer appeared on Japtan to the great displeasure of Iroij Johannes Peter, who disapproved of the dri-Enewetak drinking any alcohol. There were reports of disturbances and of Japtan residents eating in the dining hall without paying. The Joint Task Group Commander brought these matters to the attention of the DISTADREP, Ismael John, and the Council Members.[101] The council passed more ordinances prohibiting alcoholic beverages on Japtan and unauthorized travel between the islands; however, the enforcement of the ordinances did not improve.[102,103]

The situation deteriorated further when Ismael John resigned his position as DISTADREP upon being elected as the representative from Ujelang/Enewetak to the legislature (Nitijela) of the newly formed GMI. The DISTADREP appointed from the Japtan population to replace Ismael was less effective in law enforcement, as was the man hired by the council to act as policeman for the Japtan settlement.[104,105]

Meanwhile, a proposal was being discussed among government officials to permit an increase in the early settlement population by allowing families to move into the newly completed houses on Medren and Japtan. The contractors favored the idea since it would reduce their maintenance and insurance costs on the completed houses. There was considerable support for the idea among some government officials. Strong objections were voiced by the Joint Task Group Commander and the Field Command's Director of Enewetak Operations.[106] The dri-Enewetak were not enthusiastic, however, since Medren in its devegetated state appeared more bleak than their first view of Ujelang. In addition, some of the eventual owners did not care to have others living in their new homes, even on an interim basis. The TTPI disapproved because of the potential legal and contractual complications. Thus, despite repeated attempts by others to bring in several hundred more early returnees, the proposal was never implemented.[107]

Despite the difficulties, the Japtan settlement was beneficial. It was an early act of good faith by the U.S. Government, clearly showing commitment to total rehabilitation and resettlement, even before cleanup operations began. It provided many of the dri-Enewetak an opportunity to see the atoll and to experience firsthand something of what it might be like to live there again. Many others, who did not visit Japtan during the Cleanup Project, were able to see their homeland again during the Enewetak Return Ceremony in early April 1980.

ENEWETAK RETURN CEREMONY

The desirability of a ceremony to mark the completion of the cleanup project was first proposed in December 1978 by the then TTPI DISTADMI, Mr. Oscar DeBrum, during a visit to the atoll by the High Commissioner of the TTPI, Mr. Adrian Winkel, the Director, DNA, Vice Admiral Robert R. Monroe, and other government officials. The dri-Enewetak, through their counsel, expressed enthusiastic support for the idea. They wanted to contribute actively to the celebration and participate in the planning and preparations. Coordinated planning commenced at Field Command and in the Joint Task Group shortly thereafter and continued up until the week of the ceremony. A coordinated

CONPLAN[108] was distributed in early February 1980, and the JTG Operations Order (OPORD) was provided to action offices later the same month.[109]

The theme of the ceremonial events was one of gratitude on the part of the Government of the United States to the Enewetak people for the use of the atoll for nuclear testing. The events celebrated the return of the atoll to the people and marked the completion of both the cleanup project and the rehabilitation program, as had been agreed during the planning phases.[110]

Sixty-five invited guests, representing all of the organizations involved in the project, joined with 541 Enewetak people for the proceedings on the atoll. Most of the dri-Enewetak arrived from Ujelang, via Micronesian ships, for the occasion (Figure 10-41).

FIGURE 10-41. RETURNING DRI-ENEWETAK.

The ceremonies, on 8 April 1980, included presentation of two inscribed bells donated by the Cleanup Project and Rehabilitation Program personnel for the church towers at Medren and Enewetak (Figures 10-42 and 10-43); remarks by distinguished representatives of the U.S. Government, the GMI and the Enewetak people (Figure 10-44); signing of a proclamation (Figure 10-45) and a celebration supper. Ceremonial songs and dances to mark the occasion were performed by the Enewetak people. Gifts were provided to the people through the Navy's Project

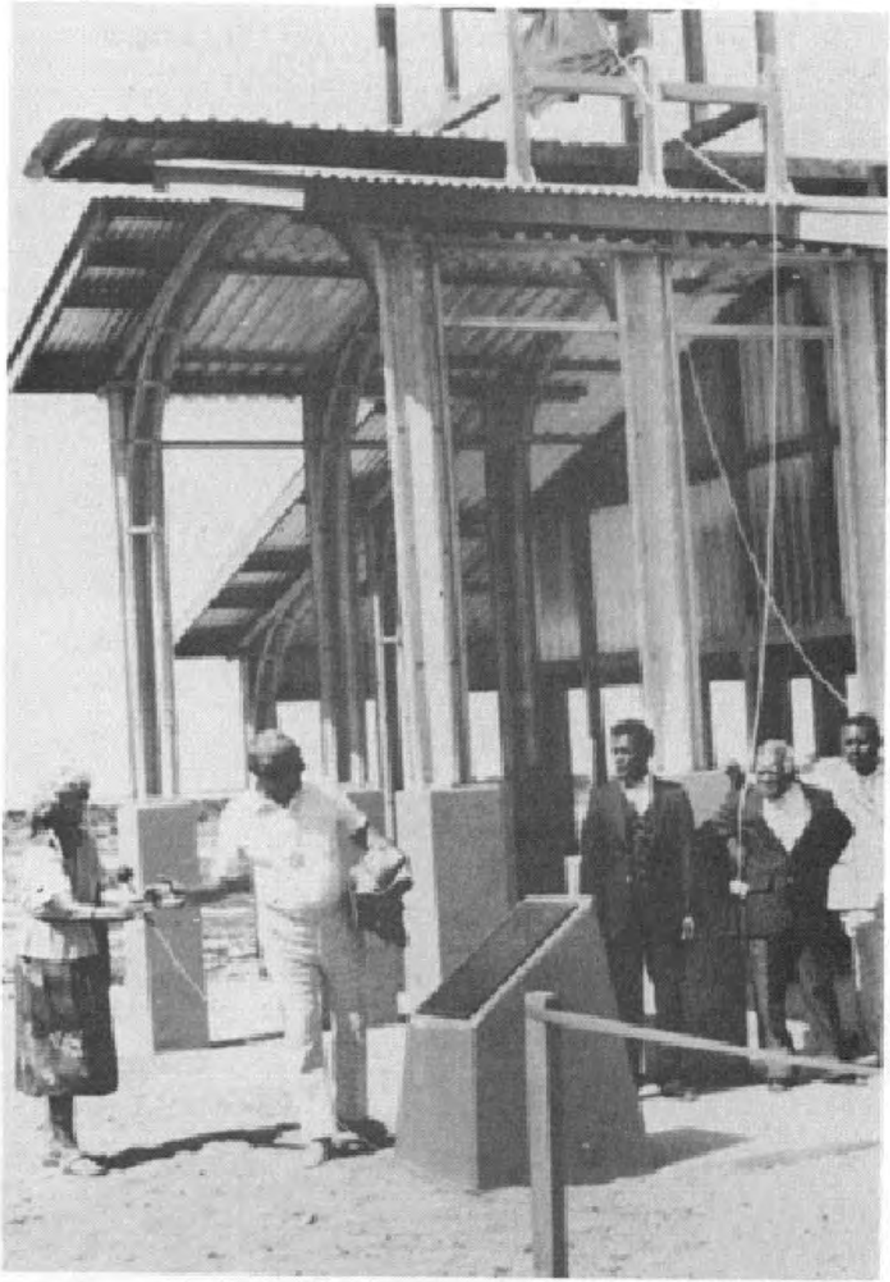


FIGURE 10-42. CHURCH BELL PRESENTATION.

FIGURE 10-43. PLAQUE COMMEMORATING THE PRESENTATION OF CHURCH BELL.

WELCOME STATEMENT	COL Kenneth E Halleran Commander, Joint Task Group
INVOCATION	Rev Biem Damon
REMARKS BY HIGH COMMISSIONER, TTPI	Honorable Adrian Winkel
REMARKS BY GMI REPRESENTATIVE	Honorable Wilfred Kendall
REMARKS BY DIRECTOR, DNA	VADM Robert R. Monroe
INTRODUCTIONS	COL Kenneth E. Halleran
REMARKS BY US DEPARTMENT OF ENERGY	Honorable Ruth C Clusen Assistant Secretary for Environment
REMARKS BY US DEPARTMENT OF THE INTERIOR	Honorable Joan M Davenport Assistant Secretary for Energy and Minerals
SPEECHES BY DRI-ENEWETAK OFFICIALS	Iroij Johannes Peter Iroij Binton Abraham
READING OF PROCLAMATION	COL Kenneth E. Halleran
SIGNING OF PROCLAMATION	Agency and dri-Enewetak Reps
PRESENTATION OF COMMEMORATIVE BELL	VADM Robert R. Monroe and DOE/Holmes & Narver Reps
BENEDICTION	Rev Biem Damon

FIGURE 10-44. PROGRAM OF EVENTS.

Nan in keañ
Proclamation

Kin an armijin Enewetak kar aikwij in emmakit jen ko jen ilo 1947 bwe aili eo an er jikin kakemmelmel kein armae ko rekauit im

Whereas the People of Enewetak were relocated from their homes in 1947 in order that their atoll could be used in the nuclear weapons testing program; and

Kin ilo kein armae ko elap air kaju kar jibadel aili in Enewetak ikõtan jilo ken 1948 im 1958 ... kom ... worm anlok ikijjen kokemmelmel ... kein armae ko eo elap ... ñon tukõt ... im

Whereas between 1948 and 1958 Enewetak Atoll served as the site for numerous nuclear tests thereby enabling the development of weapons which have contributed significantly to the security of the free world; and

Kin an program in kakammelmel kar kõmmor bwe en wor uõn jonan men ko reradioactive eo ... jen ... im

Whereas the nuclear testing program caused a degree of radiological contamination of various islands of the atoll; and

Kin an kien eo an Trust Territory of the Pacific Islands kar lelok non e aolep maron ko ilo 1976 ikijjen ... kejerbale aili eo nan ... elukie ... ekkar non mantin Marshall im

Whereas the United States in 1976 terminated all of its rights, title and interests in and to Enewetak Atoll; and

Kin ... kar kien eo an United States ko enilok aolep maron ko an ilo 1976 ikijjen bok ... kejerbale ailin eo non an kõnani im

Whereas the Government of the Trust Territory of the Pacific Islands in 1976 restored all rights, title, interests, and rights of use and occupancy in and to Enewetak Atoll to all persons who hold traditional right to the land of Enewetak; and

Kin an kar kien eo an Trust Territory of the Pacific Islands ilo etan armij in Enewetak bar ke eblak ailin eo non kien eo an United States ilo 1976 bwe en maron ko ... õne jerbal in karreo ikijjen men ko reradioactive im kebo ailiñ eo ñon an armij ... maroñ bar jokwe ie im

Whereas the Government of the Trust Territory of the Pacific Islands, acting on behalf of the People of Enewetak in 1976 entrusted the use and custody of Enewetak Atoll to the United States to enable the radiological cleanup and rehabilitation projects to be carried out; and

Kin an Congress eo an United States kar kajemmej money in 1976 non ko ... jerbal in karreo ekkal im kallib ilo ailin eo im

Whereas the cleanup and rehabilitation projects were funded by the Congress of the United States in 1976; and

Kin an kar Enjebi jab ... waan ene ko en wij koweppen ... enen jokwe ... Enjebi rekõnar ... maroñ ... jokwe ... emõkaiñ ekkar ...

Whereas the rehabilitation program did not include resettlement of the Dri Enjebi to their home island but they wish fervently to resettle there at the earliest practicable time; and

Kin an lap kwonan armij in Enewetak ... jerbal ... kab ekkal ... jen ... 1972 ... 1980

Whereas the People of Enewetak played major roles in the radiological cleanup and rehabilitation projects from their conception in 1972 until their completion in 1980

Eindrein ... renal ... etair ijin iiõl rej kwalok

Now therefore the undersigned do hereby proclaim

Bwe emwij an kien eo an United States kadredrelok jerbal in kar eoikok men ko reradioactive im jerbal in ekkal eo ilo ailin in Enewetak ekkar ñon karõk im bebe ko emwij koweppen im kajjemoi money non ... im

That the United States has completed the Enewetak radiological cleanup and rehabilitation project in accordance with the planned and funded guidelines; and

Bwe kien eo an United States ekonan kwalok kammolol eo emwilol non armij in Enewetak kin air kar kotlok an United States kejerbal ailin eo air ñon juon jerbal eo ekanuij lap tokjen ikijjen bobrae tarinae ... bareinwot kin an kar lap air bõk kwonair ilo jerbal *in karreo k ailiñ eo jen men ko reradioactive* kab bõk kwonair in jerbal in ekkal eo im

That the United States wishes to express its sincere gratitude to the People of Enewetak for the use of their atoll for this vitally important national security project and for their major role in the radiological cleanup and rehabilitation projects and

Bwe armij in Enewetak rej kwalok air kammolol elap ijin non kien eo an United States kin aolepen kate ko an ilo etan bwe ren maron bar eblak non iamoren eo air im

That the people of Enewetak hereby express their gratitude to the people of the United State for the effort expended on their behalf to enable them to return to their homeland; and

Bwe aolep ene ko em wij kar leok edro ie ñon United States bwe en karreoiki en men ko reradioactive im bar kalek ... kio rej eblak nõn armij in Enewetak ekkar non weppen eo jen kien eo an Trust Territory of the Pacific Islands im

That the United States hereby returns use and custody of the lands entrusted for the radiological cleanup and rehabilitation projects to the People of Enewetak through the Government of the Trust Territory of the Pacific Islands; and

Bwe aolep rej koba ... dron ilo kejatdrikdrik bwe ejjap etto im ... Enjebi renaj bar maroñ jeblak ñon er eo eneir ilo ejelok kauatata ñõn mour ko air

That the undersigned jointly express the hope that the Dri Enjebi will one day soon be able to return in safety to Enjebi Island

Kim ro kimij ... kamol kin men kein kimij je etañ ijin kin peim ilo April 8 ran 1980

In witness whereof we hereunto set our hands this 8th day of April 1980

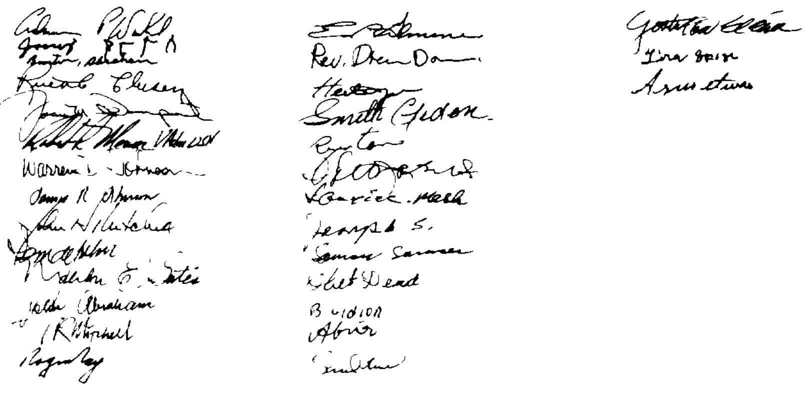
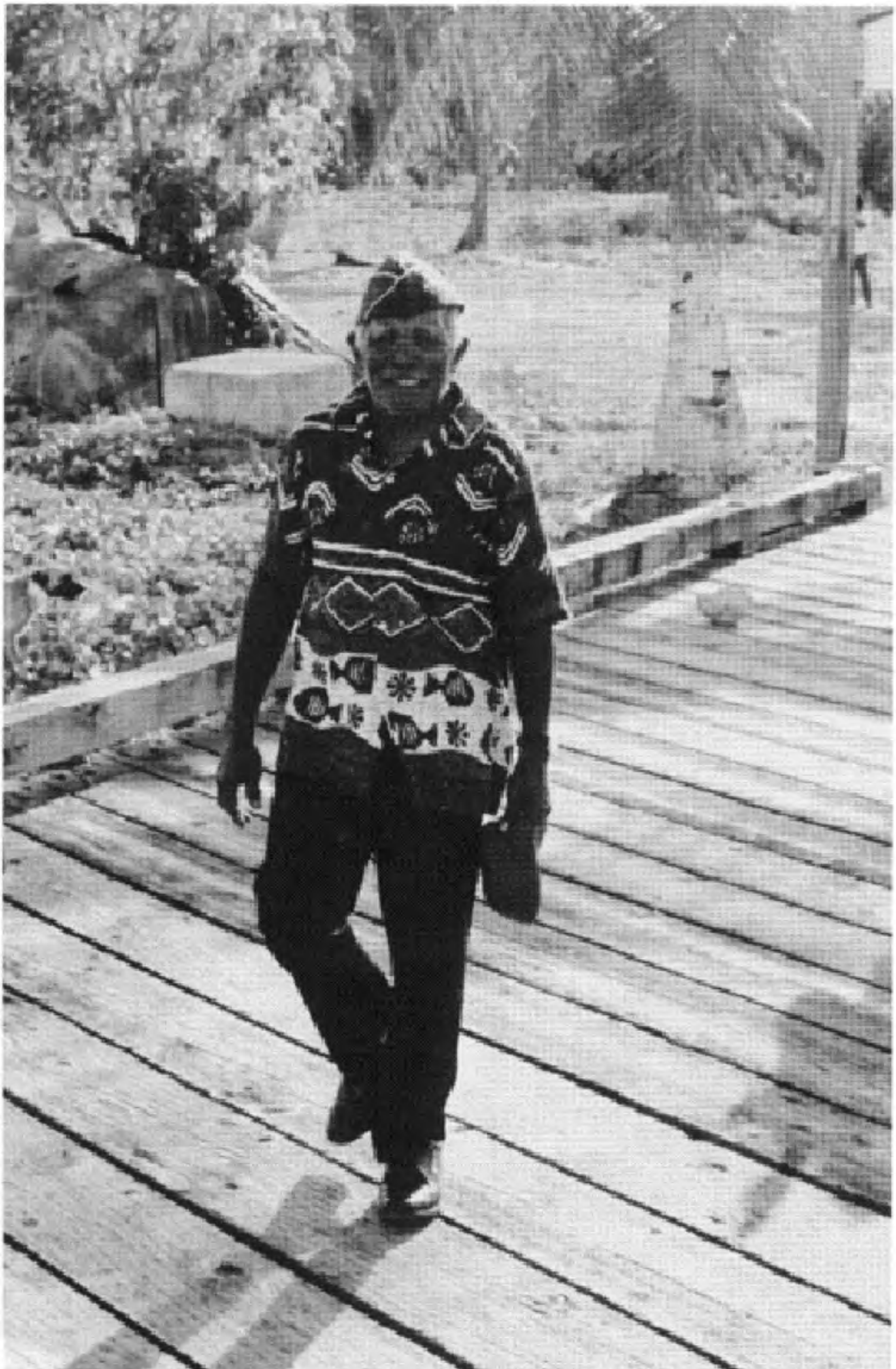


FIGURE 10-45. ENEWETAK RETURN PROCLAMATION.

Handclasp, and gifts of food were provided to the people by DNA. Attendees toured the facilities on Medren and Enewetak and were provided helicopter flights over the islands of the atoll and to the Cactus Crater dome. The events were concluded on 9 April 1980, and the American guests returned to Hickam AFB, Hawaii, that afternoon. Most of the dri-Enewetak attendees returned to Ujelang on 9 and 11 April, leaving 152 permanent dri-Enewetak residents on Japtan and Enewetak pending completion of actions by DOI/TTPI to complete the settlement of all who wished to live at Enewetak.



EPILOGUE

In early October 1980, the GMI ship Micro Pilot, making several round trips, brought nearly 400 dri-Enewetak and many of their belongings from Ujelang to Enewetak for a trial resettlement. The trial period was to last at least 90 days, after which individual family decisions would be made on who would remain at Enewetak Atoll and who would return to Ujelang should they choose to do so. A homecoming ceremony was conducted in the Enewetak Island chapel on 4 October 1980.[1] Mr. Oscar DeBrum and Mr. Wilfred Kendall represented the GMI, while Mr. Scott Stege represented the TTPI. It was a simple ceremony during which the new homes were formally presented to their new owners. The ceremony was followed by a feast which included Marshallese foods brought from Ujelang.[2]

At the end of the original trial period, many people were still undecided about where to establish permanent residence. No one was living on Japtan but the communities on Medren and Enewetak Islands appeared well established. The people gathered on Enewetak Island for Christmas and New Year's festivities and to discuss resettlement. They decided to extend the trial period another 90 days.

After New Year's, the people remained on Enewetak Island to greet the new Director, DNA, Lieutenant General Harry A. Griffith, USA, on his orientation visit to Enewetak on 7 January 1981. Despite a dearth of rain, the new plants were doing well, especially the breadfruit trees which were 5 to 7 feet tall. The people appeared to be healthy, happy, and thriving. The new houses had been furnished and given the personal touches that make a home.[3]

For the first time in 33 years, Enewetak Atoll was becoming again the homeland its people had known and loved.

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CHAPTER 3: MOBILIZATION

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APPENDIX A

ABBREVIATIONS AND ACRONYMS

A

ABC	American Broadcasting Company
ACU	Assault Craft Unit
AEC	Atomic Energy Commission
AEC-NV	Atomic Energy Commission-Nevada Operations
AFB	Air Force Base
AFCS	Air Force Communications Service
AFRRI	Armed Forces Radiobiology Research Institute
AFRTS	Armed Forces Radio and Television Service
AFSWP	Armed Forces Special Weapons Project
AFWL	Air Force Weapons Laboratory
AIC	American International Constructors, Inc
Am	Americium
ANSI	American National Standards Institute
Anti-C	Anti-Contamination
AR	Army Regulation
ARRADCOM	Army Armament Research and Development Command
ASD(ISA)	Assistant Secretary of Defense for International Security Affairs
AUTODIN	Automatic Digital Network

B

BG	Brigadier General
BTT	Boat Transportation Team

C

CAPT	Captain, Navy
CBS	Columbia Broadcasting System
CDR	Commander
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CINCPAC	Commander in Chief, Pacific Command
CIST	Cylindrical In Situ Test
CJTG	Commander, Joint Task Group
cm	centimeter

CNO Chief of Naval Operations
COL Colonel
COMEA Commander, Enewetak Atoll
COMNAVSURFPAC
Commander, Naval Surface Force U.S. Pacific Fleet
COMPHIBGRU
Commander, Amphibious Group
COMPHIBGRUEASTPAC
Commander, Amphibious Group, Eastern Pacific
CONPLAN Concept Plan
CONUS Continental United States
Co Cobalt
cpm counts per minute
CPT Captain, Army, Air Force, Marine
Cs Cesium
CY Cubic Yard

D

DARCOM Materiel Development and Readiness Command
DCS Defense Communication Service
DEIS Draft Environmental Impact Statement
DEPRA Defense European and Pacific Redistribution Activity
DIRDNA Director, Defense Nuclear Agency
DISTAD District Administrator
DISTADMI District Administrator, Marshall Islands
DISTADREP District Administrator, Representative
DLA Defense Logistics Agency
DMA Division Military Application
DNA Defense Nuclear Agency
DOD Department of Defense
DOE Department of Energy
DOE-ERSP Department of Energy-Enewetak Radiological Support Project
DOE-NV Department of Energy-Nevada Operations
DOI Department of the Interior
DPDO Defense Property Disposal Office
DPDR Defense Property Disposal Region
DPDR-PAC Defense Property Disposal Region-Pacific
DPDS Defense Property Disposal Service
dpm disintegrations per minute
DRI Desert Research Institute
DSA Defense Supply Agency

E

EAI	Enewetak Atoll Instruction
EASI	Enewetak Atoll Seismic Investigation
EG&G	EG&G, Inc., an DOE-NV contractor (formerly Edgerton, Germeshausen & Grier)
EIS	Environmental Impact Statement
EMBL	Enewetak Marine Biological Laboratory
EOD	Explosive Ordnance Disposal
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERDA-NV	Energy Research and Development Administration-Nevada Operations
ERDA-PASO	Energy Research and Development Administration-Pacific Area Support Office
ERSP	Enewetak Radiological Support Project
EXPOE	Exploratory Program on Eniwetok

F

F&S	Fenix and Scission, Inc.
FAD	Force Activity Designator
FCDNA	Field Command, Defense Nuclear Agency
FCLP	Field Command Logistics Pacific
FCLS	Professional Services Division, Logistics Directorate
FCR	Headquarters, Joint Task Group
FCRR	Headquarters, Joint Task Group, Radiation Records
FCZ	Enewetak Operations Directorate
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FORSCOM	Forces Command (Army)
FPDB	Fission Products Data Base
FPS	Fission Products Survey
FRC	Federal Radiation Council
FRST	Field Radiation Support Team
FY	Fiscal Year

G

GB	Gross Beta
GCT	Greenwich Civil Time
GMI	Government of the Marshall Islands
GZ	Ground Zero

H

H&N	Holmes and Narver, Inc
H&N-PTD	Holmes and Narver-Pacific Test Division
HEUS	High Energy Upper Stage
HICOM	High Commissioner
HQ	Headquarters
HRE	Hawaiian Regional Exchange

I

IAW	In Accordance With
ICRP	International Commission on Radiological Protection
IMP	In situ van (trademark of DeLorean Manufacturing Co.

J

J-1	Joint Task Group Administration
J-2	Joint Task Group Radiation Control
J-3	Joint Task Group Engineering
J-4	Joint Task Group Logistics
JCS	Joint Chiefs of Staff
JTF-1	Joint Task Force One
JTG	Joint Task Group

K

K-40	Potassium-40
keV	kilo-electron Volt
KMR	Kwajalein Missile Range
KT	Kiloton (thousand tons)

L

LARC	Lighter Amphibious Resupply, Cargo
LASL	Los Alamos Scientific Laboratory
LBDA	Lexington-Blue Grass Depot
LCDR	Lieutenant Commander
LCI	Landing Craft, Infantry
LCM	Landing Craft, Mechanized
LCPL	Landing Craft, Personnel
LCU	Landing Craft, Utility

LLL	Lawrence Livermore Laboratory
LORAN	Long Range Aid to Navigation
LT	Lieutenant
LTC	Lieutenant Colonel
LTG	Lieutenant General
LVT	Landing Vehicle, Tracked

M

MAC	Military Airlift Command
MAJ	Major
MARS	Military Affiliate Radio Station
MATSCO	Management and Technical Services Company
MCP	Military Construction Program
MDA	Minimum Detectable Activity
MEDEVAC	Medical Evacuation
MG	Major General
MIG	Marshall Islands Government (see GMI)
MILCON	Military Construction
MLSC	Micronesian Legal Services Corporation
MOTBA	Military Ocean Terminal, Bay Area
MPC	Maximum Permissible Concentration
MPRL	Mid-Pacific Research Laboratory
mrad	millirad
MSC	Military Sealift Command
MSN	Micronesian Status Negotiations
MT	Megaton (million tons)
M/T	Measurement Ton (40 cubic feet)
MTMC	Military Traffic Management Command
MTMCWA	Military Traffic Management Command, Western Area
μR/hr	(mu) micro-Roentgens per hour

N

NAS	National Academy of Science
NBS	National Bureau of Standards
nCi	nanocuries
NCO	Noncommissioned Officer
NCOIC	Noncommissioned Officer in Charge
NEPA	National Environmental Protection Act
NRDC	Naval Research and Development Command
NTS	Nevada Test Site

O

OCE	Office of the Chief of Engineers
OEHL	Occupational and Environmental Health Laboratory
OIC	Officer in Charge
O&M	Operations and Maintenance (O&M)
OMB	Office of Management and Budget
OPLAN	Operations Plan
OPLIFT	Opportune Sealift
OPORD	Operations Order
OSHA	Occupational Safety and Health Administration

P

PACAF	Pacific Air Forces
PACE	Pacific Cratering Experiment
PASO	Pacific Area Support Office, DOE
pCi/g	picocuries per gram
pCi/m^3	picocuries per cubic meter
PCS	Permanent Change of Station
PHIBRON	Amphibious Squadron
PMEL	Precision Measurement Equipment Laboratory
POD	Pacific Ocean Division
POE	Port of Embarkation
POL	Petroleum, Oil and Lubricants
psi	pounds per square inch
PTD	Pacific Test Division
Pu	Plutonium
PVT	Private

R

RADM	Rear Admiral
R/hr	Roentgens per hour
RCC	Radiation Control Committee
RDT&E	Research, Development, Test and Evaluation
REDAR	Radiation and Environmental Data Acquisition and Recorder System
rem	roentgen equivalent man
RPG	Radiation Protection Guide
RPO	Radiation Protection Officer
RSAIT	Radiation Safety Audit and Inspection Team

S

SAARI	Scientific After Action Reports/Investigation
SAMTEC	Space and Missile Test Center
SAR	Search and Rescue
SECDEF	Secretary of Defense
SEABEE	Construction Battalion
SFC	Sergeant First Class
SITREP	Situation Report
SLA	Sandia Laboratories, Albuquerque
SOP	Standing Operating Procedures
Sr	Strontium

T

TASA	Television-Audio Support Activity
TDY	Temporary Duty
TLD	Thermoluminescent Dosimeter
TNT	Trinitrotoluene
TRU	Transuranic Elements
TTPI	Trust Territory of the Pacific Islands

U

UDT	Underwater Demolition Team
UH-1	Helicopter
UN	United Nations
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USA	United States Army
USAE	United States Army Element
USAF	United States Air Force
USAFE	United States Air Force Element
USASCH	United States Army Support Command, Hawaii
USDA	United States Department of Agriculture
USGS	United States Geodetic Survey
USMC	United States Marine Corps
USN	United States Navy
USNE	United States Navy Element
USS	United States Navy Ship

V

VADM	Vice Admiral

W

WBCT	Water Beach Cleanup Team
WES	Waterways Experiment Station
WESTCOM	Western Command
WTCF	Warping Tug Causeway Ferry

APPENDIX B
TABLES OF RELEVANT FACTS

SECTION 1. Cleanup Summary

a. Island Characterization

CRITERIA			STATUS
Residential	—	40 pCi/g	30
Agricultural	—	80 pCi/g	7
Food Gathering	—	160 pCi/g	2
Quarantined	—		1

b. Soil Removal (Total Cubic Yards): 104,097

Boken	—	4,937	Aomon	—	10,603
Enjebi	—	53,007	Aomon Crypt	—	9,776
Lujor	—	14,929	Runit	—	10,735
			Medren	—	110

c. Debris Removal

CONTAMINATED	NONCONTAMINATED*
5,883 CY	253,650 CY

*Includes 54,500 cubic yards removed by scrap contractor and 76,340 cubic yards of concrete rubble used as shore protection.

d. Curies Contained: 14.72

SECTION 2. Project Personnel Summary

a. U.S. Army Element — 2,670

b. U.S. Navy Element — 2,207

c. U.S. Air Force Element — 740

d. DOE and Contractors — 1,011

e. DOI/TTPI	—	597
f. DNA/JTG	—	246
g. Journalists	—	49
h. Others	—	513
i. Total		8,033

SECTION 3. Financial Management Summary

a. MILCON Expenditures ($ to nearest hundred)

MOBILIZATION

Field Command Surface Shipments	$ 41.8	
MSC Surface Transportation	507.3	
MAC Air Transportation	165.5	
Commercial Air Shipments	.6	
Initial Mess Hall Supplies	67.9	
Initial Housing Supplies	124.0	
Radiological Supplies	104.0	
Stevedoring/Rigger Services (Ft Eustis, VA)	18.0	
Field Command Equipment Purchases	121.1	
Total Mobilization Costs		$1150.2

FIELD CONSTRUCTION

MSC Surface Shipments		135.9
MAC Air Shipments		350.0
Commercial Air Cargo		22.2
Packing and Crating		127.8
Marine Distillation Units		7.4
Runit Base Camp Construction		303.5
Material Cost	212.3	
Design Cost	1.3	
Construction Cost	89.9	

***FIELD CONSTRUCTION** (Cont'd)*

Enewetak Camp Expansions		645.8	
400-gallon Aqua Chems (3)	164.1		
OPLAN Building Modifications	267.7		
Electrical Modifications	10.1		
Installation of Generators/Aqua Chems	37.7		
Lens Well and Pipeline	18.2		
Laundry Facility	76.6		
Latrine Building 19	13.4		
JP-4 Discharge System	17.5		
Detention Facility	5.3		
Install Trailers	.8		
Install Reefers	15.6		
Reproduction Room, Building 15	7.7		
Women's Quarters	11.1		
Lojwa Base Camp Construction		1586.9	
Material (Army Requirements)	1051.6		
Salt Water Pump Station	27.1		
Mess Hall	219.9		
Latrine Trailers	10.1		
600-gallon Aqua Chems (4)	278.2		
Navy Momat for Beaches		28.1	
Total Field Construction Costs			3207.6

CLEANUP

Dri-Enewetak Labor	13.5
Johnston Atoll Personnel Assistance	11.3
Field Command Surface Shipments	2.6
MSC Surface Transportation	1965.4
Field Command Air Cargo	5.1
MAC Air Transportation (routine)	2194.0
MAC Air Transportation-Typhoon Alice	56.2
Oakland, CA, Army Base-Packing and Crating	19.2
Commercial Air Cargo	12.4

***CLEANUP** (Cont'd)*

Packing/Crating/Port Handling		841.9
Overland Cargo Costs		44.5
Fuel (POL)		1322.6
Inventory	2569.2	
Excess Enewetak Island Utilities	767.8	
Lojwa Utilities	258.2	
Air Force reimbursement	(5.3)	
Department of the Interior reimbursement	(106.1)	
Navy reimbursement	(259.9)	
Army reimbursement	(304.7)	
Field Command O&M reimbursement	(475.7)	
Miscellaneous Contractor reimbursement	(1120.9)	
Explosives		177.2
Medical Supplies		50.0
Subsistence		163.2
Inventory	3776.4	
Enewetak Mess Hall	(2265.1)	
Lojwa Mess Hall	(1294.0)	
Miscellaneous Contractors	(54.1)	
Recreation		9.7
Supplies, Common		33.7
Supplies, Boats Conversion		11.5
Supplies, Radiological Safety		145.3
Supplies Field Command purchased		22.0
Causeway Special Study		.8
Copy Machine Rent		24.7
Tropical Storm Rita (Repairs)		15.5
Tropical Storm Nadine (Repairs)		28.6
Typhoon Mary		195.2
Evacuation Labor	36.1	
MAC Evacuation	149.1	
Quarters and Subsistence, Guam	2.9	
Cleanup Costs	2.5	
Replace Salt Water Lines	4.6	

***CLEANUP** (Cont'd)*

Equipment		186.2
Four Boston Whalers	57.1	
Insect Sprayer	2.6	
Dust Suppression System	64.4	
Air Conditioners	4.0	
Outboard Motors	10.0	
Welding Machines (3)	1.7	
Bulk-haul Boat Pumps	10.8	
75KW Generator	13.7	
Rate Meters/Sealers and Probers	19.3	
Gas Cylinders	2.6	
Aomon Crypt		325.0
Sheetpiling/Associated Equipment	138.5	
Silt Screen	8.8	
Desilt Operation	8.3	
Excavation Labor	32.4	
Pile Driving Labor	44.3	
Construction	8.0	
Magnetometer Service	9.1	
Channel Dredge	75.6	
Core Drilling Personnel and Rig, (Mobile, AL, District Engineers)		47.1
Typhoon Alice		342.0
Roads, grounds, shore protection, water, sewer, electrical lines	291.9	
Billets, Building 462	3.1	
Hangar	.6	
Carpenter Shop	7.6	
Shipping/Receiving Warehouse	7.3	
Army Maintenance Shops	13.4	
Warehouse, General	9.1	
Warehouse, Supply	4.5	
Warehouse, Subsistence	2.0	
Tradewind Club	2.5	
Total Cleanup Costs		8276.4

RUNIT OPERATIONS (CRATER CONTAINMENT)

MSC Surface Transportation		814.5	
MAC Air Transportation		2.5	
Packing and Crating		158.5	
Explosives		412.6	
Cement and Attapulgite		1225.6	
Pre-cast Forms		4.4	
Engineering Services		3.0	
Concrete Technician Assistance		49.0	
Corp of Engineer On-site Review		8.0	
Factory Representative for Concrete Pumps		13.3	
Equipment		81.4	
Cement Pump	12.1		
Concrete Pump	40.1		
Harrows and Screeds	24.6		
Core Drill	4.6		
Total Runit Operations Costs			2772.8

RADIOLOGICAL SUPPORT

Department of Energy, Nevada Office	1500.0	
Total Radiological Support Costs		1500.00

DEMOBILIZATION

MSC Surface Shipments	442.1	
Transport Satellite Communications Service	58.9	
MAC Air Shipments	56.3	
Packing and Crating	167.9	
Rebag Attapulgite	2.5	
Offloading Navy Opportune Lift	9.3	
Lojwa Tear Down and Restoration	76.9	
Miscellaneous Supplies	21.1	
Total Demobilization Costs		835.0

SCIENTIFIC AFTER ACTION REPORTS/INVESTIGATION (SAARI)

National Academy of Science (travel)	14.2	
Army Engineer Core Sampling (Cactus Crater)	104.6	
National Academy of Science Contract	289.5	
Soil Sampling, Sediment and Water Analysis (LL)	27.1	
Total SAARI Costs		435.4
Total Obligations as of 6 March 1981		18,177.4
MILCON Appropriations		20,000.0
Balance (at the time when all accounts are closed, will be returned to the Treasury of the United States)		1,822.6

b. Base Camp Expansion O&M Costs

(1) FY 76 ($ to the nearest hundred) . . . . $ 558.2

Warehouse renovation	$12.4	Repair POL Lines	2.0
Rehab Chapel	4.5	Buy and install Aqua Chem Units	73.5
Replace Roof (fresh water tank)	9.6	Repair Cargo Pier	21.8
Repair and clean sewer	17.5	Rehab Carpenter Shop	2.1
Repair and Install Generator	11.4	Replace Personnel Pier	45.0
Repair and Install Salt Water Pump	6.6	Activate Fire Protection System	20.2
Complete Electrical Distribution	27.0	Rehab Foamite Pump House	1.1
Replace Cold Storage Building	22.8	Rehab POL Storage System	40.9
Air-Conditioning & Exhaust Bldg 462	6.0	Repair Fresh Water Dist System	67.4
Repair Consolidated Maintenance Shops	23.1	Repair Salt Water Dist System	63.1
Rehab Building 462	17.5	Repair POL Liners	20.0
Repair Garbage Pier	4.1	Rehab Building 643	17.9
		Rehab Mess Hall (Phase I)	20.7

(2) FY 76T 115.3

Rehab Mess Hall (Phase II)	52.2
Rehab POL Tanks	63.1
	115.3

(3) FY 77 .... 689.3

Repaint Airstrip	43.8	Construct Dispensary	52.7
Pressurize Fresh & Salt Water Sys	27.8	Street Lights (Camp Area)	13.3
Rehab Mess Hall (Phase III)	163.9	Rehab Building 10 (Quarters)	12.5
Repair & Extend Elect Dist Sys	29.0	Rehab Building 24 (Quarters)	26.4
Rehab Fresh Water Tank	17.4	Rehab Building 11 (Quarters)	38.0
Modify Building 4 (Quarters)	30.3	Rehab Building 12 (Quarters)	34.7
Purchase/Install 2 Aqua Chems	129.2	Rehab Building 16 (Quarters)	34.6
		Rehab Housing Trailers	17.5
		Additional/Alternate POL Sys	18 2

c. O&M Expenditures by Fiscal Year (in thousands): $19,692.0

FY 75 ------------ $ 477.3
FY 76 -------------- 1,557.7
FY 76T ------------ 1,114.5
FY 77 -------------- 4,666.3
FY 78 ----------- $4,377.0
FY 79 ------------- 4,678.0
FY 80 ------------- 2,821.2

d. Service Costs ($ to nearest hundred)

	Air Force	*Army*	*Navy*	*TOTAL*
Mobilization	505.6	9274.2	1472.5	11252.3
Personnel Cost	143.5	233.8	162.9	540.2
Subsistence	15.7	34.4	23.8	73.9
Personnel Movement	91.3	43.9	50.0	185.2
Supplies	137.5	375.2	484.7	997.4
Contract Support	39.0	57.3	48.1	144.4
Equipment	78.6	8309.2	667.5	9055.3
Transportation	—	220.4	11.8	232.2
POL	—	—	23.7	23.7
Field Construction	419.4	3668.2	—	4087.6
Personnel Cost	266.5	1416.8	—	1683.3

	Air Force	*Army*	*Navy*	*TOTAL*
***Field Construction** (Cont'd)*				
Subsistence	39.2	177.8	—	217.0
Personnel Movement	61.1	384.8	—	445.9
Supplies	31.2	303.7	—	334.9
Contract Support	21.0	330.8	—	351.8
Equipment	.4	828.6	—	829.0
Transportation	—	191.1	—	191.1
POL	—	34.6	—	34.6
Cleanup	2532.0	19349.0	5534.2	27415.2
Personnel Cost	1766.7	7536.4	2508.7	11811.8
Subsistence	240.0	1118.1	363.6	1721.7
Personnel Movement	243.2	1998.1	667.8	2909.1
Supplies	106.5	3082.0	817.2	4005.7
Contract Support	175.6	2803.1	608.9	3587.6
Equipment	—	1672.3	68.6	1740.9
Transportation	—	768.1	229.6	997.7
POL	—	370.9	269.8	640.7
Crater Containment	—	3474.8	—	3474.8
Personnel Cost	—	1340.4	—	1340.4
Subsistence	—	186.9	—	186.9
Supplies	—	95.6	—	95.6
Equipment	—	1851.9	—	1851.9
Demobilization	420.1	(1968.7)	857.1	(691.5)
Personnel Cost	245.9	515.3	383.4	1144.6
Subsistence	29.4	75.8	50.0	155.2
Personnel Movement	79.4	338.2	93.6	511.2
Supplies	15.4	(296.6)	56.5	(224.7)
Contract Services	50.0	303.6	246.0	599.6
Equipment	—	(2990.6)	—	(2990.6)
Transportation	—	79.4	27.6	107.0
POL	—	6.2	—	6.2
TOTAL	3877.1	33797.5	7863.8	45538.4

SECTION 4. Radiation Exposure Data

a. Types and Number of Records

FILE	*NUMBER IN SYSTEM*
Master	10,776
Island Access	17,581
Bioassay	2,338
Dosimetry	12,248
Pocket Dosimeter	501
Nose Swipes	1,145
TLD	7,519
Total	52,108

b. Bioassay Data

Potassium-40 (K-40)	– Range <50 to 4,100 pCi/Liter – 2,313 Readings (98.9%) ≤2500 pCi/Liter
Gross Beta (GB)	– Range <300 to 4200 pCi/Liter – 2,315 Readings (99.0%) ≤2500 pCi/Liter
GB to K-40 Ratio	– Range 0.27 to 3.05 – 2,305 Readings (98.6%) ≤2.00
Plutonium-239	– Range <MDA to 0.12 pCi/Day – 2,332 Readings (99.7%) <MDA

c. Dosimetry File

Doses Recorded	12,248
Zero Readings	8,361 (68.3%)
1-10 mrem	3,712 (30.3%)
11-20 mrem	157 (1.3%)
>20 mrem	18 (0.1%)
(99.97% ≤70 mrem)	

d. Pocket Dosimeter File

Doses Recorded	501
Zero Readings	486 (97.0%)
1-10 mrem	10 (2.0%)

d. Pocket Dosimeter File (Cont'd)

11-20 mrem	1 (0.2%)
>20 mrem	4 (0.8%)
(99.8% ≤25 mrem; HIGH READING - 42 mrem)	

e. Nose Swipe File

Number taken	1145
Range	<MDA to 1.64 pCi
<MDA	439 (38.3%)
Zero	317 (27.7%)
>MDA	389 (34.0%)

f. TLD File

Doses Recorded	7519
Zero Readings	2763 (36.7%)
1-10 mrem	4735 (63.0%)
11-20 mrem	12 (0.2%)
>20 mrem	9 (0.1%)
(99.97% ≤42 mrem)	

g. Air Sampling Data

Cubic Meters of air sampled	866,227
Number of filters analyzed	5,204
Zero readings	2,667 (51.2%)
≤ 0.27 pCi/m^3	2,336 (44.9%)
0.27.to 2.7 pCi/m^3	201 (3.9%)
≥ 2.7 pCi/m^3	0
(MPC- - -27 pCi/m^3)	

SECTION 5. Lost Time Accidents*

SITREP	RANK	SERVICE	DATE	TYPE OF INJURY
7	—	USA	30 JUN 77	Heat stroke
19	E-4	USA	5 SEP 77	Eye injury
19	E-5	USA	17 SEP 77	Back strain, (Hvy equip opt)
19	CIV	H&N	23 SEP 77	Lower back strain - lifting manhole cover

SECTION 5. Lost Time Accidents* (Cont'd)

SITREP	RANK	SERVICE	DATE	TYPE OF INJURY
20	E-4	USA	27 SEP 77	Strained shoulder
21	E-3	USA	3 OCT 77	2nd degree burns - gas soaked trash
21	E-3	USN	5 OCT 77	Severe laceration - right index finger
21	E-6	USN	9 OCT 77	Solar burn to eyes
22	E-3	USN	11 OCT 77	Laceration - right hand
23	E-4	USN	18 OCT 77	Twisted ankle - slipped on personnel pier
24	CIV	KOLAR	24 OCT 77	Burn - hot slag into boot
25	E-5	USAF	1 NOV 77	FRST member fell from dozer, back and arm injuries
25	0-2	USN	13 NOV 77	Bitten by moray eel
27	E-5 (SP 5)	USA	14 NOV 77	Broken finger
27	E-2	USN	14 NOV 77	Back strain
27	E-5	USA	14 NOV 77	Burned hand - hot D-7 muffler
31	CIV	KOLAR	11 DEC 77	Lacerated finger
33	CIV	H&N	22 DEC 77	Leg Burns
33	E-5	USN	27 DEC 77	Broken hand
36	CIV	KOLAR	14 JAN 78	Knee injury
37	—	USN	20 JAN 78	Back injury
37	E-3	USA	24 JAN 78	Electrical burns
40	E-4 (SP 4)	USA	12 FEB 78	Severe sunburn
40	E-4 (SP 4)	USA	12 FEB 78	Severe sunburn
42	E-4 (SP 4)	USA	1 MAR 78	Dislocated toe
46	CIV	MPML	2 APR 78	Shark bite
46	CIV	MPML	2 APR 78	Shark Bite
53	GS-12	USA CIV	15 MAY 78	Broken nose, tooth and facial lacerations

SECTION 5. Lost Time Accidents* (Cont'd)

SITREP	RANK	SERVICE	DATE	TYPE OF INJURY
53	E-4	USA	16 MAY 78	2nd and 3rd degree electrical burns on hand
56	E-3	USA	7 JUN 78	Dislocated left hip
61	E-2	USA	15 JUL 78	Crushed fingers
62	CIV	H&N	18 JUL 78	Fracture - swimming accident
62	E-2	USN	21 JUL 78	Convulsion from elect shock
63	CIV	KOLAR	26 JUL 78	Fracture of right pelvis
71	E-3	USA	24 SEP 78	Bleeding right eye
74	E-2	USN	12 OCT 78	Eye burns - welding
76	E-4	USN	27 OCT 78	Lower back injury
77	E-5	USA	1 NOV 78	Back injury
77	E-3	USA	30 OCT 78	Back injury
77	CIV	H&N	1 NOV 78	Lower back injury
78	E-4	USA	6 NOV 78	Back trauma
78	CIV	AIC	12 NOV 78	Ear injury
83	E-5	USA	13 DEC 78	Eye and cheek - battery acid burns
87	WG-3	CIV	5 JAN 79	Lacerated lower left leg
87	E-7	USA	13 JAN 79	Burns on legs, upper arms and neck
91	E-5	USAF	10 FEB 79	Internal injuries, pinned between two vehicles
93	E-3	USA	22 FEB 79	Dining hall accident
100	E-3	USA	10 APR 79	Fractured bone in foot
103	CIV	AIC	5 MAY 79	Burns - upper right arm and shoulder
110	E-3	USA	22 JUN 79	2nd degree burns - radiator
111	CIV	H&N	27 JUN 79	Fractured right hand

SECTION 5. Lost Time Accidents* (Cont'd)

SITREP	RANK	SERVICE	DATE	TYPE OF INJURY
111	E-5	USAF	28 JUN 79	Puncture wound on left foot
114	CIV	H&N	17 JUL 79	Chlorine gas inhalation
120	E-3	USA	28 AUG 79	Laceration on leg
120	CIV	H&N	1 SEP 79	Ingested pesticide
120	E-2	USN	29 AUG 79	Foot sprain (volleyball)
121	W-2 (CW 2)	USA	6 SEP 79	Abrasion to knees, feet
129	E-4	USA	3O OCT 79	2nd degree sunburn, legs
134	CIV	H&N	6 DEC 79	Compound finger fracture
137	CIV	H&N	24 DEC 79	Soft tissue injury left foot
137	E-4	USA	26 DEC 79	Soft tissue injury right foot
145	CIV	H&N	23 FEB 80	Broken bones in left foot
146	E-5	USN	24 FEB 80	Cut on head - five sutures

*Less Fatalities. Total Lost Time Accidents — 63.

SECTION 6. Reference Library Materials

a. Files

Operational Files	145 linear feet
Island Files	32 linear feet
Reference Files	12 linear feet
Total	189 linear feet

b. Materials

Video Tape Cassettes	208
- - Viewing Time	136 hours
Color Slides, 35mm	19,083
Briefing Charts	39 (850 sheets)
Maps and Sketches	370

SECTION 6. Reference Library Materials (Cont'd)

Vu-Graphs	290
Photographs	4,231

Location: Building 20364,
Kirtland Air Force Base, New Mexico

APPENDIX C – EQUIPMENT AVAILABILITY

APPENDIX C
EQUIPMENT AVAILABILITY

SECTION I. ARMY EQUIPMENT (Percent Available Monthly)

	Compressor, 750 & 600 CPM	Crane, 12½ Ton	Crane 25 Ton	Bulldozer, D7E, F	Bulldozer, D8	Drill, Pneumatic	Forklift, 4,000 lb.	Forklift, RT 10,000 lb	Helicopter, UH-1	LARC	Pump, Cement	Pump, Concrete	Pump, 600 & 400 GPM	Road Grader	Scoop Loader 2½ CY, Tracked	Scoop Loader, 2½ CY, Whld	Scoop Loader, 5 CY	Tractor, Backhoe	Truck, Transit-Mix	Truck, Dump 5 Ton	Truck, Dump 20 Ton	Truck, Tractor 5 Ton
NUMBER ON HAND*	7	6	4	7	5	6	6	6	4	4	2	3	7	5	4	16	2	5	7	16	25	5
NOV 77	-	-	14	-	-	-	17	-	100	-	-	-	-	25	25	25	-	25	-	4	23	-
DEC	-	-	80	-	-	-	40	-	20	-	-	-	-	10	20	24	-	33	-	7	10	-
JAN 78	-	30	20	-	-	-	67	-	40	20	-	-	-	50	33	24	-	40	-	17	7	-
FEB	17	66	33	-	-	-	100	-	100	30	0	-	-	67	67	47	-	67	-	72	14	-
MAR	70	60	100	-	7	-	33	7	100	40	60	-	-	30	84	48	-	40	-	50	14	-
APR	25	38	100	-	7	-	17	8	100	75	40	25	-	25	100	35	-	30	-	17	7	-
MAY	50	50	100	-	7	-	25	22	50	75	25	0	-	40	100	16	-	25	-	7	11	-
JUN	25	38	100	-	8	-	33	5	100	75	25	60	-	25	100	25	-	40	-	8	7	-
JUL	10	70	100	20	53	-	93	7	40	100	25	80	-	40	100	96	-	60	13	17	4	27
AUG	12	100	25	8	33	-	83	7	100	0	25	0	-	63	25	95	-	50	33	33	1	40
SEP	13	90	100	58	25	-	58	8	50	0	25	10	-	50	20	95	-	25	50	30	27	58
OCT	60	63	100	83	67	13	7	83	40	60	60	20	-	30	100	96	-	0	13	50	31	13
NOV	88	88	100	100	0	50	8	100	50	75	25	100	-	100	100	100	-	0	17	0	34	25
DEC	71	37	35	31	23	40	77	50	75	75	90	33	69	48	35	34	70	36	54	43	49	56

JAN 79	61	50	25	30	33	60	44	53	67	58	50	33	62	58	25	46	33	27	29	45	60	67
FEB	42	42	42	46	56	50	67	54	63	50	50	33	46	63	19	42	50	55	57	58	58	65
MAR	55	50	100	44	50	67	80	50	60	60	100	-	51	70	55	45	40	56	41	54	60	76
APR	65	-	-	64	56	94	92	75	18	44	100	-	56	81	31	52	50	45	67	52	58	95
MAY	60	-	-	67	69	81	96	57	81	33	100	-	69	75	25	44	62	100	67	41	62	75
JUN	76	63	-	64	67	90	90	51	85	53	100	-	82	75	0	40	50	25	63	37	57	80
JUL	75	81	-	53	64	75	100	72	50	33	100	-	70	71	50	58	25	-	75	56	79	72
AUG	78	70	-	67	71	61	100	65	61	-	100	-	73	56	60	44	100	-	67	50	63	72
SEP	75	88	-	63	100	50	96	61	100	-	82	-	83	54	75	55	100	-	79	50	54	73
OCT	62	94	-	66	100	-	100	69	75	-	100	-	83	44	0	71	50	-	50	-	47	85
NOV	93	85	-	68	70	-	95	77	100	-	-	-	-	100	100	58	0	-	33	-	69	83
DEC	65	67	-	60	50	-	90	76	100	-	-	-	-	40	100	64	67	-	50	-	74	99
JAN 80	100	89	-	90	100	-	0	92	88	-	-	-	-	15	100	100	100	-	100	-	100	100
FEB	100	100	-	100	-	-	-	100	88	-	-	-	-	-	100	100	-	-	100	-	100	100
MAR	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	-	-	-	-	-	-
APR	-	-	-	-	-	-	-	-	88	-	-	-	-	-	-	-	-	-	-	-	-	-
% Required to Complete Msn on Sched.	28	33	25	42	20	33	50	50	25	25	50	33	28	40	25	32	-	20	42	36	55	60

* Number on hand is applicable only to those months which show a percentage. Dashes indicate that none were on hand that month.

SECTION 2. NAVY EQUIPMENT (Percent Available Monthly)

	LCU	LCM 3	LCM 6	LCM 8	Whaler	Warping Tug	LCPL	LCVP	J-Boat (Taxi)	Self-Propelled Side-by-Side Causeway
NUMBER ON HAND*	3	1	2	9	5	1	2	1	1	1
JUL 77	75	0	0	63	67	50	.	0	.	.
AUG	67	17	50	42	56	33	.	33	.	.
SEP	50	0	100	75	58	50	.	100	.	.
OCT	100	0	50	58	50	100	.	67	.	.
NOV	83	0	75	64	75	100	.	0	.	.
DEC	92	100	38	71	46	75	.	25	.	.
JAN 78	58	63	25	43	50	100	.	0	.	.
FEB	100	100	13	82	80	75	.	.	.	.
MAR	92	88	50	82	50	75	.	100	.	.
APR	93	90	100	89	80	80	88	.	100	.
MAY	100	43	100	93	50	100	100	.	75	.
JUN	100	50	100	61	30	50	50	.	100	.
JUL	71	1	27	49	36	53	1	.	53	.
AUG	75	.	53	53	78	46	17	.	83	.
SEP	77	.	0	47	70	76	76	.	77	.
OCT	84	.	0	61	65	71	24	.	19	67
NOV	70	.	0	65	61	59	46	.	42	75
DEC	64	.	27	63	61	52	.	.	23	83

JAN 79	69	-	83	61	56	13	-	-	92	71
FEB	73	-	92	75	60	0	-	-	79	83
MAR	49	-	71	59	53	13	-	-	85	53
APR	75	-	4	74	54	67	-	-	79	**
MAY	78	-	83	44	26	46	-	-	52	-
JUN	68	-	75	61	48	96	-	-	63	-
JUL	74	-	79	62	44	67	-	-	67	-
AUG	89	-	74	58	59	53	-	-	54	-
SEP	88	-	79	77	64	99	-	-	-	-
OCT	81	-	80	79	54	76	-	-	-	-
NOV	69	-	39	46	48	41	-	-	-	-
DEC	53	-	38	31	46	59	-	-	-	-
JAN 80	50	-	43	47	49	63	-	-	-	-
FEB	64	-	-	102	91	74	-	-	-	-

* Number on hand is applicable only to those months which show a percentage. Dashes indicate that none were on hand that month.

**Conversion to warping tug as stated Navy SITREP 94. Oct 78 through Mar 79 the causeway was self-propelled. Apr 79 through Apr 80 the causeway was moved by the warping tug.

APPENDIX D
KEY PERSONNEL

SECTION 1. Joint Task Group Commanders and Staffs

	1977-1978	1978-1979	1979-1980
CDR	COL E. Mixan	COL R. Bauchspies	COL K. Halleran
DEP/CS	NA	LTC R. Barret	LTC E. Barone
J-1	LTC G. Garner	MAJ D. Schumacher	MAJ D. Harazsko
J-2	MAJ C. Day LTC E. Dodd	COL B. Adcock	COL B. Kennedy CPT E. Tupin
J-3	MAJ/LTC J. Briggs	LTC E. Prall	LTC A. Erickson MAJ W. Price
J-4	LTC J. Sitten	LTC J. Welch LTC J. Rogers	LTC C. St Arnaud

SECTION 2. Element Commanders

	1977-1978	1978-1979	1979-1980
USA	LTC L. Tucker	LTC V. Polich	LTC G. Kleb MAJ M. Foster
USAF	MAJ H. Rumzek MAJ W. Kaul	MAJ H. Thrash LTC P. Crandall	MAJ J. Prenez LTC D. Nomura
USN	LCDR J. Hopkins CDR J. Gunther CDR J. Hahn	CDR B. Byrne CDR W. Hiatt	CDR B. Byrne LCDR D. Trandal

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