April 1973

SUGGESTIONS FOR INCLUSION IN THE
ENVIRONMENTAL IMPACT STATEMENT FOR THE ENIWETOK ATOLL CLEANUP

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3.f. The U. S. Development of the Islands for Nuclear Testing

The testing of nuclear detonation requires testing grounds that, among other factors, are remote from populated areas. Previously, two tests had been conducted at Bikini Atoll in June and July 1946 under Operation Crossroads and, earlier, near Alamogordo, New Mexico on 16 July 1945 as Operation Trinity. However, for a continuing program of testing, Bikini suffered deficiencies in that the land areas were neither large enough nor properly oriented to the prevailing winds to permit construction of a major airstrip.[1] This led to the selection of Eniwetok Atoll for testing nuclear detonations, a selection administratively approved by President Truman on 2 December 1947.

The selection of Eniwetok Atoll was based on a study of possible ocean sites made by Captain J. S. Russell, USN, Deputy Director of the Division of Military Applications, and by Dr. Darol K. Froman of the Los Alamos Scientific Laboratory. In regard to possible fallout, Eniwetok Atoll was well located by having hundreds of miles of open sea lying from the Atoll in the westwardly direction of the prevailing winds.

1. N. O. Hines, Proving Ground (U. of Washington Press, Seattle, 1926) p 81.

The first of the groups assembled to conduct nuclear weapons tests on Eniwetok Atoll organizationally came into being on 18 October 1947. Called Joint Task Force Seven, the group was composed of personnel from many U. S. governmental Agencies.[2] Not having significant ground facilities on Eniwetok Atoll, the Task Force Seven operated from their many surface ships. Three nuclear detonations were made in this Operation Sandstone, which occurred during April and May in 1948.[3] The detonations were on 200 ft. towers; the first on Engebi, the second on Biijiri, and the third on Runit. The largest yield was the second with a yield of 49 kilotons.[4,5] This kiloton terminology means that the explosive energy of the nuclear detonation equals 49 thousand tons of high explosive. (A table at the end of this section gives for each of these and the following tests at Eniwetok the test name, date, time, location, height of burst, position (airdrop, barge, ground surface, or underwater) of nuclear explosive, cloud height, and yield.)

In preparation for the next series of nuclear tests, the Atomic Energy Commission in mid-1949 decided to facilitate further testing by refurbishing Eniwetok with improving ground-based structures and by providing more adequate technical facilities[5] This work was based on a survey submitted by Holmes and Narver, Inc., on 7 January 1949. The Commission approved the recommendation for construction in April 1949, and the contract was signed in June.[6]

2. Reference 1, p 85.
3. Reference 1, p 86.
4. Samuel Glasstone, The Effects of Nuclear Weapons, Department of the Army Pamphlet No. 39-3 (February 1946), and Mary A. Edwards, "Tabulation of Data on Announced Nuclear Detonations by All Nations through 1965," Report UCRL-14786, 17 March 1966 (Available from clearin house for Federal Scientific & Tech Info, Springfield, Va.)
5. Reference 1, p 87.
6. Reference 1, pp 113, 115

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On 31 January 1950, President Truman made public the decision to develop a thermonuclear bomb, a decision which, of course, was to have great impact on Eniwetok Atoll. Test of weapons with such large increases in yield and fallout radiation are not suitable for tests on the continental United States, but are better suited for the remoteness of the Pacific Proving Ground. To facilitate tests of devices that at first were limited to the 20-kiloton nominal yield of the Hiroshima weapon, the Nevada Proving Ground, near Las Vegas, Nevada, was additionally established in the autumn of 1950. The first tests there were in a 1951 series starting on 27 January.

The Eniwetok Atoll test series also planned for 1951 was designated as Operation Greenhouse and included, among other tests, activities related to thermonuclear research, but not yet involving a full thermonuclear explosion. Between 7 April and 24 May 1951, four tests from towers were conducted at Eniwetok, with the second one called Easy announced as 47 kiloton yield.[4.7]

A full thermonuclear explosion was achieved the following year in the 1952 test series Operation Ivy at Eniwetok Atoll.[4,8] This involved only two tests, but ones of considerable significance and consequences. The first was Test Mike, the first thermonuclear detonation , which was a ground level explosion amounting to 10.4 megatons (equivalent of 10.4 million tons of high explosive) on 1 November 1952 on a small island, Elugelab (Eluklapin in Marshallese, and Flora by the U.S. code name), at the north end of the Atoll. Being a surface explosion and having this large yield, Test Mike actually removed this small island from the Atoll chain. A large reinforced concrete building built on the nearby large island of Engebi to test effects of pressure was partly damaged. The second test of Operation Greenhouse was a "high yield" explosion, Test King, from an air drop over Runit Island.

7. Reference 1, p 125.
8. Reference 1, p 135.

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Associated with the greater yield of Mike, which was dozens of times greater than previously experienced, was a corresponding increase in the fallout radiation. Contrary to expectations, the winds prevailing at the time were from the south or southeast,[9] and so most of the radioactive debris fell on the open seas to the north and northwest. Nevertheless, fallout did occur on the northern islands of the Atoll. Since these islands continued to be uninhabited, no harm resulted to humans from this local fallout.

U.S. tests were conducted only at the Nevada Proving Grounds in 1953, thereupon starting the pattern of tests entirely at the Nevada Proving Grounds or the Pacific Proving Grounds, each on alternate years. The next series of tests in the Pacific was in 1954 under the name Operation Castle. It involved a task force, which retained the number Task Force Seven of the 1947 force. Five out of the six tests in this series were at Bikini Atoll, which had not been used for nuclear tests since 1946. The 15-megaton thermonuclear tests Bravo in this series was conducted on the surface in Bikini Atoll on 1 March 1954.[4,10] The radioactivity of this Bravo event was particularly troublesome by unexpectedly being carried to the east, rather than to the north as had been foreseen. Harmful amounts of radioactivity fell out on the inhabited atolls of Rongelap Ailinginae, and Rongerik and on the Japanese fishing ship Fukuryu Maru. These events resulted in sharply renewed interest in radiological consequences, with principal focus on the Bikini series of tests. The Atomic Bomb Effect Research Commission, which had been established after the atomic bombing of Japan, became involved. The Shunkotsu Maru of the Japanese Fisheries Training Institute cruised the Marshall Island area for survey purposes; this was followed by a U.S. cruise on the Coast Guard Cutter Roger B. Taney under the name Operation Troll.

9. Melvin P. Klein. "Fall-Out Gamma Ray Intensity" Lawrence Livermore Laboratory Report, UCRL-5125, (1958)
10. Reference 1, p 165.

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Operation Castle continued with other tests at Bikini Atoll, but with an enlarged exclusion of the oceanic areas of possible fallout. The only detonation of Operation Castle made in Eniwetok Atoll was the Nectar shot, detonated on 14 May 1954 on a barge in the lagoon over the Mike crater.

By 1954 the large island of Engebi (Janet in the U.S. code name) had become a barren, sandy island from which the coconut palms and other trees had long since disappeared. This major island of 291 acres had been subjected to World War II bombardment and, by 1954, to four series of nuclear weapons tests. The nuclear explosions produced blast and irradiated the island by instantaneous radiation from nuclear detonations and by delayed radiation of fallout. Nevertheless, colonies of rats continued to thrive on this isolated island in 1955,[12] even though casulties resulted from the tests.

The 1956 series of tests in the Pacific Proving Ground was called Operation Redwing. These took place at both Bikini and Eniwetok Atolls, with eleven at Eniwetok Atoll. Part of Bogan Island (Irene in the U.S. code name) was removed on 6 June 1956 by test Seminole, which was positioned on the land surface. This Seminole crater is on the east side of the remainder of Bogan Island. The other surface test in Operation Redwing was test Lacrosse, which formed a crater at the Northern tip of Runit Island (Yvonne is the U.S. code name) in the tide lands on the ocean side of the island. One Bikini test in Operation Redwing was an airplane drop of a thermonuclear bomb[4,13] with a yield of several megatons.

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12. Reference 1, p 207.
13. Reference 1, p 221.

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Early in 1958 a moratorium against further testing of nuclear explosions was under consideration, partly in reaction to international concern about the world-wide fallout of radioactivity from nuclear tests by the several nuclear nations. Before the moratorium, however, an intensive series of tests called Operation Hardtack was conducted. Operation Hardtack took place in 1958 both at Eniwetok Atoll as Phase I and at the Nevada Proving Grounds as Phase II, thereby breaking the pattern of alternate testing years at the sites.

Between 5 May and 26 July 1958, twenty-two tests were conducted at Eniwetok under Operation Hardtack, Phase I. This one intense period of testing thereby constituted over half of the 43 total tests conducted at the Atoll over the entire ten years of testing. Following Operation Hardtack, the joint moratorium on testing by the U.S., and the U.S.S.R. started on 31 October 1958. This marked the end of all nuclear tests at Eniwetok. The intervening 15 years until the present time have allowed some natural restoration of vegetation on affected islands and have provided the time for a tremendous decrease in the residual radioactivity resulting from the tests.

Two islands were altered in this Operation Hardtack, Phase I. The test Koa was a surface explosion on the small island Bogeirik (Bokaidrik in Marshallese and Helen by the U.S. code name). This test removed the island from the Atoll. The other was Test Cactus at the northwest tip of Runit Island (Yvonne by the U.S. code name). This produced a crater nearby and to the Southwest of the La Crosse crater.

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Further tests did occur in the Pacific, but they were in the vicinity of Johnston Island and Christmas Island,[4] so far to the east that there was no effect upon Eniwetok Atoll. These tests followed the 1 September 1961 announcement by the U.S.S.R. of its intention to resume nuclear testing. The U.S.S.R. tests occurred within days of this announcement. Many months later the United States started testing under a series called Operation Dominic, but, as just stated, not at Eniwetok Atoll. This test series was completed by the end of 1962 and was followed by the Limited Test Ban Treaty, which was signed in September 1963. This Treaty prohibited all nuclear tests except those conducted underground. Although underground tests have been conducted in the continental United States and at Amchitka in Alaska, none have been conducted at Eniwetok Atoll.

In these test series, a total of 43 nuclear detonations or attempts at nuclear detonations have been made at Eniwetok Atoll. The geographical distribution of these 43 tests follows: [14]

	Island Name			
Number of Tests	Board of Geo. Name	Marshallese	Other	U.S. Code Name
18	Runit	Runit		Yvonne
10	Enjebi	Enjebi		Janet
4		Eluklap	Elugelab	Flora*
3	Aomon	Aomon	Aranit	Sally
2	Eberiru	Aleleron		Ruby
1	Bogallua	Bokoluo		Alice
1		Dridrilbwij		Gene**
1	Bogeirik	Bokaidrik		Helen
1	Rujiyoru	Lujor		Pearl
1	Buganegan	Mut	Mui	Henry
1	Bogan	Boken	Pokon	Irene

14 Information obtained from W. Robison, Lawrence Livermore Laboratory, 16 January 1973.

* This island no longer exists. It was removed by test Mike on 1 November 1952.

** This island no longer exists. It was removed by test Koa on 23 May 1958. The underwater craters from Mike and Koa overlap each other.

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The positioning of 35 of the nuclear explosives before detonation follows: 14

Positioning	Number of Tests
Barge	17
Tower	9
Land Surface	5
Air Drop	2
Underwater	2

Of course, land surface tests were the most destructive to the physical condition of the islands by producing still-existing craters or by removing an island entirely. Most barge tests were offshore on the lagoon side off the islands of Runit (Yvonne) and Enjebi (Janet). Being generally west of these islands, the tests produced radioactivity that the prevailing winds from the northeast generally carried away from the island and over the lagoon.

In either the case of a successful nuclear detonation or the case of an unsuccessful nuclear detonation, a spread of radioactivity results in addition to physical damage to the land, vegetation, and animals. In the case of a successful detonation, the following principal radioactive results are:

1. fission products resulting from the fission of the uranium or plutonium used for the nuclear explosive, with significant fission products being cesium-137 and strontiom-90. (Their 27- and 28-year half lives, respectively, roughly correspond to human lifetimes, so they do not decay appreciably in an acceptable waiting period, nor do they decay sufficiently slowly to result in a low amount of radioactivity.

2. cobolt-60, largely from activity induced in iron used for towers, etc., in the tests. (Its 5-year lifetime makes waiting times for decay more acceptable).

3. various isotopes of plutonium produced from the capture of neutrons by uranium in the nuclear detonation.

4. The unconsumed plutonium and/or uranium used for the nuclear explosive but not having undergone fission. (When nuclear explosives misfire, the chemical-type high explosive used for assembling these nuclear components ultimately ends instead in spreading them.)

5. Tritium induced in water by neutrons and from thermonuclear reactions. (However, the mobility of the water in the ocean quickly dissipates this hazard.)

Even misfires or near misfires (low yield) of nuclear explosives result in a spread of radioactivity, as is seen by Item 4. In these misfire cases, the residual uranium or plutonium is deposited over a much smaller area than for the case of the spread from a nuclear explosive (perhaps square yards of spread in the former case, but worldwide or at least square miles in latter). Some misfires are essentially intentional in that they are safety tests. A particular concern in a misfire is the spread of plutonium-239; the lower radiological hazard of uranium-235 causes very much less of a radiological concern when used as the nuclear material. This plutonium concern is complicated by its long 24-thousand year half life for decay, which is far too long for planning on decay to eliminate the hazard.

Just such difficulties of plutonium contamination have occurred around Runit Island. For example, the test Scaevola in Operation Hardtack I was a

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one-point safety test. Therefore, it was planned only to explode by high explosive but not by a nuclear explosion. Local spreads of plutonium exist near the middle of this long, narrow island.

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NUCLEAR DETONATIONS AT ENIWETOK ATOLL

NAME	DATE (GCT)	TIME (GCT)	HEIGHT OF BURST (FEET)	TYPE OF BURST	GEOGRAPHICAL COORDINATES NORTH LAT	EAST LONG	YIELD	REMARKS
SANDSTONE								
X-ray	14/4/48	1817	200	Tower	11°40'	162° 14'	37 kT	
Yoke	30/4/48	1809	200	Tower	11°37'	162° 19'	49 kT	
Zebra	14/5/48	1804	200	Tower	11°33'	162°'21'	18 kT	
GREENHOUSE								
Dog	7/4/51	1834	300	Tower	11°33'21"	162°21'16"		
Easy	20/4/51	1827	300	Tower	11°40'08"	162°14'25"	47 kT	
George	8/5/51	2130	300	Tower	11°37'37"	162°18'53"		
Item	24/5/51	1817	300	Tower	11°40'23"	162°14'55"		
IVY								
Mike	31/10/52	1915		Surface	11°14'14"	162°11'47"	10.4 MT	Experimental Thermon clear Device
King	15/11/52	2330	1,480	Air Drop	11°33'44"	162°21'09"	High Yield	
CASTLE								
Nectar	13/5/54	1820		Barge	11°40'14"	162°11'47"		
REDWING								
Lacrosse	4/5/56	1825		Land Surface	11°33'28"	162°21'18"	40 kT	
Yuma	27/5/56	1756			11°37'24"	162°19'13"		
Erie	30/5/56	1815	300	Tower	11°32'40"	162°21'52"	-	
Seminole	6/6/56	0055		Land Surface	11°40'35"	162°13'02"	12 kT	
Blackfoot	11/6/56	1826	200	Tower	11°33'04"	162°21'31"		
Kickapoo	13/6/56	2326			11°37'41"	162°19'32"		
Osage	11/6/56	0114	680	Air Drop	11°32'48	162°21'39"		
Inca	21/6/56	2156			11°37'53"	162°18'04"		
Mohawk	2/7/56	1806			11°37'39"	162°18'49"		
Apache	8/7/56	1806		Barge	11°40'17"	162°12'01"		
Huron	21/7/56	1816		Barge	11°40'19"	162°12'01"		
HARDTACK, PHASE I								
Cactus	5/5/58	1815		Land Surface	11°33'23"	162°21'15"	18 kT	
Butternut	11/5/58	1815		Barge	11°32'28"	162°21'02"		
Koa	12/5/58	1830		Land Surface	11°40'30"	162°12'20'	1.37 MT	
Wahoo	16/5/58	0130	-500	Underwater	11°20'41"	162°10'44"		
Holly	20/5/58	1830		Barge	11°32'38"	162°21'22"		

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NAME	DATE (GCT)	TIME (GCT)	HEIGHT OF BURST (FEET)	TYPE OF BURST	GEOGRAPHICAL COORDINATES NORTH LAT	EAST LONG	YIELD	REMARKS
HARDTACK, PHASE I CONTINUED								
Yellowwood	26/5/58	0200		Barge	11°39'37"	162°13'31"		
Magnolia	26/5/58	1800		Barge	11°32'34"	162°21'14"		
Tobacco	30/5/58	0215		Barge	11°39'48"	162°13'48"		
Rose	2/6/58	1845		Barge	11°32'28"	162°21'06"		
Umbrella	8/6/58	2315	-150	Underwater	11°22'51"	162°13'09"		
Walnut	14/6/58	1830		Barge	11°39'37"	162°13'31"		
Linden	18/6/58	0300		Barge	11°32'39"	162°21'23"		
Elder	27/6/58	1830		Barge	11°39'48"	162°13'48"		
Oak	28/6/58	1930		Barge	11°36'28"	162°06'28"	8.9MT	
Sequoia	1/7/58	1830		Barge	11°32'39"	162°21'23"		
Dogwood	5/7/58	1830		Barge	11°39'48"	162°13'48"		
Scaevola	14/7/58	0400			11°32'39"	162°21'23"		One-Point Safety Test
Pisonia	17/7/58	2300			11°32'	162°21'		
Oliver	22/7/58	2030		Barge	11°39'48"	162°13'48"		
Pine	26/7/58	2030		Barge	11°39'22"	162°13'11"		
Quince	6/8/58	0215			11°32'59"	162°21'34"		
Fig	18/8/58	0400			11°32'59"	162°21'34"		

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From Box 3108 Job # 7238

May 11, 1973

T. F. McCraw
Division of Operational Safety

POSSIBLE DEGREES OF ENIWETOK CLEANUP

Drs. Barr, Grahn, Goldman and Harley have read R. B. Leachman's draft entitled as above. The following is a consolidation of their comments.

1. BEIR report is available and offers credible risk estimates which are conservative. Use BEIR in lieu of G&T.

2. In paragraph 3, page 1, the meaning of the statement "radiological levels that happen to be presented as isodoses . . ." is not clear. Also, how do "customary standards" enter in balance between the financing and insult to islands mentioned in paragraph 1, page 1. One cannot particularize island situations and use generally applicable standards.

3. The "worst case" approach is invalid. The fallacy of basing plans and actions on a "worst case" analysis is that one is correcting a non-existent situation; therefore, he finds a high price on any real reduction in population exposures which should be the objective of and basis for deciding between the alternatives for cleanup.

4. In III, page 3, values containing more than one significant figure will be questioned. For example, how will you measure 131 micro R/hr?

5. All reviewers were uneasy about the paragraph on page 6. Comments on this paragraph are as follows: We need to know what means are available to reduce population exposures. How much do they reduce populations exposure? How does the reduction match with dollar and environmental costs? While the "worst case" analysis avoids difficulties in the above approach, it does not solve the problem. The Pu doses, external beta-gamma exposures, and internal emitter doses should be clarified. Bring out relationship between reduction of external exposure rate and the internal emitter risk. ^{90}Sr cannot control when the major gamma is from activation; be more concerned with Pu than is indicated.

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Form AEC-318 (Rev. 9-53) AECM 0240 GPO 943-16-81465-1 445-678

Staff concerned with Eniwetok believe that this method of "forecasting" the report of the radiological survey can lead to difficulties which may be hard to correct in the future if a document such as this is circulated. Being unclassified, it has a potentially wide readership. We would be reluctant to see anything distributed which might prejudice the expensive, time consuming and painstaking work of the radiological survey, the report, and the judgements and recommendations based on them.

/S/

W. W. Schroebel
Analysis and Evaluation Branch
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Environmental Research

cc: L. J. Deal, DOS
N.F. Barr

Orig. Signed

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