ROUTING AND TRANSMITTAL SLIP		ACTION
1 TO: Mr Tommy McCraw 402916	INITIALS	CIRCULATE
	DATE	COORDINATION
2 Div of Opn'l Safety ERDA	INITIALS	FILE
	DATE	INFORMATION
3	INITIALS	NOTE AND RETURN
	DATE	PER CONVERSATION
4	INITIALS	SEE ME
	DATE	SIGNATURE

REMARKS

Herewith is the FC Radiological Clean up Plan, 23 July of which I spoke about 31 Aug. We didn't see the 1st copy. We also feel that there is much in this that should come out — it sounds more like a policy paper than an operational plan. Please call when you can see us. Also an article on Pu in kish - from Wash Post 1 Sept

Do NOT use this form as a RECORD of approvals, concurrences, disapprovals, clearances, and similar actions

FROM	DATE
Stevens LGEC, DMA	1 Sept 76
	PHONE 325-7132

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High Levels of Plutonium Found in Pacific Fish

By Anthony Tucker
Manchester Guardian

Mysteriously high levels of plutonium, a highly poisonous radioactive element produced in nuclear reactors, have been found in fish in an apparently uncontaminated part of the Pacific Ocean.

According to scientists at the Biomedical Environmental Research Division of the University of California's Livermore Laboratory—one of the world's leading centers of research in environmental radiobiology—the discovery may mean that present assumptions about the way plutonium concentrates in the marine food chain may be wrong, and that present calculations of the limits of plutonium discharges may also be wrongly based.

Plutonium is one of the radioactive toxins released into the environment by the nuclear industry and is of importance because of its immensely long half-life, 24,000 years.

Some areas are already plutonium-rich through military and civil nuclear activities such as Eniwetok Atoll and lagoon—where nuclear tests were carried out—and the discharge from the British nuclear fuel Windscale plant in the Irish Sea. The international basis for calculating permitted rates of discharge assumes steady diffusion throughout the oceans, and it would be expected that fish living in a contaminated area would accumulate more plutonium (and other radioactive toxic material) than fish in uncontaminated areas.

But investigators carried out by the Lawrence Livermore scientists and reported in Nature magazine have shown the plutonium levels in fish from Kwajelein Lagoon in the Pacific—which is contaminated only to the extent of the rest of the earth through nuclear weapons test fallout—are as high as those in Eniwetok Lagoon, where the water plutonium levels are 100 times higher.

Further, if the levels of plutonium in Atlantic fish are used as a basis to calculate the way concentration takes place in the food chain, then the Kwajelein fish contain 10 times the amount they should, a situation that forces scientists "to concede that the concept of a plutonium concentration factor in fish is meaningless".

The discovery worries scientists because no explanation can be found, in fish feeding habits or the nature of the lagoon environment. Careful comparison with figures from other leading laboratories, such as the Woods Hole Oceanographic Institution, has confirmed that the water plutonium level at Kwajelein is no higher than that in the ocean generally, and the immediate conclusion is that some unknown environmental factor is somehow increasing plutonium absorption and accumulation in the lagoon.

Singapore Airman Missing

SINGAPORE, Aug. 31 (AP)—A Singapore air force Skyhawk aircraft crashed today into the sea off Pulau Fawai while on a bombing training mission today, the government announced. It said the pilot was missing and presumed dead

J. McGraw Rec'd 8/2
Lt Sanches

DRAFT

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1. How to average over area.

RADIOLOGICAL CLEANUP PLAN FOR ENEWETAK ATOLL

23 JULY 76

FIELD COMMAND, DEFENSE NUCLEAR AGENCY

DRAFT

RADIOLOGICAL CLEANUP PLAN FOR ENEWETAK ATOLL

RADIOLOGICAL CLEANUP PLAN FOR THE ENEWETAK ATOLL

I. PURPOSE

This Plan serves as the basis on which the radiological cleanup of Enewetak Atoll will be conducted. (Nonradiological cleanup is included only where necessary to differentiate the two.) The Plan attempts to structure a cleanup which incorporates the Atomic Energy Commission (AEC) Task Group Recommendations (Reference 1, Vol. II, Tab B) and other established radiation principles and practices with engineering methods and technology available for cleanup within the major constraint of limited funds authorized by the Congress. It covers the cleanup of contaminated soil and debris in accordance with the Environmental Impact Statement (EIS, Reference 1), and the radiation safety necessary to accomplish these endeavors in a satsifactory manner.

II. BACKGROUND

1. An AEC Task Group evaluated the radiological hazards at Enewetak Atoll and recommended (Reference 1, Vol II, Tab B) that "all radioactive scrap metal and contaminated debris now or later identified" and any soil which has a Pu concentration greater than 400 pCi/g should be removed as part of the Cleanup. The Task Group encouraged removal of soil with Pu concentration in the range of 40–400 pCi/g where practical, but since such soil was deemed to pose a lesser hazard, circumstances were envisioned which might justify leaving it in place. Thus, The Task Group also recommended that decisions on soil removal be made "on an individual case basis" when Pu is in the range of 40 400 pCi/g.

2. The "Case 3 Cleanup" as described in Reference 1 is to accomplish a cleanup which conforms with the Task Group Recommendations (See e.g. Reference 1, Vol I, pg 5-18). Thus, it is incumbent on Cleanup to radiologically monitor all scrap and debris which concievably might be contaminated, and to classify soil according to its Pu concentration as either (1) greater than 400 pCi/g (mandatory cleanup), (2) less than 40 pCi/g (no cleanup required), or (3) in the range of 40 pCi/g to 400 pCi/g (negotiable cleanup).

III. DEBRIS CLEANUP

A. GENERAL

1. An aerial radiological survey of Enewetak Atoll was conducted from an elevation of about 50 ft as part of the AEC Enewetak Radiological Survey (the "AEC Survey," Reference 2). The aerial survey data were used to calculate an estimated average exposure rate over each island. Results of the calculations (Reference 2, pg 80) permit dividing the islands of the Atoll into two groups: those in the south—Boko (Sam) clockwise through Kidrenen (Keith)-- which have average exposure rates less than 8μR/hr, and those in the north-- Biken (Leroy) clockwise through Runit (Yvonne)--which average greater than 8 μR/hr. Since the general level of contamination in the southern

islands is very low (in fact, lower than most locations in the continental United States), any "hot spots" indicative of contaminated scrap metal or debris would readily stand out in the aerial survey. A few isolated hot spots were in fact observed for the southern islands and they were found to be due to radioactive sources which were subsequently removed. One hot spot on Medren (Elmer) was suspected of being a radioactive waste burial site; however, extensive soil sampling in the area failed to reveal the presence of any significant quantities of contaminated soil or scrap. Based on the aerial survey, and prior knowledge of where nuclear-weapon tests were conducted and their resulting fallout patterns, it is reasonable to conclude that the likelihood of any contaminated scrap metal or debris being on the southern islands is minimal. Cleanup, therefore, will plan to search for contaminated scrap metal and debris only in the northern islands as listed in Enclosure 1.

2. The contaminated scrap metal and debris at Enewetak Atoll which was identified as part of the AEC Survey, (Reference 2, pgs 372-426) was located during a brief two-week period in 1972 by monitors from the Environmental Protection Agency working under the direction of the AEC. This search for contaminated scrap metal and debris was limited to a ground survey for gamma contamination (alpha and beta contamination were not sought) present on the 11 islands which had either surface ground zeros or heavy, close-in fallout. Structures and scrap metal which were on the surface, visible and accessible were inspected, but no attempt was made to search for structures not shown on as-built drawings. The aerial survey was of little use in pin pointing the location of hidden contaminated debris in the northern islands because of the generally higher overall level of contamination--hot spots did not stand out above background. Even though about 400 items of debris are reported (Reference 3) for the 11 islands, only about 190 items were radiologically surveyed. Moreover, the ground survey only reported a single gamma exposure rate (presumably the highest) for the general area of items which were monitored. For example, a "scattered junkpile" on Bokoluo (Alice) is given a value of 120 μR/hr and without any indication as to the quantity of junk which gives that exposure rate. Cleanup, therefore, will require a more thorough radiological inspection of the northern islands than has been accomplished here-to-fore. Right On.

B. CRITERIA

1. The EIS expresses the AEC Task Group philosophy that materials which migh be used by people in place or removed for use elsewhere are of concern. Specifically, Cleanup should minimize the possibility that radioactive scrap metal or debris is left after Cleanup, as it might be used and cause harm. Since there are post-Cleanup contraints on the use of "contaminated" organic materials (plants and animals) until they become "clean" by natural radioactive decay or by other processes, the Cleanup materials available for differentiation (contaminated or noncontaminated) are only metal and concrete. These items will henceforth collectively be called "debris" and the identification, collection and disposal of such debris will be called "debris cleanup."

2. Although the AEC Task Group recommended that contaminated debris be removed, they did not specify any numerical quidelines for defining materials as either contaminated or noncontaminated. No material is totally devoid of radi activity; however, the AEC Task Group clearly did not intend that every item of material should be considered as a radioactive pollutant unworthy of remaining on the Atoll after Cleanup. Some level of radioactivity below which debris should not be regarded as "contaminated" is proper. This is particularly appropriate at Enewetak since the general background to remain after Cleanup will in many places be greater than the radiation level from any individual item present in the area.

3. The EIS specifies that unuseable noncontaminated debris programmed for removal as part of Cleanup will be dumped into the Enwetak Atoll lagoon, while contaminated debris will be entombed in an existing crater on Runit (Yvonne) To avoid the possibility that any contaminated debris from the northern islands might escape detection and find its way into direct use by the public, all debris removed from the northern islands will be sent to one of two places--the lagoon or the crater. Since no Federal or International rules and regulations are directly suitable for differentiating which of the two places should receive any specific item of debris; i.e. there is no universally accepted definition of "contaminated," Cleanup will arbitrarily employ the following guideline:

> If a gamma exposure rate exceeding 100 μR/hr is measured on or near an item of debris which is removed from a northern island, the item will be entombed in the Runit (Yvonne) crater; otherwise, the item will be disposed of as noncontaminated debris in the Atoll lagoon.

4. Although most debris will be removed from the northern sector, not all need be removed; e.g. debris which is neither contaminated nor a safety hazard might be left. The decision to classify an item of debris as noncontaminated and to be left would not be made as casually as that of sending it to the crater or lagoon since a mistake in the latter decision would be less likely to cause an adverse impact than a mistake in the former decision. Thus, before a final decision is made to leave any debris, the debris will be monitored thoroughly in accordance with the criteria contained in Reference 4; e.g., removeable alpha and beta contamination must not exceed 20 dpm/100 cm^2 and 200 dpm/100 cm^2, respectively. Since the guidelines of Reference 4 explicitly exclude items which are activated, and activated debris is common on the northern islands, Cleanup will also adopt the following guideline for deciding if debris might be left on a northern island:

> If a gamma exposure rate exceeding 15μR/hr occurs within a distance of 30 cm from any point on an item of debris, then the item must be removed to either the Yvonne crater or the Atoll lagoon as appropriate, based on criteria in paragraph IIIB.3 above.

Problem Here

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C. PROCEDURES

1. To ensure that all debris is properly appraised, each island listed in Enclosure 1 will be sufficiently devegetated to allow a thorough visual inspection and radiological monitoring. The devegation will be performed with the least possible disturbance to the top soil and root structures to minimize the redistribution of any plutonium-contaminated soil which might be present and to minimize erosion at sites which may prove not to require any soil excision. The vegetation which is harvested will be collected, chopped and stored for later use as mulch or compost. After each island is certified "clean," it is to be sown with grass seed per the EIS (Reference 1, Vol I, pg 8-14). The mulch and compost will be added back to the soil at that time to aid the establishment of new vegetation. If on-going ERDA programmatic activities on Enewetak plant-radionuclide-uptake are able to confirm by that time that the uptake cycle can be halted or significantly reduced by removing decayed vegetation, the mulch and compost will not be broadcast over the island but will be incinerated in deep burn pits as provided for in Reference 1, Vol I, pg 8-14, and any residues will be covered over.

2. A detailed visual search of each island will be performed. Where appropriate, the visual search will be complimented by an electronic search using the Army AN/PSS-11 metal detector which is capable of sensing shallow-buried debris. All debris discovered will be "roughly" monitored for gamma radiation upon discovery and classified according to whether it gives an exposure rate (1) greater than 100 μR/hr--goes to the crater, (2) less than 100 μR/hr--goes to the lagoon, or (3) uncertain--requires additional measurements. Lightweight debris which can be manually picked up will be collected during the search and placed in appropriate containers marked to indicate "debris for lagoon," "debris for crater," or "debris to be rated." Heavier debris will be marked similarly for subsequent disposition. The reconnaisance personnel will compare observations with as-built drawings, and make additions or subtractions as appropriate when heavier debris is discovered or is not found. The revised drawings will indicate the location, description and the radiation classification of heavier debris.

3. The AEC Survey lists (See Enclosure 2) several suspected or known burial sites of radioactive debris which will be investigated as part of Cleanup. The precise locations of some of these sites is not known nor is the amount of contaminated debris they contain. To facilitate locating these indefinite sites and minimizing on the amount of earth which must be moved to verify their presence, military magnetometers, e.g. Army Portable Differential Magnetometers, capable of sensing metallic anomalies at depths up to about 10 ft will be used. If the burial site is located, it will be excavated and the contents will be classified and disposed of as any other debris.

4. Debris which is classified "for the lagoon" potentially could avoid the lagoon fate. If nonradiological considerations indicate the debris need not be removed, then it will be thoroughly monitored as prescribed in paragraph III.B.4 above to ensure that it is not contaminated and deserves to remain. These items will be monitored subsequent to the visual search, however, as they probably will require considerably more time and effort to be monitored. When they are confirmed as complying with the criteria of III.B.4, the "debris for lagoon" marking will be removed or obliterated and a "debris to remain" marking will be added. (No debris should be without a marker once a visual search is completed; and all "uncertain" markings must be resolved prior to certification.) For these debris items, radiation readings and results of smear analyses must be documented.

5. Debris which has been marked for disposition will be transported to staging areas in open-bed trucks. The trucks will be monitored to assure that the absorbed dose rate at no point on the external surface exceeds 0.5 mrem/hr. The trucks carrying debris will be transported by barge to the respective disposal sites, and their contents discharged. Contaminated debris delivered to Runit (Yvonne) will be stockpiled at a convenient location there unt the crater entombment operation is ready to receive it, at which time it will be transported again by truck to the crater.

IV. SOIL CLEANUP

A. GENERAL

1. The Cleanup guidelines specify removal of soil when Pu concentration exceeds 400 pCi/g regardless of the depth at which the contaminated soil is found, and a negotiable removal of soil when Pu concentration is in the range of 40-400 pCi/g. The guidelines obviously do not intend that soil cleanup involve a complete search of the Atoll for buried Pu, rather buried Pu should be looked for ~~only~~ where it is suspected of being present. The suspected locations are listed in Enclosure 2. The AEC Survey confirmed the presence of buried Pu exceeding 400 pCi/g on Boken (Irene), Lujor (Pearl) and Runit (Yvonne). Cleanup will excise these contaminated burial sites, and investigate the others in Enclosure 2 to determine if they too warrant removal. However, unless additional information is forthcoming to suggest that high Pu concentrations exist beneath the surface elsewhere, only those sites listed in Enclosure 2 will be searched for buried Pu contaminated soil. Since the major hazard of Pu results from resuspension into the air, and that is more feasible from the surface than from depths beneath the surface, soil cleanup will primarily focus on identifying and removing Pu contaminated soil from the surface.

2. The AEC Survey reports analyses of soil samples collected from about 1100 spots throughout Enewetak Atoll. Samples from about 900 of these spots were labeled as "surface samples" containing soil from within 30 cm^2 of ground and to a vertical depth of 15 cm. The remaining spots yielded "profile samples." Each soil profile was for a column of ground whose surface area was 100 cm^2 and which was sectioned into component profile samples at depth increments of 0 to 2, 2 to 5, 5 to 10, 10 to 15, 15 to 25, 25 to 35 cm and at 10-cm increments to the total depth sampled which varied from as little as 35 cm as to as much as 185 cm. The surface samples thus had a volume of 450 cm^3 while the profile samples had either 200, 300, 500 or 1000 cm^3. Samples were analyzed for Pu as well as other radioactive elements, including Am-241.

3. From 306 surface samples and 55 profiles (approximately 450 additional samples) taken on islands in the south, Boko (Sam) clockwise through Kidrenen (Keith), it was found that no sample had a Pu concentration greater than 1.1 pCi/g and most had much less than this amount. The absence of significant contamination on these islands was expected as none were the site of any nuclear tests, and they were not downwind of sites where tests did occur. Since the soil data obtained are consistent with other facts (aerial survey, nuclear test locations, fallout patterns), it is reasonable to assume that the southern islands avoided receiving any Pu at concentration levels which might warrant soil removal as part of Cleanup. The southern islands as a group fall in the "no cleanup required" category.

4. For the northern islands, on the other hand, 50 surface samples and 59 profiles were reported in the AEC Survey to have Pu concentrations exceeding 40 pCi/g, and eight of these profiles included samples with more

than 400 pCi/g. These data indicate that extended regions generally exceeding 40 pCi/g probably are present on 11 islands, although the shape of the regions is uncertain because in many instances the distance between two samples having more than 40 pCi/g was either relatively large or it included a sample givin much less than 40 pCi/g. Another uncertainity resulted from the AEC survey employing more than one sample configuration. For example, the following concentrations are reported (Reference 2, Vol. II, Fig. B.15.1.i) for the top 15 cm of the profile #101 from Lujor (Pearl): 420 pCi/g at 0-2 cm, 115 pCi/g at 2-5 cm, 5 pCi/g at 5-10 cm, and 2.7 pCi/g at 10-15 cm, while the "surface sample" #101 (covering the entire 0-15 cm) is given (Reference 2, Vol II, Fig. B.15.2g) as 83 pCi/g. The location thus could be listed as either "mandatory cleanup" or "case-by-case cleanup."

5. Although the paucity of data and the problems of comparing surface sample data with profile sample data prevent one from knowing with certainity the areas or volumes qualifying for Cleanup, the AEC Survey is considered sufficient to permit classifying the northern islands into two kinds of regions--one which probably has soil containing Pu at concentrations greater than 40 pCi/ (high concentration) and the other as unlikely to have significant amounts of Pu at concentrations greater than 40 pCi/g (low concentration). The high concentration regions are described in Enclosure 3. The low concentration regions include all of Biken (Leroy), the two groups of islands (1) Kidrinen (Lucy), Taiwel (Percy), Bokenelab (Mary) and Elle (Nancy) and (2) Bijire (Tilda) Lojwa (Ursula), Alembel (Vera) and Billae (Wilma), and the areas outside the high concentration regions for the other northern islands.

6. During Cleanup, the high-concentration regions listed in Enclosure 3 will be reinvestigated in more detail than was done during the AEC Survey; e.g. whereas the AEC Survey averaged only about 1 sample per acre for all northern islands, Cleanup will achieve at least 10 samples per acre. The low concentration regions, although having Pu concentration ranges greater than are typical for the southern islands, do not include samples with Pu concentration in excess of 40 pCi/g. Thus, these areas might be considered as already complying with the AEC Task Group recommendations and not requiring any soil Cleanup; however, they will be programmed for reinvestigation at about the same sample frequency as obtained by the AEC Survey for the purpose of confirming the apparent findings of no significant Pu contamination. If contrary data are obtained; i.e. if Pu concentration is found to exceed 40 pCi/g at any spot in a low-concentration region, then that area will be thoroughly investigated.

OK

B. METHOD

1. Plutonium concentration contours (isopleths) will be developed for each of the northern islands which contain high-concentration regions (Enclosure 3), and any other northern islands which might be shown during Cleanup to have high concentrations. (In general, the confirmatory data obtained from low-concentration regions will not be sufficient to structure meaningful isopleths.) The isopleths will be computed by the most advanced automatic contouring method available at the time of Cleanup, and comparable to or exceeding the SURFACE II program described in Reference 5. The raw data to be contoured will consist of the Pu concentrations obtained during Cleanup by laboratory analysis of soil samples collected from within the areas under investigation. The concentration contours will be used for ranking areas according to their cleanup requirements, e.g.--mandatory (>400 pCi/g), negotiable (between 40-400 pCi/g), or no cleanup (<40 pCi/g). When the area within an isopleth becomes programmed for Cleanup, then the soil therein will be removed in successive layers until samples collected from the residual surface show Pu concentration to be as low as is reasonably achievable (<40 pCi/g).

2. It is highly probable that a minimum of ten thousand soil samples will require analysis in order to adequately define the regions deserving soil cleanup and to verify that all the necessary Pu-contaminated soil has been removed. Prompt Pu analyses are necessary to expedite Cleanup. The quantitative assay of soil for Pu at the concentration levels of interest to Cleanup, however, is laborious by any method. Nuclear radiation detection methods are essential as the quantity of Pu amounts to only a few parts per trillion by weight; however, the nuclear methods are made difficult because Pu is predominantly an alpha emitter. For the most precise nuclear methods, the Pu must be separated from its soil matrix prior to alpha counting, and that extends the time per analysis.

3. To achieve the necessary accuracy and speed of analysis, the Cleanup will have an on-site Radiological Laboratory capable of determining Pu in soil by a combined solvent extraction-liquid scintillation method modeled after that of Reference 6. Should a more suitable laboratory method become available prior to or during Cleanup, it would be employed if feasible. To avoid the possibility that data obtained from the "field lab" is later questioned, an adequate fraction of the on-site analyses will be repeated for verification of accuracy at the USAF/McClellan Central Laboratory (USAF/MCL) which has an established reputation for performing high-quality radiochemical analyses of environmental samples.

4. After decisions have been made that the soil in an area deserves to be excised, and engineers begin removing the soil, a less accurate analysis method is suitable to monitor the progress of soil removal if the method provides "instant" results. The alpha scintillation counting of soil without any Pu separation, as reported in Reference 7, appears to be a relatively fast

method which would serve this purpose. It will be used during the "digging phase" of Cleanup. When these rough analyses indicate that the Cleanup of a site is complete, however, the more accurate laboratory analyses will be made for confirmation that soil removal may terminate.

5. The AEC Survey reported a weak correlation between the amount of americium in Enewetak soil and the amount of Pu; namely, the Am-241/Pu-239+240 activity ratio ranged between about 0.1 and 0.5. Americium-241 is relatively easy to detect quantitatively since it is a gamma emitter--some gammas will penetrate a soil sample thereby making the separation of Am from the soil matrix unnecessary. Thus, if techniques become available to predict an acceptable ratio of Am-241/Pu-239+240 at any specific location, then Pu concentration might be promptly inferred from a laboratory determination of the Am-241 concentration in soil samples. Moreover, if the Pu-239+240 and Am-241 depth distributions also can be adequately predicted, then the Pu concentration may be inferred by an in situ measurement of the Am-241 activity as described in References 8 and 9. These indirect methods may be availab to support Cleanup; however, for planning purposes, the principal analytical methods will be Pu alpha radiation counting, either with or without chemical separation.

C. PROCEDURES

1. The specific locations from which samples will be taken in high-concentration regions will be determined by the requirements of the automatic contouring program which is employed. As is often the case, more than one set of samples will be needed before acceptable concentration contours evolve. The locations to be sampled in subsequent sampling rounds will be indicated by the contouring results achieved from earlier rounds. Engineering and operations considerations will also play a part in determining how and where samples must be selected; e.g., the bounds of a region would not be refined better than the minimum capability of the earth-moving equipment to be used in the region. For the low-concentration regions, however, sample locations will be selected on a random basis as was done by the AEC Survey, since these data are to be collected merely to confirm the absence of any significant Pu contaminated soil, and not to structure concentration contours. The exact locations (horizontal coordinates and elevations) from which samples are removed will be determined by engineer surveyors.

2. Samples will be removed from the surface by means of a "cookie-cutter" type tool which will permit removing top soil to a depth of 5 cm within a rectangular area 10 cm by 10 cm. The 5-cm depth is a compromise dimension between the thinner (near-surface) samples preferred by persons who consider the prime Pu hazard to be that of resuspension by natural phenomena; e.g., wind, rain, animal movement, etc., and the thicker samples preferred by those who fear resuspension by mechanical means such as might accompany the plowing of a site for agricultural purposes. Moreover, the 5-cm depth dimension is conservative since the AEC Survey found that most profiles diminish with depth and Pu concentration frequently peaks slightly

beneath the surface--the 2-5 cm layer contained more Pu on a weight basis than either the 0-2 cm or 5-10 cm layers. Thus, a 5-cm deep sample is not as diluted as a 15-cm deep sample might be, and it covers the siuations where the very top layers of ground are contamination free while the next lower layers are not. The 100 cm^2 sample surface area was arbitrarily selected as a compromise between being large enough so that the presence of any Pu "hot particles" would not bias the sample analysis and small enough that it could be handled in the laboratory.

3. Each soil sample will weigh about 750 g which is considered too large to be completely analyzed by radiochecmial methods in the time available. Since aliquots (weighing about 10 g) must be taken, the entire sample will first be homogenized so that any aliquot will be representative of the entire sample. The Radiological Laboratory will include a facility to accomplish the needed homogenizing of samples. A ball-milling method similar to that used on environmental samples at the Nevada Test Site (Reference 10) will be employed unless a more efficient alternative becomes available. (A possible alternative to be investigated is high-temperature sample decomposition followed by blending.) Aliquots will be baked in a muffle furnace to decompose any organic matter present and convert the coral to the readily soluble calcium oxide (CaO). The aliquots will be analyzed in the on-site Radiological Laboratory as previously described and forwarded to the USAF/MCL for comparisons as necessary. Each blended sample will be retained until the island from which it was obtained is certified to be clean.

4. The Radiological Laboratory will also have a high resolution gamma-ray spectroscopy capability to include intrinsic germanium detectors and computer-based data acquisition and analysis systems. As Pu concentrations can be estimated relatively fast by such a capability, it will be used in setting upper limits on concentrations in certain samples (a conservative Am/Pu ratio, say 0.1, will be assumed) and thereby to confirm that some sites do not have Pu contamination deserving Cleanup. Additionally, the computer used for spectrum analysis will also serve for the automatic contouring.

5. The surface samples will permit defining the perimeter of sites requiring soil removal. The amount of material to be removed from the site may be estimated from the defined area and the profile data reported in the AEC Survey. A precise estimate should not be necessary, however, as past cleanups indicate that contamination from upper layers will spill to lower layers during soil removal operations and consequently, soil is removed to greater depths than initially predicted.

6. Based on a review of the laboratory results and the other factors which enter "case-by-case" decisions, the sites requiring soil removal will be designated. These sites will be marked in the field by engineer surveyors. All debris will be removed from the site if it has not already been removed. Removal of contaminated soil will commence using appropriate earth-moving equipment. The soil will be taken up in thin layers with

respect to the expected depth at which soil is considered contaminated. Soil samples will be taken continuously during these operations to monitor the success of reducing the amount of contamination remaining. These samples will weigh about 100 g but will not have a precise configuration; they will be conveniently scooped from the work site. The locations from which the samples are collected will only be approximately identified—surveyors will not be required.

7. A trailer-contained Field Radiological Laboratory will be stationed at each work site to expedite analysis of samples collected during the soil removal operations. The Field Radiological Laboratory will contain sample storage facilities, muffle furnaces, alpha scintillation counters, and necessary power supplies to operate laboratory equipment as well as the exterior air samplers operating at the site (See Part V.H on air sampling). Samples will be prepared for alpha counting by baking them in a muffle furnace, and by uniformly spreading the dried powder which is formed into a flat counting container whose surface area is about the same as the alpha counter probe. (Reference 7 uses a 100 cm diameter petri dish and smooths the soil surface by means of a tongue depressor.) As the data from these samples will influence the amount of digging, it is essential that very prompt analyses are performed; thus, the Field Radiological Laboratory will have sufficient capability so that soil assays do not delay soil removal. Since the alpha counting method used will only measure Pu near the sample surface, i.e., PU sources no deeper than about 50 microns beneath the surface, a representative number of the samples will be sent to the Radiological Laboratory for repeat analysis. The remaining samples will be retained until after the island from which they are obtained is certified to be clean.

8. When a site appears to be cleaned to an acceptable Pu concentration level based on alpha conuting, it will be graded level and sampled bymeans of the 5-cm deep "cookie cutter." The samples will be randomly taken from precise locations at a frequency acceptable to the on-site ERDA Representative, and analyzed by radiochemical methods in the Radiological Laboratory. If these samples show Pu concentrations not exceeding 40 pCi/g, then the ERDA Representative will certify the site as "clean"; if there are concentrations greater than 40 pCi/g, the site will be cleaned as necessary.

9. The suspected soil burial sites (Enclosure 2) will be sampled by means of a truck-mounted auger capable of drilling into the ground to depths up to 10 ft. Material will be removed from the auger as it penetrates the ground and assayed in a Field Radiological Laboratory. If the presence of a burial site is confirmed, it will be excised and verified as clean by the same methods used for cleanup of surface sites.

V. RADIATION SAFETY

A. GENERAL.

The level of radioactivity at Enewetak Atoll, as reported in the AEC Survey, is sufficiently low that persons may visit almost every location there without fear of being exposed to radiation in excess of established radiation protection guides. Cleanup is needed, however, because these guides would be exceeded if persons were to dwell throughout the Atoll. Cleanup itself needs radiation safety precautions because possibilities exist that previously undetected contamination will be uncovered, stockpilin of contaminated debris will enhance local radiation intensity, and cleanup activities will make plutonium more readily available for assimilati before it is contained. The safety precautions will result from a cleanup radiation safety policy which complies with the Federal guides, as well as makes every reasonable effort to maintain radiation exposure as low as is reasonably achievable taking into account the state of technology and the economics of improvements in relation to benefits to health and safety, and other societal and socioeconomic considerations.

B. APPLICABILITY.

1. Cleanup is a responsibility assigned to the Department of Defense (DOD) and delegated to the Defense Nuclear Agency (DNA). Military personnel from DOD will be assigned to perform the physical and radiological cleanup for, and under the overall management of, a DNA Joint Task Group; accordingly, radiation safety will comply with military regulations insofar as is practical.

2. The military radiological safety regulations will apply to all individuals who are at Enewetak Atoll during the period of Cleanup. Personnel not under control of DNA shall comply in all respects with the regulations or be denied access to Enewetak Atoll. The Cleanup Commander may permit variances however, if, in his judgement, an essential task cannot otherwise be accomplished. In such cases, adequate alternate safety procedures will be established.

C. RADIATION AREAS.

A "radiologically controlled area" is a defined area in which the exposure of personnel to ionizing radiation is under the supervision of an individual responsible for radiation protection. A "radiation area" is a specific type of radiologically controlled area in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose equivalent in excess of 2 mrem or in any five consecutive days a dose equivalent in excess of 100 mrems. Initially, all the northern islands listed in Enclosure 1 will be designated as controlled area Radiation areas will be established on Runit (Yvonne), Lujor (Pearl) and the northern half of Enjebi (Janet) as the AEC Survey showed contaminated

debris to be present at these sites having exposure rates exceeding 2 mR/hr. Additional radiation areas will be established during Cleanup as appropriate based on radiation measurements to be made. Controls on an island will not be removed until the island is certified as clean.

D. RADIATION PROTECTION STANDARDS.

1. A "radiation worker" is an individual who might be exposed to more than 10 percent of the basic radiation protection standards (See Enclosure 4) as a result of his employment or duties in a controlled area. An "occasionally exposed individual" is one whose work is not normally performed in a controlled area and whose duties do not normally involve exposure to ionizing radiation; however, the individual may have reason to enter a controlled area in the performance of duties. Occasionally exposed individuals will not receive an exposure to ionizing radiation in excess of that allowed for any individual in the population at large.

2. Essentially all of cleanup can be accomplished by personnel categorized as occasionally exposed individuals; accordingly, the majority of the workforce will be treated as such insofar as radiation limits are concerned. Personnel working in radiation areas, however, conceivably might exceed the exposure limits set for occasionally exposed individuals. Thus, work on these sites will be assigned to the personnel having the most experience with radiation and qualifying as radiation workers.

E. MEDICAL EXAMINATIONS.

1. Preplacement and termination medical examinations will be given to all cleanup personnel. The examinations will include a review of prior occupational exposure and a description of any unusual exposure resulting from previous occupations, accidents, incidents, or therapeutic procedures, for the purpose of evaluating an individual's acceptability into the cleanup operation.

2. Plutonium represents the greatest radiation hazard facing Cleanup workers. Although plutonium at Enewetak is harmless while it remains outside the body, it could cause deleterious effects if it enters the body. Precautions will be taken to prevent the inhalation or ingestion of plutonium, but a bioassay program will be prescribed to monitor the effectiveness of the precautions.

3. The principal bioassay method will be urine analysis. Urine samples will be taken on a periodic basis to include the start and end of assignment from all workers who at any time are in the vicinity of plutonium contamination. Urine samples will be analyzed for plutonium at the USAF/Radiological Health Laboratory, or a comparable laboratory, to a sensitivity of at least 0.3 pCi. If positive readings should be obtained, additional bioassays; e.g., fecal analyses or lung counts, will be prescribed.

F. TRAINING.

All personnel assigned to Enewetak Atoll will receive training in the form of lectures, briefings, handouts and notices, concerning:

(a) Health hazards associated with exposure to radioactive material or radiation,

(b) precautions or procedures to minimize exposure,

(c) purposes and functions of protective devices employed,

(d) decontamination purposes and procedures,

(e) responsibility of each individual to promptly report any condition which may lead to or cause a violation of radiological safety regulations and procedures or unnecessary exposures,

(f) radiation exposure reports which will be maintained on each person, and

(g) management's commitment to keep occupational exposures as low as is reasonably achievable.

Such training will be sufficient to ensure that the workers can correctly answer questions on radiation protection as it relates to their job.

G. PERSONNEL DOSIMETRY.

1. The primary dosimetry device will be the film badge, and the Army Photodosimetry Service will be employed. The film badge contains one or more photographic emulsions and is designed to differentiate between beta particles, gamma rays, and x-rays. A film badge will be worn by all personnel upon entering a radiologically controlled area.

2. A self-reading pocket dosimeter will be worn, in addition to the film badge, at all times when an individual is in a radiation area. Exposure accumulated by the pocket dosimeters will be documented.

H. PROTECTIVE MEASURES

1. Plutonium is the primary radiological threat of Cleanup. As previously noted, Pu in the ground is not a hazard, but if the ground is disturbed, personnel may come into contact with the Pu and be harmed. Persons operating in the vicinity of the disturbed ground might either inhale resuspended Pu directly, or become externally contaminated and susceptible to subsequent internal contamination of themselves or others. All Cleanup operations which disturb Pu-contaminated soil will thus be performed by personnel adequately protected.

2. The protective clothing prescribed for Pu operations may range from shoe covers and a surgical mask to a full compliment of shoe covers, coveralls, gloves, head covers and facepieces with either filters or air lines. Although it is proper to don adequate protective clothing, there are numerous reasons for not overdressing. For example, full suiting may be intorerable when worn for extended periods in the warm, humid climate indigenous to Enewetak. The "protection" provided by the clothes could in fact cause harm by leading to heat injuries. Thus, there is an incentive to wear just what is necessary and no more. The proper and minimum clothing however, will only be determined after an evaluation of on-site conditions against permissible contamination limits (See Enclosure 4).

3. The local conditions will be determined by analysis of low-volume (about 2 cubic feet per minute flow rate) air samplers operating in the vicinity of each site which might have resuspendable Pu-contaminated soil at concentrations exceeding 40 pCi/g. The air samplers will be similar to the "Gelman Vacuum Pump Samplers" described in Reference 11 and used at the Nevada Test Site. The air filters will be collected at the end of each work day and counted by alpha proportional counting. If readings indicate high air concentrations, the filters will be collected on a more frequent basis. A representative number of air filters will be forwarded to the USAF/MCL for more detailed radiochemical analysis.

4. With perhaps the exception of certain areas on Runit (Yvonne), no surface locations at Enwetak Atoll have a sufficiently high Pu concentration to pose a hazard to persons merely walking on them; i.e., ordinary "foot traffic" is assumed to not create any resuspension problems and accordingly it requires no protective measures. Runit is currently quarantined and any persons who walk there are required to wear surgical masks and observe other radiological safety precautions. The quarantine will continue in force, or be made more stringent as appropriate, until Runit is certified as clean.

5. Operations which are likely to stir up dust however, such as soil excavation, loading and disposal, could pose problems. Air sampling will be done before and during these operations to establish appropriate protective clothing requirements. Further, since any resuspended Pu might be spread downwind from these operations, all personnel in the immediate downwind area will also wear appropriate protective clothing. Cotton swab nose smears will be taken from each person working near resuspendible Pu-contaminated soil at each time their protective clothing is removed, to check on the adequateness of protective measures. These swabs will be analyzed in the Radiological Laboratory by liquid scintillation counting.

I. DECONTAMINATION

1. In addition to making the atoll safe for resettlement, an objective of Cleanup is to prevent contaminated debris from becoming available on the world market. Since decontamination of contaminated debris is not a viable alternative, all such debris which is collected will be disposed of as

described in Part III. Cleanup equipment, on the other hand, may possess a residual value which merits decontamination. Thus, all equipment deemed worthy will be decontaminated to permissible levels before they are returned to use in contamination free sites (on or off the Atoll). If the permissable levels cannot be achieved following thorough decontamination efforts, the equipment will either be transferred safely to users having appropriate licences or disposed of in the same manner as contaminated debris. Unworthy contaminated equipment will be disposed of as described in Part III.

2. To prevent the spread of contamination by personnel, each person will be thoroughly monitored and decontaminated as necessary prior to exiting from any controlled area.

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4. "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use," American National Standards Institute, ANSI N328-1976.

5. Sampson, R. H. "User's Manual for the SURFACE II Graphics System, Kansas Geological Survey, Univ. of Kansas, Lawrence (1973).

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ENEWETAK ISLANDS TO BE SEARCHED FOR CONTAMINATED DEBRIS

ISLAND	TOTAL AREA* (acres)	HIGH PU CONCENTRATION REGIONS (acres)
Leroy (Biken)	14	0
Alice (Bokoluo)	22	6
Belle (Bokombako)	30	22
Clara (Kirunu)	7	7
Daisy(Louj)	21	10
Edna (Bokinwotme)	10	-0-
Irene (Boken)	45	25
Janet# (Enjebi)	291	74
Kate (Mijikadrek)	16	16
Lucy (Kidrinen)	20	-0-
Percy (Taiwel)	2	-0-
Mary (Bokenelab)	12	-0-
Nancy (Elle)	11	-0-
Olive (Aej)	41	5
Pearl (Lujor)	54	17
Ruby (Eleleron)	4	-0-
Sally (Aomon)	99	10
Tilda (Bijire)	52	-0-
Ursula (Lojwa)	40	-0-
Vera (Alembel)	38	-0-
Wilma (Billae)	-0-	-0-
Yvonne (Runit)	94	25
	923	212

*From Ref I Table 5-16
#Approximately 12 acres under experimental cultivation by ERDA will be excluded from Cleanup.

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SUSPECTED OR KNOWN BURIAL SITES FOR RADIOACTIVE DEBRIS AT ENEWETAK ATOLL*

Island	Contamination	Quanity	Location	Confidence
IRENE	Soil	Large	Unknown/central island	Fair
JANET	Activated metal	Large	Around SGZ's	Fair
PEARL	Activated metal	Unknown	Around SGZ	Suspected
RUBY	Soil/activated metal	Unknown	Old SGZ	Positive, high
SALLY	Debris	Unknown	Western SGZ area	Suspected
	Pu debris	Unknown	KICKAPOO SGZ	Absolute
	Pu debris	Unknown	Western SGZ area	Absolute
	Pu debris	Unknown	Causeway, SALLY/ TILDA	Absolute
YVONNE	Pu debris	Large	FIG/QUINCE SGZ- lagoon side	Absolute
	Pu debris	Unknown	Disposal area-- location unknown	Positive, high
	Activated metal	Unknown	Anywhere--exact locations unknown	Absolute
	Contaminated debris	Unknown	West of CACTUS crater	Suspected
	Contaminated debris	Unknown	ERIE SGZ	Positive, high
	Contaminated soil	Unknown	North of HARDTACK Sta. 1310	Positive, high

* Ref 2, Pg. 84

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AREAS OF ENEWETAK ATOLL TO BE SEARCHED DURING CLEANUP FOR PLUTONIUM CONTAMINATED SOIL

ISLAND	SURFACE SAMPLES[a] (pCi/g)	PROFILE SAMPLES[a] MAX CONC (pCi/g)	PROFILE SAMPLES[a] DEPTH MAX CONC (cm)	PROFILE SAMPLES[a] DEPTH CONC EQUALS 40 (cm)	HIGH PU CONCENTRATION REGIONS[b] (Acres)
LEROY	0	0	0	0	None.
ALICE	68	170	3.5	9	Approximately 220 m near island running from ocean to lagoon.
		120	1.0	3	
		100	1.0	3	
BELLE	48	200	3.5	14	Approximately 3/4 of the island, toward northwestern end.
	70	110	1.0	2	
	43	220	1.0	4	
	46				
	94				
	56				
	100				
CLARA	45	65	12.5	16	Entire island.
	55	96	3.5	8	
	88	85	1.0	6	
	44				
DAISY	54	64	12.5	15	Western half of island.
	51	46	30	none[c]	
	90	190	1.0	4	
	98				
EDNA	0	0	0	0	None.

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IRENE	280		74	80	84	Approximately 600 m along periphery of Seminole
	95		100	30	57	crater and extending landward about 100 m; also
	210		170	30	none[d]	approximately 100 m X 350 m on the southern coast.
			670	12.5	none[e]	
			170	30	43	
JANET	41		65	1.0	2.0	A 300 m wide strip running from the northern promintory
	45		55	2.5	9.0	800 m southward to the large test structure; and a 200 m wi
	170		110	3.5	8.0	strip extending westward from the structure for about 300 r
	41					
	51					
	46					
	67					
	48					
	52					
	120					
	66					
	40					
	57					
KATE	50		62	1.0	2.0	Entire island.
LUCY	0	0	48	1.0	48 1.5	None.
PERCY	0		43	7.5	8.0	None.
MARY	0		55	3.5	5.0	None.
			40	3.5	3.5	
NANCY	0		42	7.5	8.0	None.
OLIVE	0		85	1.0	2.0	Approximately 120 m X 180 m toward the northern end.

PEARL	170 530 63 55 83 85 81 50 83 89 100 170	410	1.0	5.0	Approximately 200 m X 340 m near island center.
BY	0	0	0	0	None.
SALLY	44 130	40 64	130 1.0	130 2.0	The islet (often called "Sally's Child") and the area along the lagoon shore toward the western end.
TILDA	0	0	0	0	None.
URSULA	0	0	0	0	None.
VERA	0	0	0	0	None.
WILMA	0	0	0	0	None.
YVONNE A		75 180	5 15	14 19 & 108	Approximately 80 m X 30 m toward the northwestern lagoon shore;

YVONNE B	150	800	95	112	520 m from lagoon to ocean near island center;
		520	15	23	
		820	70	140	
		480	35	55	
		75	75	77	
		110	35	48	
		95	25	30	
		100	15	20	
		450	5	32	
		220	5	8	
		730	5	9	
		310	5	32	
		320	5	9	
		370	5	23	
		62	5	6	
		52	2.5	4	
		52	5	6	
		300	5	30	
		62	5	7	
		160	5	11	
		150 or 15	?	?	
YVONNE C	50	62	14	15	100 m by 100 m near northern side of runway.
		290	75	93	

[a]AEC Report NVO "ENEWETAK RADIOLOGICAL SURVEY" Oct 75, Pu Concentration $\geq$ 40 pCi/g.

[b]Areas enclosing locations which yielded Pu concentrations $\geq$ 40 pCi/g.

[c]Increases to max depth samples (30 cm).

[d]Essentially 110 to max depth sampled (60 cm).

[e]115 at max depth samples (37 cm).

RADIATION PROTECTION STANDARDS FOR CLEANUP

A. Control of Occupational Exposure to Ionizing Radiation.

(1) The accumulated dose equivalent of radiation of the whole-body, head and trunk, active blood-forming organs, gonads, or lens of the eye will not exceed--

(a) 1.25 rems in any calendar quarter,

nor

(b) 5 rems in any 1 calendar year.

(2) 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--

(a) 7.50 rems in any calendar quarter,

nor

(b) 30 rems in any 1 calendar year.

(3) The accumulated dose equivalent of radiation to the hands and wrists or the feet and ankles will not exceed—

(a) 18.75 rems in any calendar quarter,

nor

(b) 75 rems in any 1 calendar year.

(4) The accumulated dose equivalent of radiation to the forearms will not exceed—

(a) 10 rems in any calendar quarter,

nor

(b) 30 rems in any 1 calendar year.

(5) The accumulated dose equivalent of radiation to the thyroid, other organs, tissues, and organ system will not exceed--

(a) 5 rems in any calendar quarter, nor

(b) 15 rems in any 1 calendar year.

(6) Individual(s) under 18 years of age, females known to be pregnant, and occasionally exposed individual(s) will not be exposed to a whole-body dose equivalent of more than--

(a) 2 millirems in any 1 hour, nor

(b) 100 millirems in any 7 consecutive days nor

(c) 500 millirems in any 1 calendar year,

(d) nor more than 10 percent of the values in (2), (3), (4)

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and (5), above, for other areas of the body.

(7) Individuals over 18 years of age, but who have not yet reached their 19th birthday, may be occupationally exposed to ionizing radiation provided that they do not exceed 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.

B. Permissible Contamination Levels

(1) Soil:

Less than 40 pCi (Pu)/g (Ref 1)

(2) Debris, vehicles and other equipment released after any cleanup:

(a) Transuranic alpha emitters--less than 20 dpm/100 cm2 (Reference 3)

(b) Beta/Gamma emitters--less than 0.1 mrad/hr at 1 cm (Reference 3)

(3) Personnel:

No removable contamination

(4) Air:

Less than 4.4 dpm (Pu-239)m3