UNITED STATES
ATOMIC ENERGY COMMISSION
NEVADA OPERATIONS OFFICE
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October 4, 1972

Those on Attached List

PLANNING AND OPERATIONS DIRECTIVE (NVO-121) - 1972 - ENIWETOK ATOLL RADIOLOGICAL SURVEY

This directive outlines the purpose, objectives, and plan for the 1972 Eniwetok Atoll Radiological Survey, establishes authorities, responsibilities, and procedures for its execution, and sets forth program policy, definition, coordination, and authorization for funding.

Mahlon E. Gates
Manager

OO:JDS

Enclosure:
Planning & Opns Directive
(NVO-121) - 1972 - Eniwetok
Atoll Radiological Survey

Distribution - Memorandum dated 10/4/72

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PLANNING AND OPERATIONS DIRECTIVE (NVO-121) - 1972
ENIWETOK ATOLL PRE-CLEANUP RADIOLOGICAL SURVEY

I. Background

A. History and Purpose

The Eniwetok Atoll was extensively used during the 1950's for atmospheric nuclear testing, necessitating displacement of individuals living there. Since the United States Government is prepared to release legally the entire atoll to the trust territory government at the end of 1973, subject to retention of some minor residual rights, rehabilitation of the atoll has been proposed. In anticipation of possible rehabilitation, a preliminary survey of the Eniwetok Atoll was conducted by NV during May 1972 to facilitate comprehensive survey planning. This survey established partial information on the extent of radioactive material on the atoll, but the information was not sufficiently comprehensive to permit careful assessment of the radiological implications of test debris remaining on the atoll or of cleanup costs for material that must be removed before the native population can return. A comprehensive survey is required in order that these assessments may be made. The AEC has accepted responsibility for conducting this survey and has assigned it for Headquarters coordination to DMA and has directed NV to implement the program.

The purpose of this Planning and Operations Directive is to provide guidance and to define responsibilities for the conduct of this survey.

B. ~~Political Considerations and~~ Interagency Arrangements

Within the AEC the Assistant General Manager for Military Application is responsible for coordination with the Department of the Interior (including Trust Territories Administration), the Department of Defense, the Environmental Protection Agency, and all other Washington level agencies and officials. There has been established an interagency Washington level coordinating group charged with definition of overall Eniwetok Atoll objectives, with one member each from the Department of Interior, Department of Defense, and AEC.

C. Objectives of the Survey

Specific objectives of the Eniwetok Atoll pre-cleanup radiological survey are as follows:

1. To locate and identify contaminated and activated test debris.

2. To locate and evaluate any significant radiological hazards which may complicate cleanup activities.

3. To identify sources of direct radiation and food chain-to-man paths having radiological implications.

D. Survey Plan

The Radiological Survey Plan, which describes the manner in which the technical objectives are to be achieved, is attached as Appendix A.

II. Authorities and Responsibilities

Authorization and guidance for the Eniwetok Atoll pre-cleanup radiological survey was furnished NV per teletype from AEC Headquarters dated September 13, 1972, attached as Appendix B.

The Division of Military Application will provide overall Washington direction and will coordinate AEC policy relating to the conduct of the survey itself. Standards and requirements for the survey have been defined by the Division of Operational Safety and Biomedical and Environmental Research, and are incorporated in the Survey Plan.

Within the Nevada Operations Office, the Assistant Manager for Operations will be responsible to the Manager for successful accomplishment of the objectives of the Eniwetok Atoll radiological survey, laboratory analysis effort and for preparation of the required survey and study reports. He will be supported by a Technical Director who shall have full authority and responsibility for the technical conduct and execution of the survey plan. The Assistant Manager for Operations will be assisted, to the extent required by the Assistant Manager for Engineering and Logistics, and the Director, Pacific Area Support Office, in matters of field support. Within this framework, NV's responsibilities are as follows:

1. To prepare a plan for the conduct of the field survey and for the analysis of samples obtained, utilizing necessary laboratory and contractor support.

2. To select personnel to conduct the field survey.

3. To select laboratories and personnel to accomplish the laboratory analysis work. This task includes the establishment of procedures, standards and methods for the correlation of data between laboratories.

4. To support AEC Headquarters activities required for pathway and dose assessment.

5. To arrange for necessary logistical support.

6. To maintain direct liaison with DNA for field support and to keep AEC Headquarters Divisions cognizant of field activities.

7. Pending further guidance, to address priority considerations in planning for sample analysis and for the biological pathway and dose assessment portions of this task.

8. To develop the appropriate survey reports and submit them to AEC Headquarters.

III. Organization

The organization for the Eniwetok Atoll radiological survey program is incorporated in Appendix A.

IV. Survey Execution

The survey will be conducted over a period of about eight weeks starting on or about October 13, 1972.

The field party performing this survey is expected to include representatives of:

1. Division of Operational Safety, (DOS), HQ

2. Office of the Assistant Manager for Operations (AMO), NV

3. National Environmental Research Center (EPA/NERC), Las Vegas, Nev.

4. Laboratory of Radiation Ecology (LRE), University of Washington

5. Lawrence Livermore Laboratory (LLL)

6. Holmes and Narver, Inc. (H&N)

7. Eberline Instrument Corporation (EIC)

The laboratory effort will continue for some months following the survey and is described in detail in Appendix A.

Initial deployment of equipment and personnel will be via military special air mission from Travis Air Force Base to Eniwetok. Personnel rotation and sample shipments will be handled by normal military and commercial aircraft. A schedule of field survey personnel is attached as Appendix C.

V. Program Funding

Funds in the amount of $314,000 have been made available for this survey. Of this, $100,000 was provided by DOS and $214.000 by DMA.

Costs will be reported by contractors in category 03-30-01-02 (on-continent technical support). The Finance Division will record costs as necessary to account for the various funding sources.

Contractors will be provided funding in financial plans in the above category.

LLL internal effort associated with this survey will be costed within LLL program funding.

APPENDIX A

ENIWETOK RADIOLOGICAL SURVEY PLAN

29 September 1972

W.E. Nervik, Technical Director

I. INTRODUCTION

Purpose: AEC Headquarters has accepted responsibility for conducting a comprehensive radiological survey of the Eniwetok Atoll. DMA has been given responsibility within Headquarters for the survey and they, in turn, have delegated the responsibility to NVOO. In the wording of the 13 September 1972 implementing directive from DMA to NVOO:

> "It is the overall AEC purpose to gain a sufficient understanding of the total radiological environment of Eniwetok Atoll to permit judgments as to whether all or any part of the atoll can safely be reinhabited and, if so, what steps toward cleanup should be taken beforehand and what post-rehabilitation constraints must be imposed. It is necessary to thoroughly examine and evaluate radiological conditions on all islands of the atoll and in the local marine environment prior to commencement of clean-up activities in order to obtain sufficient radiological intelligence to develop an appropriate cleanup program.
>
> Specifically, it is necessary:
>
> 1- To locate and identify contaminated and activated test debris,
>
> 2- To locate and evaluate any significant radiological hazards which may complicate cleanup activities, and
>
> 3- To identify sources of direct radiation and food chain-to-man paths having radiological implications.
>
> You are directed to plan, organize, and conduct a radiological field survey to develop sufficient data on the total radiological environment of Eniwetok Atoll to permit the assessments on which the judgments described above can be made. This survey should be accomplished as soon as possible upon completion of the necessary planning and coordination. It should consider the total environment pertinent to rehabilitation including both external radiation dosage

and biological food-chain considerations. It is anticipated that technical standards and requirements will be provided by responsible divisions within AEC Headquarters."

Organization: The organization of the field survey, the analytical work, and the interpretive effort associated with the Eniwetok Program has largely been determined by the following considerations:

1. At the Headquarters level the Division of Biology and Environmental Research (DBER) will have responsibility for assessing the radiological implications of sources of direct radiation and food chain-to-man paths. DBER will provide guidance as to the data needed from the field to conduct that assessment.

"2. The Division of Operational Safety (DOS) will share responsibility for planning the survey and will provide the coordination of these plans and their extension during the survey with the Assistant General Manager for Environmental Safety (AGMES). DOS will also provide information on the survey to EPA staff at the Washington level upon request. DOS will review and evaluate all data and assessments relevant to the feasibility of various cleanup methods and methods for disposal of hazardous materials, and will make recommendations on requirements, guidelines, and environmental and health protection standards to be employed during cleanup operations."

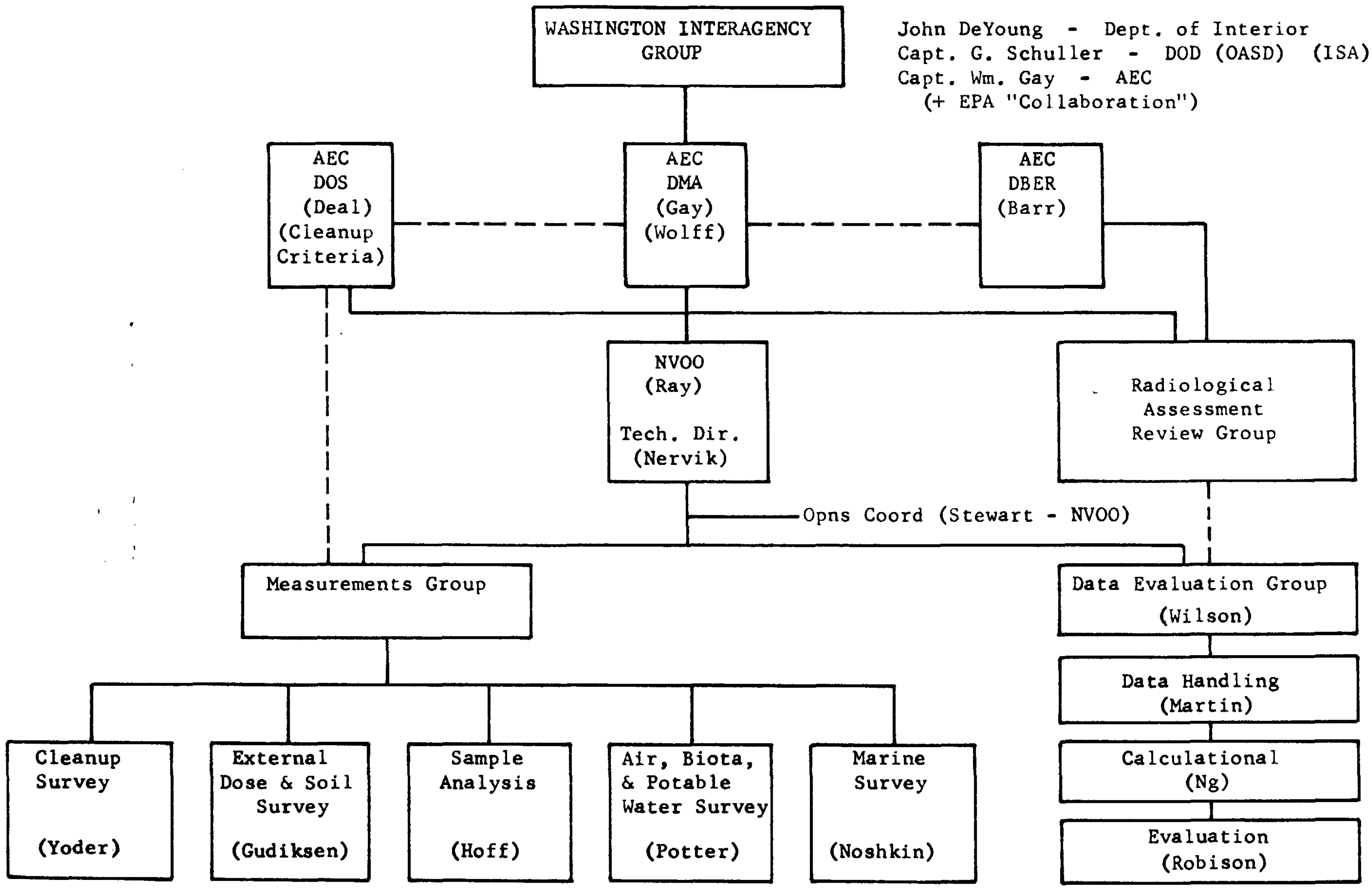
4. The Radiological Survey [illegible] on technical organizations which already have made commitments for their people for FY 73. The number of qualified organizations able and willing to respond is therefore limited.

5. Since no compromise on the quality or comprehensiveness of the survey will be acceptable, participants are being chosen on the basis of their being able to do the necessary high quality work in the time frame in which it is needed.

With these considerations in mind, an organizational chart of the Eniwetok Survey Program is shown in Fig. 1. NVOO is the primary organization for implementing the survey, interacting with DMA, DBER, and DOS at the Headquarters level. The survey itself, and the interpretive effort associated with it, have been divided into eight categories:

Figure 1

ORGANIZATION OF THE
ENIWETOK SURVEY PROGRAM



the Radiological Assessment Review Group appointed by DBER; Field Operations Coordination at NVOO; measurements involving the Cleanup Survey; External Dose and Soil Survey; Air, Biota, and Potable Water Survey; Marine Survey; and Sample Analysis; and Data Evaluations. Authors of detailed plans for each of the last six categories are indicated on the chart. It is now expected that the program will involve personnel from the following organizations: NVOO, NERC (EPA), LLL, LASL, MCL, Univ. of Wash., HASL, Eberline Inst. Co., TTPI, Univ. of Hawaii, DOS, and DBER, plus organizations not yet identified involved in the Radiological Assessment Review Group.

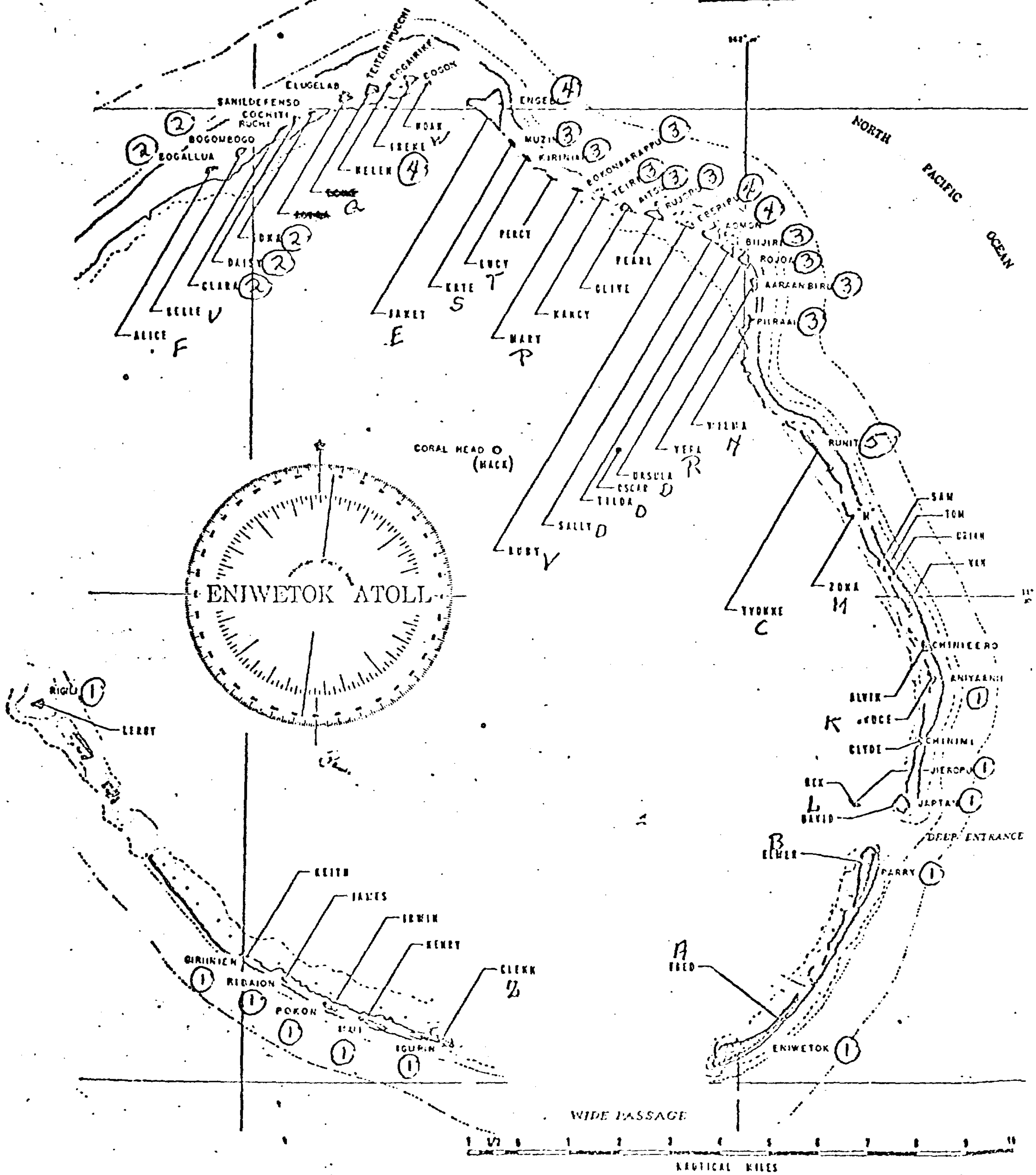
For orientation purposes a map of Eniwetok Atoll is shown in Fig. 2. Previous surveys in May and July of this year indicate that radiological contamination levels vary from light (1-10 μR/hr at 3') for islands on the southern half of the atoll to heavy (> 1000 μR/hr at 3') on Runit, with islands on the northern half of the atoll in intermediate categories. As can be seen from Fig. 2, no survey data are available for at least 10 of the islands. Data on radiological levels in the marine environment and in air are particularly scarce. Our intent is to obtain samples and data from the least contaminated islands first, then move to the more highly contaminated islands, and end on Runit. The marine work will run concurrently with the terrestrial survey. This is not, however, meant to imply that the least contaminated land areas have the least contaminated adjacent marine environment. Currents and other processes in the lagoon have probably redistributed the initial inventories of radionuclides to the extent that any attempt to predict relative contamination levels in the marine area near each island is presently impossible.

In this survey, we will design and carry out our field studies in the Atoll with sensitivity to preservation of the natural environment. This means that we will make an effort to utilize the literature, outside experts, and our own experience in order to sample living populations and soils so as not to generate imbalances. Special care will be taken to avoid the addition of persistent toxic material, wastes and refuse, and to leave the environment of Atoll in as least as good a condition as when we entered it.

II. RADIOLOGICAL STATUS AND DOSE EVALUATION:

The Data Evaluation Group is an integral part of the program plan for

Fig. 2



1- Least contaminated

2- Lightly contaminated (already surveyed)

3- Believed lightly contaminated (not surveyed)

4- Moderate contamination

5- Heavy contamination

Eniwetok, and this Group has been involved since the inception of the study in the development of a measurement and evaluation plan which optimizes the return of information aimed at the objectives. The design of the program has been formulated after considering the following requirements:

1. Program focus. That the program plan be developed in response to a well-defined charter and objectives, as stated and discussed in the first section of this report.
2. Use of existing data. That past studies and data be brought to bear on the measurement and evaluation program design, including survey data from Eniwetok and Bikini and the more general literature on radioactivity in food chains in the Atoll. Such data have provided guidance for developing measurement plans which will give comprehensive information for assessing radiological aspects of future habitability and the feasibility of clean-up prior to rehabilitation.
3. Integrated program structure. That information and materials flow through a system of sample collection, identification, analysis, and interpretation which provides for the best utilization of time and resources, minimizes errors and losses, and allows for rapid feedback and long term access to samples, raw data, and logic sequences which lead to results and interpretations.
4. Technical resources for evaluation. That the evaluation of data for radiological assessment be approached in a way which utilizes the very latest understanding of radioactive transport in the environment and of mechanisms and parameters affecting the dose to man. This principle is to be implemented by drawing on resources and capabilities in a number of institutions, including LLL, LASL, HASL, and the University of Washington. In addition, information on projected living patterns of future inhabitants which might influence a radiological assessment will be evaluated with the assistance of experienced individuals. Contact is being made with Dr. John Tobin, an anthropologist very familiar with the living habits of the native population, in this matter, and we will also draw on scientific investigators of long experience in the Atoll, such as Dr.'s Held and Seymour of the University of Washington. Additional key participants and consultants

are listed in Table 1.

Table 1

Major Participants in the Data Evaluations Group

Group Leader:	D. Wilson, LLL
Data Handling and Computations:	W. Martin, W. Phillips, (LLL)
Calculations:	Y. Ng (LLL), B. Bennett (HASL), B. Rich (LLL)
Evaluations and Applications:	W. Robison (LLL), B. Rich (LLL), C. Richmond (LASL), D. Wilson (LLL)
Consultants:	J. Tobin (TTPI), E. Held (AEC), A. Seymour (U of Wash.), P. Gustafson (ANL), M. McLaughlin (HASL), R. Conard, M.D. (BNL).

5. Communication of results. Finally, that the evaluation, as it proceeds in time, will be in close communication with the Division of Bio-Medical and Environmental Research (DBER) through a review committee headed by Dr. Nathaniel Barr (See Figure 1). The advantages to such a communication are two-fold:
   a. For maintaining point-in-time cognizance of our activities, methods, and results, which will enable DBER to review the final product more intelligently and more effectively under time constraints, and
   b. For providing guidance during the progress of the survey and to serve as a point of contact for information available across the whole research program in the AEC on environmental radioactivity, including AEC experience in DBER and DOS regarding radiological assessment and rehabilitation on Bikini.

The "Radiological Report on Bikini Atoll," April, 1968, by Dr. P.F. Gustafson, then of DBM/AEC and now of ANL, provides an excellent backdrop against which to view the current Eniwetok evaluation program. Comparison and contrast of the two situations (Bikini and Eniwetok) regarding radiological aspects provides a number of facts useful in developing a program plan. Most relevant to the Eniwetok program is to emphasize the similarity in the environments and the expected lifestyles of the future inhabitants. One could elaborate on second-order differences as they exist or as they are to be expected, but it is most important to point out two major considerations:

1. Regarding the major pathways, evaluation can be based primarily upon the expected similarity which will exist in lifestyle and habits between the returning Bikinians and Eniwetokese. The predominant protein source will be from marine fish, but, where possible, coconuts, pandanas, and arrowroot will be cultivated for food. A diet can be constructed on the basis of the Rongalese diet, as was done by Gustafson for Bikinians, and adjusted as indicated by information gained on the specifics of Eniwetok Atoll.
2. Serious contrast can be made, however, between Eniwetok Atoll and Bikini Atoll as regards the base radiological contamination, which is both larger for Eniwetok and compounded by the larger amounts of ^{239}Pu and other transuranics. Thus, while we cannot yet speak of the relative importance of long-lived fission products, activation products, or alpha radioactive elements, it will be necessary to provide comprehensive assessment of the latter class of radionuclides in order to put these in perspective to the others. This will include assessment of both the inhalation and ingestion pathways.

In brief, the assessment is organized around a pathway-dose two dimensional matrix. Radionuclide composition of dose transfer media such as foods, air, and water will be coupled with existing models of intake and metabolism to calculate potential dosages, taking into consideration the projected patterns of living of the future inhabitants.

The major pathways under consideration are:

1. External Radiation
2. Internal Radiation
   a. Terrestrial Foods
   b. Marine Foods
   c. Water
3. Inhalation, Submersion

An understanding of the data base to be generated for these assessments can be obtained in the following sections of this program plan. It is our goal to provide all the data needed to order the relative importance of radionuclides and pathways on the overall picture of radiological assessment for habitability at this time, and to provide data and interpretations which will guide clean-up assessment. These data, however, will not, in all cases, be sufficient to predict potential dosages over the long-term. This point is made to emphasize that limitations in the data base may exist which will not allow detailed pathway modeling and projection of infinite future dosages in all cases.

Previous studies at Eniwetok provide a basis for developing a list of radionuclide species to be encountered in the measurements program (see Table 2). This list may not be complete, and the study may turn up other induced activities. Nevertheless, it is most probable that a small number of radionuclide species will lead to the majority of significant dosages as was found for Bikini. In addition to the transuranics, we expect ^{90}Sr, ^{137}Cs, ^{60}Co, and perhaps ^{55}Fe to be major contributors to dosage, depending on the pathway considered and the circumstances.

Most of this work of assessment will be straightforward and will consist of applying food-chain and dosimetric data well in hand in the literature and available in such sources as ICRP No. 2. However, we recognize the importance of the results of the measurement program in generating new information on the transport and fate of the heavy elements and we also recognize our reliance on other current research and evaluation activities in the areas of heavy element biological distribution and dosimetry in man.

We plan to work closely with DBER and groups such as the NVOO Applied Ecology Group and the AIBS Advisory Committee on Plutonium, particularly to interpret the significance of plutonium in the context of habitability and clean-up.

III. EXTERNAL DOSE AND SOIL SURVEY:

This soil survey plan is based largely on the draft plan dated 31 August 1972 developed through consultation among the following individuals: Drs. Seymour, Held, Nelson, Welanda, and Schell (Univ. of Wash.), Drs. Eberhart, and Gilbert (BNW), Mr. McCraw (DOS), and Mr. Lynch (NVOO).

The survey has been divided into four phases. Phase I is designed to identify any unsuspected radiological problems on the least contaminated islands. Phase II includes islands which have been subjected to fallout to various degrees (minor to somewhat severe) and construction activities which

Table 2. Radionuclides › be expected in the Eniwetok ·ironment

Isotope	$T_{1/2}^{phys}$ (days)	$T_{1/2}^{Eff.}$* (days)	Emission	Critical Organ***	Energy (MeV)** $\Sigma EF(RBE)_n$
^{3}H	$4.5x10^3$	12	β^-	W.B.	0.0063
^{14}C	$2x10^6$	12	β^-	Sol. Fat	0.054
		10		Submersion W.B.	0.054
^{55}Fe	$1.1x10^3$	600	ε(x-ray)	Sol. spleen	0.0065
		$3.2x10^3$		Insol. Lung	"
				Insol. GI	"
^{60}Co	$1.9x10^3$	9.5	β, γ	Sol. W.B.	1.5
				Sol. GI	0.44
				Insol. Lung	0.72
				Insol. GI	0.44
^{63}Ni	$2.9x10^4$	800	β	Sol. Bone	0.11
				Insol. Lung	0.021
				Insol. GI	0.021
^{90}Sr	10^4	$6.4x10^3$	β	Sol. Bone	1.1
				Insol. Lung	1.1
				Insol. GI	1.1
^{102}Rh	$1.06x10^3$	10.4	ε(x-ray)	W.B.	1.2
^{102}Rh	206	10.4	β^-, β^+	W.B.	0.39
^{125}Sb	876	38	β, γ	Sol. W.B.	0.34
		100		Sol. Bone	0.69
				Sol. GI	
		100		Sol. Lung	0.23
		100		Insol. Lung	0.26
				Insol. GI	
^{137}Cs	$1.1x10^4$	70	γ, β	Sol. W.B.	0.59
		138		Insol. Lung	0.41
				Insol. GI	0.34
^{147}Pm	920	570	β	Sol. Bone	0.35
				Sol., Insol. GI	0.069
				Insol. Lung	0.069

*Half-life in man following uptake in tissue

**Effective energy for deposition in human tissue. (includes active decay products)

***Abbreviation: GI (Gastrointentinal tract), W.B. (Whole body).

Table 2. (continued)

Isotope	$T_{1/2}^{phys}$ (days)	$T_{1/2}^{Eff.}$ (days)*	Emission	Critical Organ	Energy (MeV)** $\Sigma EF(RBE)_n$
^{151}Sm	$3.7x10^4$	$1.4x10^3$	β	Sol. Bone	0.13
				Sol., Insol. GI	0.041
				Insol. Lung	0.042
^{152}Eu	$4.7x10^3$	559	β, γ	Sol. GI	0.65
		$1.1x10^3$		Sol. Kidney	0.71
				Insol. Lung	0.71
^{154}Eu	$5.8x10^3$		$\beta^-, \epsilon, \gamma$	Sol. GI	0.20
		$1.2x10^3$		Sol. Kidney	0.25
		$1.2x10^3$		Sol. Bone	0.45
				Insol. Lung	0.86
^{155}Eu	621	314	β, γ	Sol. GI	0.075
		438		Sol. Kidney	0.083
		439		Sol. Bone	0.28
				Insol. Lung	0.095
^{207}Bi	$2.9x10^3$	5	γ	Sol. GI	0.24
		6		Sol. Kidney	0.33
				Insol. Lung	0.45
^{235}U	$2.6x10^{11}$	100	α, β, γ	Sol. GI	46
				Sol. Kidney	46
				Sol. Bone	230
				Insol. Lung	46
^{238}U	$1.7x10^{12}$	100	α, γ	Sol. GI	0.43
		15		Sol. Kidney	43
				Insol. Lung	43
^{238}Pu	$3.3x10^4$	$2.3x10^4$	α, γ	Sol. Bone	280
				Insol. Lung	57
^{239}Pu	$8.9x10^6$	$7.2x10^4$	α, γ	Sol. Bone	270
				Insol. Lung	53
^{240}Pu	$2.4x10^6$	$7.1x10^4$	α, γ	Sol. Bone	270
				Insol. Lung	53
^{241}Am	$1.7x10^5$	$2.3x10^4$	α, γ	Sol. Kidney	57
		$5.1x10^4$		Sol. Bone	280
				Insol. Lung	57

could have modified the distribution of radionuclides. Phase III deals with islands which have been sites for, or very near to, surface ground zeros and/or extensive test activities. Contamination exists in the form of activated metal debris, radioactive waste disposal areas, distributed fallout, and localized plutonium contamination. The survey will also include an estimate of the extent of radioactive scrap metal situated on these islands. Finally, Phase IV addresses Runit (Yvonne), the most heavily contaminated island.

The selection process for survey priorities is based upon insult determination of each island from examination of historical records and current radiological data provided by preliminary surveys of Eniwetok Atoll in July 1971, May 1972, and of Runit in July 1972.

Field Meter Survey

The survey includes a very detailed examination of the geographical variability of the gamma exposure rate in air on each island due to the gamma rays of greater than 100 Kev emitted by radionuclides deposited in the soil. These nuclides are primarily fission and neutron activation products. The Baird-Atomic scintillation instrument, which utilizes a 1" x 1" NaI crystal, will be used to make these measurements. Similarly, the flux of gamma rays of energies less than 100 Kev due to ^{239}Pu and ^{241}Am will be measured by the FIDLER. This instrument consists of a 1/8" thick x 5" diameter NaI crystal connected to a rate meter. The geographical variation of these measurements will enable the survey teams to locate the areas contaminated with radioactivity where soil samples may be collected for laboratory analysis to determine the concentrations of specific radionuclides present.

Aerial Radiological Measurements

This method has been used by EG&G, Inc. for several years for rapidly and economically surveying large land areas for radioactive deposition and for the location of lost radioactive sources. The data provided by such a survey will be extremely valuable in guiding the field survey teams in the conduct of their surveys. It will greatly reduce the possibility of the survey teams missing contaminated areas and at the same time increase their efficiency by eliminating their need to extensively survey uncontaminated areas.

The EG&G airborne radiation detection system that we propose to utilize consists of two pods mounted on a helicopter or light aircraft. Each pod contains 20 5" x 2" NaI crystals. The signals from these detectors are summed and submitted to a data acquisition system. The output is monitored by 8 single channel analyzers and a multichannel analyzer for gamma spectral analysis. Also included in the system is an inertial navigation system whose output is recorded simultaneously with the radiation data on magnetic tape.

If the system were mounted on a helicopter travelling at 100 ft/sec, the spatial resolution for ^{241}Am on the surface is approximately 100 feet when using the single channel mode of operation. High energy gamma emitters may be located with a spatial resolution of about 50 feet based upon the accuracy of the inertial navigation system. The minimum limits of detection for ^{60}Co and ^{137}Cs is about 1 μR/hr and approximately 1 μCi/m^2 for ^{241}Am. The system may also be flown satisfactorily on small fixed wing aircraft, but the spatial resolution is directly related to airspeed.

The total weight of the system is 1400 lbs and requires 3 people to operate. It would take approximately 1-3 weeks to complete the survey depending upon meteorological conditions.

Aerial photographs of the islands may also be taken with a separate EG&G system which incorporates four Hasselblad cameras equipped with 80 mm lenses. High resolution photographs obtained with this system are a necessity in order to accurately identify locations where soil samples and survey meter readings were obtained as well as to assist in assessing the amount of cleanup that will be required.

Soil Sampling Program

The soil sampling program of the survey will be conducted in a manner that will insure statistically meaningful results. Several types of soil samples will be collected for analysis: (1) A sample consisting of two 15 cm deep cores of 30 cm^2 area each; (2) A surface soil sample collected by a "cookie cutter" of 30 cm^2 area to a depth of 5.0 cm; and (3) A profile collection based upon side wall sampling in a trench in which complete samples of fixed horizontal area are taken to selected depths. The increments of depth are chosen according to predicted, suspected, or known radioisotope concentration vs. depth relationships and also according to any soil horizons present at the sample location. Nominal depth increments in centimeters will be: 0-2, 2-5, 5-10, 10-15, 15-25, 25-35 and at 15 cm intervals below 35 cm. If a soil horizon is encountered the interface lines will be chosen as the increments from the horizon rather than the fixed nominal increments from the surface.

Locations for the collection of soil samples will be chosen on the basis of (1) random selection and (2) ground or aerial survey meter readings. These are described below:

A. Samples collected on the basis of random selection.

1. Each island will be divided by a narrow grid, (i.e., approximately 2500 points or 50' x 50' grid whichever is smaller). All areas defined by such a grid will be numbered.
2. If stratification is desired and in order, the strata will be chosen and indicated on the grid network.
3. Individual sample areas will then be chosen within each stratification or grid by selection of the appropriate coordinate number utilizing random number tables. The number of samples per island or group has been previously determined through consideration of desired goals and statistical significance.
4. The exact location of the sample collection is to be the center of the area chosen by the random number technique described in No. 3 above. It is realized that the determination of such a point with any great precision or accuracy in the field is technically impractical in most cases. It is most important however that the sample collector make every reasonable effort to locate the position as closely as possible. In particular, the sample should come from within a 10 foot by 10 foot area defined as the center area of the grid point. Ideally, the sample will come from the exact center of this limited area as just stated. In the field the location will be identified as indicated on the map but will be located probably by pacing or other field direction. The spot so determined by such pacing will be the actual spot at the end of the designated number of paces, and no other. If there is some obstacle to sampling at this specified location (e.g., a concrete pad) then that fact should be recorded in the field and no sample taken.

5. Each sample will be bagged and marked with an appropriate identification code.

B. Samples collected on the basis of survey meter readings.

1. Additional samples will be collected from locations where abnormally high readings were obtained from either the Baird-Atomic scintillator or the FIDLER.
2. Each sample will be bagged and marked with an appropriate identification code.

Field Analysis

A radiation counting laboratory will be established on Eniwetok Island. This laboratory will contain a 3" x 3" NaI and an intrinsic Ge detector plus associated electronics. These detectors will allow scanning of the samples for gamma emitting fission and neutron activation products as well as for ^{241}Am. The data obtained by this scanning process should provide information which may influence the collection of additional samples from contaminated areas. This information will also be valuable in determining future analyses to be performed on the samples after their arrival on the continent.

Preliminary Soil Sampling Schedule

As mentioned earlier, the survey will address the least contaminated islands first and proceed to the more heavily contaminated islands.

The following is a more detailed listing of the islands within each of the four phases. Also included is a preliminary estimate of the number and types of soil samples to be collected from each island. The number of 0-5 cm and 0-15 cm samples is arrived at on the basis of one of each for approximately 10^5 sq ft of surface area and the number of 0-35 cm (Profile) samples on the basis of one per 8×10^5 sq ft of area or a minimum of two per island. The other (Profile) samples are for special situations such as decontamination pads or areas in which field activities have disturbed the original soil.

Phase I

Island	Approx. Area (10^5 sq ft)	Number of Samples 0-5 cm	0-15cm	0-35 cm (Profile)	Other (Profile)
Glenn	25	25	25	3	
Henry	13	13	13	2	
Irwin	7.5	8	8	2	
James	4.8	5	5	2	
Keith	11	11	11	2	
Leroy	7	7	7	2	
Rex	2	3	3	2	
Bruce	9	9	9	2	
David	48	48	48		6 (4ft.)
Elmer	80	96	96	4	10 (4ft.)
Fred	140	58	58		7 (4ft.)
Total		283	283	21	23

Phase II

Island	Approx Area 10^5 sq ft	0-5 cm	0-15 cm	0-35 cm(Profile)	Other
		Number of Samples			
Alice	10	20	20	2	
Belle	20	30	30	3	
Clara	2	8	8	2	
Daisy	1	8	8	1	
Edna	0.3	5	5	1	
Kate	8	20	20		2 (2ft.)
Lucy	10.5	20	20		3 (2ft.)
Mary	6	20	20	2	
Nancy	9	20	20	3	
Olive	14	21	21	3	
Pearl	27	41	41	3	
Tilda	15	30	30	3	
Ursula	12	24	24	3	
Vera	10	20	20	2	
Wilma	7	20	20	-	2 (2ft.)
Total		307	307	28	7

Phase III

Island	Approx Area 10^5 sq ft	0-5 cm	0-15 cm	0-35 cm(Profile)	Other
		Number of Samples			
Irene	20	30	30	6	4 (6ft.)
Janet	120	150	150		15 (6ft.)
Sally	37	40*	40*	10*	6 (6ft.)*
Total		220	220	16	25

*Will be influenced by the extent of PACE activities on this island.

Phase IV

The only island included in this phase is Yvonne, which to our knowledge is the most contaminated island in the atoll. Field surveys will be conducted with the FIDLER and the Baird-Atomic scintillator in order to supplement data obtained during previous surveys. The objective here will be to obtain survey data on at least as small a grid pattern as is obtained for the other islands. Similarly, a number of soil samples will be collected in selected locations for purposes of evaluating the extent of cleanup required to rehabilitate the island. The extent to which additional data can be obtained by the survey group which speak to either the radiological hazard on Runit or to the engineering aspects of the cleanup operation is not clear at this time. The kind and amount of such additional data will be determined in the field by the survey team.

Thermoluminescent Dosimetry Program

Since the energy response of the Baird-Atomic NaI scintillator is nonlinear, the measurements made by this instrument may not be a true measure of the external dose rate produced by the gamma emitting radionuclides deposited in the soil. To overcome this deficiency we plan to incorporate a thermoluminescent dosimetry (TLD) program which will provide a correlation between the NaI scintillator measurements and the actual dose rate measured by the TLDs.

This program will utilize a combination of LiF and CaF_2:Dy TLD packets. Approximately 40 packets will be placed at selected locations in such a manner that a broad range of dose rates from 2 μR/hr to 200 μR/hr will be measured for the correlation study. In order to eliminate exposure during transit time, the dosimeters will be annealed at Eniwetok Island just prior to their placement in the field. After having been exposed for one month or more in the field, the TLD packets will be recovered and read out at Eniwetok Island.

IV. AIR, BIOTA, and POTABLE WATER SURVEY

The objectives of the terrestrial air, biota, and potable water sampling program are:

a) To collect representative samples of edible plants and animals for radionuclide analysis and subsequent estimation of food-chain transfer of radionuclides to future inhabitants.

b) To measure airborne radioactivity for assessment of the inhalation pathway of exposure, particularly for ^{239}Pu. The air sampling program will address this exposure route at the numerous "clean islands" and also in the more contaminated areas such as the environment on Runit (Yvonne).

c) To correlate the food-chain sampling program with the field gamma measurements and soil sampling program in order to maximize the information available to quantify rates and mechanisms of transfer of radionuclides from soil to man through food-chains. The field survey team will obtain plant samples wherever possible from the soil sampling sites; the terrestrial food-chain team will obtain some soil samples, where necessary, in the areas where they sample edible plants such as pandanus and arrowroot.

1. Air Sampling

Airborne particulates will be sampled by means of three types of samples:

a. Ultra-high volume (UHV) samples: - Two calibrated UHV samplers will be operated at a rate of 1000 cfm. One such sampler will be operated continuously on Eniwetok Island (Fred). The other sampler will be transported from island to island for measurements. Measurements will be made also at selected offshore sites on the LCU. Both samplers will be supported by gross meteorological measurement of wind speed and direction to aid in the interpretation of sources of detected radioactivity.

b. Low-volume (LV) samplers: - A large number of calibrated 5 cfm LV samplers will be fielded and operated on a semi-continuous basis. Banks of these samplers will operate continuously on board the Palumbo and the LCU used in marine sampling and transportation. Others will be fielded strategically to investigate radionuclide levels in ai downwind from contaminated areas.

c. Anderson Cascade Impactors - Two 20 cfm, 5 stage cascade impactors will be used to obtain long-term samples of air for investigation of the size distribution of airborne radioactive particles.

This combination of air samplers will be utilized to address the question of potential exposure to future inhabitants through inhalation of airborne radioactive particles. The initial plan will provide sufficient data to ascertain whether-or-not ^{239}Pu exists in the air at levels in excess of worldwide fallout background and to define the locations and circumstances of any such elevated levels. These samples will be analyzed on a priority basis so that results can be reviewed by the Data Evaluations Group early in the study. These evaluations will be used to decide on any adjustments in the air sampling program design and scope which can be proposed to the Technical Director for implementation.

2. Biota Sampling

The terrestrial food-chain team will focus their effort on obtaining samples of arrowroot, pandanus, coconut, crabs, birds and such other plant and animal organisms as may constitute the diet of future inhabitants. The edible vegetation samples will be collected as available and in conjunction with appropriate soil samples. Edible animal species will be collected as available by trapping or shooting.

Inedible plant species to be used as indicators for soil-root-plant pathways will be collected with the soil survey group. At least two or three species that occur on all islands will be used for this purpose in order to obtain comparative data. Samples of these will be collected on the lagoon side, ocean side, and in the central parts of each island at points where soil samples are collected. These will be returned to the Eniwetok laboratory for identification and processing.

Rats, which are not considered to be a part of the human food chain, are the only mammals existing on the islands and may be considered as an indicator species. These will be trapped and specific organs will be analyzed for radioactivity. Collection sites for all specimens will be identified on the radiological survey maps for later correlation.

3. Potable Water

The only potable water on the Atoll is derived either from rain water or the distillation plant on Eniwetok. Samples of these will be collected for radiochemical analysis along with sludge samples from the distillation plant. In addition, a marginal lens exists on Engebi which we plan to sample.

4. Onsite Laboratory at Eniwetok

An onsite laboratory will be established on Eniwetok for processing samples obtained by the biota field teams. This will include; forced draft ovens for drying plant material for shipment; dissecting equipment for separating organs from animal species, and counting equipment screening of specimens before they are returned to LLL. The principle equipment to be used will consist of a pair of 4" x 4" NaI detectors and two single channel analyzers. A few selected samples will also be screened with a Ge(Li) system in order to determine their radionuclide content.

The Data Evaluations Group will be in charge of co-ordinating collection of data and samples, sample coding, preparation, counting, and other activities in this onsite laboratory.

V. ENIWETOK AQUATIC PROGRAM

The mission of the aquatic survey will be to define the contributing radioactivities in the lagoon and reef areas of the atoll to assess exposure pathways to individuals utilizing the aquatic environment. Sources and levels of activity in the lagoon and reef will be defined using indicator organisms, in-situ detectors, sediment, and water analyses. Samples of edible marine vertebrates and invertebrates will be collected and analyzed for specific radionuclides. Many species will be collected from the reef and lagoon areas that were surveyed in 1964. Changes in activities levels noted over the 8 year period will be assessed. Several methods of assessing the residence time of specific radionuclides in the lagoon environment will be employed.

The types and quantities of samples required will be discussed in the next sections. The entire program, covering both survey and food chain sampling, will be integrated in order to best use our available sampling facilities.

Program Implementation

The development of the aquatic program in the Eniwetok lagoon was originally designed to take advantage of facilities offered by the research vessel, R. V. Palumbo from the Puerto Rico Nuclear Center. The Palumbo left Puerto Rico on August 20 enroute to San Diego, Hawaii, Kwajalein, Bikini and Eniwetok. The mission of the vessel is in support of a DBER funded program involving individuals from the University of Washington, Lawrence Livermore Laboratory and Puerto Rico Nuclear Center investigating the biogeochemical behavior of the transuranium elements in a labelled marine environment. Due to mechanical failures and other operational problems, the Palumbo has been in the San Diego Naval shipyard since September 9 undergoing extensive repairs. The vessel left San Diego on 28 September. If no further delays are encountered enroute, the Palumbo's present schedule would delay its arrival time in Eniwetok by 16 days. The ship will therefore be available in the Eniwetok area no earlier than 18 November. Although it will be very useful to utilize the Palumbo in the Eniwetok lagoon survey we are unable to plan on its availability. In order to conduct a meaningful program early in the survey, additional vessels are being readied for the lagoon work. They include:

1) LLL Boston Whaler - 17' length

Equipped with bottom depth indicator; 65 HP Mercury outboard and 7.5 HP auxillary motor; davit for over the side work with approximately 500 feet of 3/32" steel cable on a hand-operated winch. The vessel will be available for coring, water sampling, dredging, plankton tows and in-situ detection measurements. The ship will be used principally to support near-shore and reef work.

2) An "A" frame is presently under construction to mount on the LCU now enroute to Eniwetok. A portable gasoline engine-powered winch containing 1000 feet of 3/32" stainless steel hydrographic cable will also be mounted on the vessel. The LCU will have the capability to conduct all phases of marine sampling and would be used principally to sample the off-shore region of the lagoon.

3) Other ships of opportunity would be used to ferry personnel and gear to reef areas and, when practical, to assist in plankton tows.

If and when the Palumbo arrives in Eniwetok, its facilities will be employed to supplement the on-going program. If, however, the two facilities (Boston Whaler and the LCU) are the only ships available, a complete program addressing all the survey goals could be conducted in 10-12 weeks without the Palumbo. This estimate is based on having perfect weather the entire period for 8-10 hours per day, 6-7 days per week.

A network of buoys will be placed in the lagoon as fixed reference points during the survey. All personnel operating the whaler and sampling from the LCU will be trained and knowledgeable in all sampling techniques. All samples gathered will be properly coded and sample locations plotted on charts. Locations will be determined by using sighting compasses and estimates based on running time and speed from fixed reference points. The Whaler will contain all necessary safety equipment and tow a spare 6 man raft. The raft will be a means of transport to shallow reef areas.

The aquatic program, independent of the Palumbo, will require five personnel. Two people will operate the Whaler and three will sample from the LCU.

The sampling program will proceed from less contaminated areas of the lagoon to the more highly contaminated areas in order to lessen the probability of sample contamination.

Aquatic Survey Goals and Methods

Purpose: To define the activity levels in the lagoon and reef environment in order to assess levels of external exposure and the degree of ~~areal~~ AERIAL contamination.

	Objective	Method
A.	To assess surface exposure over the reef. Only reef covered w/less than 3 feet of water will be assayed.	Personnel operating from rafts or on foot utilizing β-γ survey meters.
B.	Immersion dose in off-shore beaches.	Analysis of water and sediment samples and in-situ detection methods using the Boston Whaler.
C.	Definition of activity levels in the lagoon and major outflow areas over the reefs.	
	1. Assessment of sediment concentration levels. A) shore to 10 fm terrace in lagoon. B) terrace to deep basin of lagoon. C) deep basin. D) craters.	Using the Whaler and LCU, sediment cores, grab samples, suspended material, and bottom water will be collected and analyzed. An in-situ detector will be used to define relative activity levels of the bottom. A detailed bottom survey using an in-situ NaI detector will be conducted off Runit, followed by extensive sediment sampling. The device used to obtain a bottom sample in any area will depend entirely on the composition of the sediment. The sediment in the lagoon varies from fine sand to coral and algae. The percent of each type of bottom material depends on location, although, in general, a higher percentage of fine material is found closer to shore where a corer may be used. In the deeper area of the lagoon higher percentages of formanifera and nolimeda debris dominate. In these areas dredging and grab sampling will be more successful.

Objective	Method
2. Water concentration	Surface-to-bottom profiles will be obtained by pumping 55 L water samples. Samples will be obtained from 18 stations in the lagoon and 18 stations over the reef. Both the Whaler and LCU will be utilized. 50 - 5 gal bottom water samples and suspended sediment will be obtained in the Runit area.
3. Additional supplementary data required to assess relative concentration levels in the lagoon.	A variety of indicator organisms will be obtained by dredging the sediment and coral knolls in the lagoon from the LCU and Whaler. Daily plankton collections and invertebrates will complement this effort. Species of algae will be obtained from reef areas for analysis.

Miscellaneous activities

The desalination plant will be studied, with emphasis on the fate of the sludge discharged from the plant.

Samples to meet survey requirements

Water

48-55 L water samples from the open lagoon and reef

50-5 gal bottom samples from the Runit area and craters.

Sediment

100 core samples 2" and 3" diameter

200 grab samples

100 dredge samples

50 suspended sediment samples

50 Runit cores

Detailed vertical profiles of radionuclide concentrations in 20 selected cores will be determined. All other samples will be rapidly scanned for relative activity levels and selected samples quantitatively analyzed. Activity levels in vertical sections of Runit cores will be determined in about 50 samples.

Biota

1) 200 plankton samples

If similar areas are sampled, many individual tows will be combined for analysis, especially if the plankton yield is low. All samples will be rapidly scanned in the field and a selected number quantitatively analyzed on-continent.

2) Invertebrates, including -

Sponges

Specimens will be collected from all accessable reef areas. 400-500

Objective	Method
Urchins Sea cucumber Clams Coral Starfish Langusta	individual samples are anticipated and all will be surveyed for relative activity levels. A selected number, probably no more than 200 will be quantitatively analyzed. Included in the latter estimate are all species used in the diet. Some selected shells and coral will be carefully analyzed and correlated with growth rates, concentrations, as indicators of changes in the environment as a function of time.

3) Gut contents of bottom-feeding fish collected in different areas will be analyzed to assess concentration levels in lagoon areas.

Comparison of the activity levels in each of the above sample types will be used to contour activity levels in the lagoon and reef. Data from many sample types, especially edible organisms, will be used for dose assessment. Field recommendations will be forwarded to the laboratory for guidance in sample preparation and analysis.

Food chain dose assessment requirements

Purpose: To provide samples in order to determine the activity levels in all edible marine species. The data are required to assess dose from aquatic food sources.

There will be close coordination with the radiological assessment team who will generate the information regarding Marshallese diet and define the percentage of each marine trophic level in the diet. This information is necessary to determine the sample size of a species needed, type of species, and post-treatment method of the sample. Assessment of the levels of activity in carnivores, bottom feeding carnivores, omnivores, herbivores and all invertebrates will be made. Dietary habits of the Marshallese people will be considered in the treatment of samples. Some species may be consumed whole. The analysis on these defined specimens will be made on the entire fish. For those species where only the flesh or other organs are consumed, the samples will be dissected and the tissue analyzed. The variability in activity levels in similar species from different areas will be determined. Sampling sites will include those areas visited by the 1964 survey team. Fishing methods will include trawls, gill nets, long lines, traps, rod and reel, and spearing. Although the fishing will be operationally defined, 200 to 300 samples are anticipated for quantitative analysis of all detectable radionuclides.

VI. RADIOCHEMICAL ANALYSES

Required analytical measurements on samples recovered in the survey of Eniwetok Atoll are summarized in this document. The information is presented in tabular form, beginning with a description of various sample types and estimated quantities to be recovered. In Table II we summarize how samples will be handled, including treatment at Eniwetok, form in which the material will be shipped, and necessary initial treatment required before samples are ready for routine analysis.

In Table III we summarize the kinds of analyses expected to be necessary, including a list of nuclides which have been detected in Eniwetok samples taken in earlier years. Most of the samples will be GeLi gamma counted as a routine matter. The question as to how many samples will require dissolution and wet chemical analyses can be answered accurately only as the planning and sample recovery progress. We need an assessment of the importance of ^{90}Sr analyses; we expect to infer Pu content from ^{241}Am measurements in some samples where more precise Pu analytical measurement by wet chemistry is not required. We anticipate that the more difficult ^{55}Fe and ^{63}Ni analyses will be performed only on selected samples, principally from the aquatic food chain.

Table I. Sample type, quantity

I. Soil survey program

A. Soil profiles, 200 x 6 = 1200

3" diam, 0-1, 1-2, 2-3, 3-6, 6-9, 9-12

115 cc/in., 170 g/in.

B. Six-inch deep cores 800

3" diam, 0-6", 2 adjacent (=2 kg)

C. Two-inch deep cores 800

3" diam, 0-2", 300 g each

II. Aquatic sampling program

	Predicted Total
A. Plankton	200
B. Sediment	100 + selected samples
C. Seawater (48 (55 liter), 50 (18 liter)	100

Table I. Sample type, quantity (continued)

		Predicted Total
D. Coral	Selected samples for use as indicator organisms	
E. Invertebrates: Sea cucumbers, Tridacna, Spider snail, Spiney lobster		200
F. Vertebrates: Edible reef fish and indicator species; Larger lagoon fish (Sharks, albacore, tuna, grouper, etc.)		200-300
III. Biota samples		
A. Vegetation	- non-edible	300
	- edible	50-100
B. Terrestrial animals (including disected parts)		150
C. Potable water		15
IV. Air samples		
A. High volume samplers		100
B. Low " "		80
C. Anderson cascade impactors		80

Table II. Initial sample processing

	Treatment at Eniwetok	Shipping form	Initial treatment
I. Soils	Package	As recovered.	Dry, grind (ball mill), weigh, package, NaI count.
II. Aquatic samples			
A. Plankton	Freeze	Frozen	Dry ash.

Table II. Initial sample processing (continued)

	Treatment at Eniwetok	Shipping form	Initial treatment
B. Sediment			
1. Grab samples	Freeze	Frozen	Dry, grind, weigh, analyze.
2. Cores	Freeze	Frozen	Section (volume, wet wt), thaw, dry, grind, weigh, analysis.
C. Sea water	Acidify	As water	Analysis
D. Coral	Freeze	Frozen	See Soils.
E. Invertebrates	Freeze	Frozen	Weigh, thaw, (dissect?), dry, (dry ash), weigh, analysis.
F. Vertebrates	Freeze (filet?)	Frozen	Same as item E.
III. Biota samples			
A. Vegetation	Dry	Dry	Dry, grind, homogenize, analysis.
B. Terrestrial animals	Freeze	Frozen	Weigh, thaw, (dissect?), dry, (dry ash), weigh, analysis.
C. Potable water	Acidify	As water	Analysis
IV. Air samples	Package	As recovered	Analysis

Table III. Kinds of analyses required

I. Gamma counting

A. In general, no dissolution nor chemical separation will be required prior to gamma spectrometry. There could be occasional exceptions to this rule, e.g., sea water will require processing.

B. It is expected that essentially all samples will be gamma counted. In many cases, this may be the only analysis required.

C. Nuclides which are expected to be observed and which can be quantitatively measured by gamma spectrometry:
^{40}K, ^{60}Co, ^{106}Ru, ^{137}Cs, $^{152,154,155}Eu$, ^{241}Am, ^{125}Sb, ^{207}Bi, ^{108m}Ag, ^{65}Zn, ^{102}Rh, U and Th chain daughters

II. Dissolution of sample

A. Plutonium analyses

1. Alpha counting $^{238,239+240}Pu$

2. Mass spectroscopy $^{239,240,241,242}Pu$ where warranted

B. ^{90}Sr - beta counting of ^{90}Y daughter

C. Other nuclides: ^{55}Fe, ^{63}Ni, ^{147}Pm, ^{151}Sm, ^{14}C

Soft radiation emitters will require specific chemical separation.

III. Tritium

Table IV. Laboratory analytical capability

Laboratory	Kind of analytical work	Sample rates
LLL	Initial sample prep., soils	400 samples/month
	" " " , biota (including dissolution of all marine samples)	for initial sample prep. of soils
	Complete analytical treatment, sea water	
	Gamma analysis, all types of samples	

Table IV. Laboratory analytical capability (continued)

Laboratory	Kind of analytical work	Sample rates
MCL	Gamma analysis	
	Soil dissolution, chemical analyses for Pu, ^{90}Sr	
	Complete analytical treatment, air filters	
UW	^{55}Fe analysis	Not established
	^{90}Sr analysis	
Contract analyses	Gamma analysis	
	Soil dissolution, chemical analyses for Pu, ^{90}Sr	200-500 samples/month
NERC (EPA)	Chem. Anal. for Pu	Not established

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VII. CLEAN-UP ASSESSMENT PLAN

During the field survey of the Islands in the Eniwetok Atoll, an attempt will be made to evaluate possible clean-up mechanisms and provide data for future engineering estimates of the decontamination operation. This decontamination assessment is anticipated to take the following form:

1. An estimate of the quantity of activated materials and debris from previous tests will be made. Special attention will be made to record, in a preliminary sense, location, amount, and radiation levels of the debris that should be removed before reoccupation.

2. An attempt will be made to evaluate the feasibility of collecting single particles or "hot spots" by simple excavation techniques or sieving. Various sized screens will be taken to evaluate the feasibility of separating contaminated debris rather than removal of all contaminated soil and/or coral. The character of the contamination in various areas will be evaluated in terms of the feasibility of removing localized hot spots in preference to whole-scale excavation. An attempt will also be made to locate localized hot areas which will require total excavation.

3. A literature search is presently underway and will be continued to evaluate the applicability of modifying existing techniques, other than whole-

scale bulldozing, in decontaminating large contaminated areas.

4. Thorough evaluation of field survey data, the extent of contaminated areas will be mapped, and contamination profiles folded into the data in order to estimate the total area requiring clean-up.

VIII. SCHEDULES

A schematic diagram of the schedule for the Eniwetok Radiological Survey Program is shown in Figure 5.

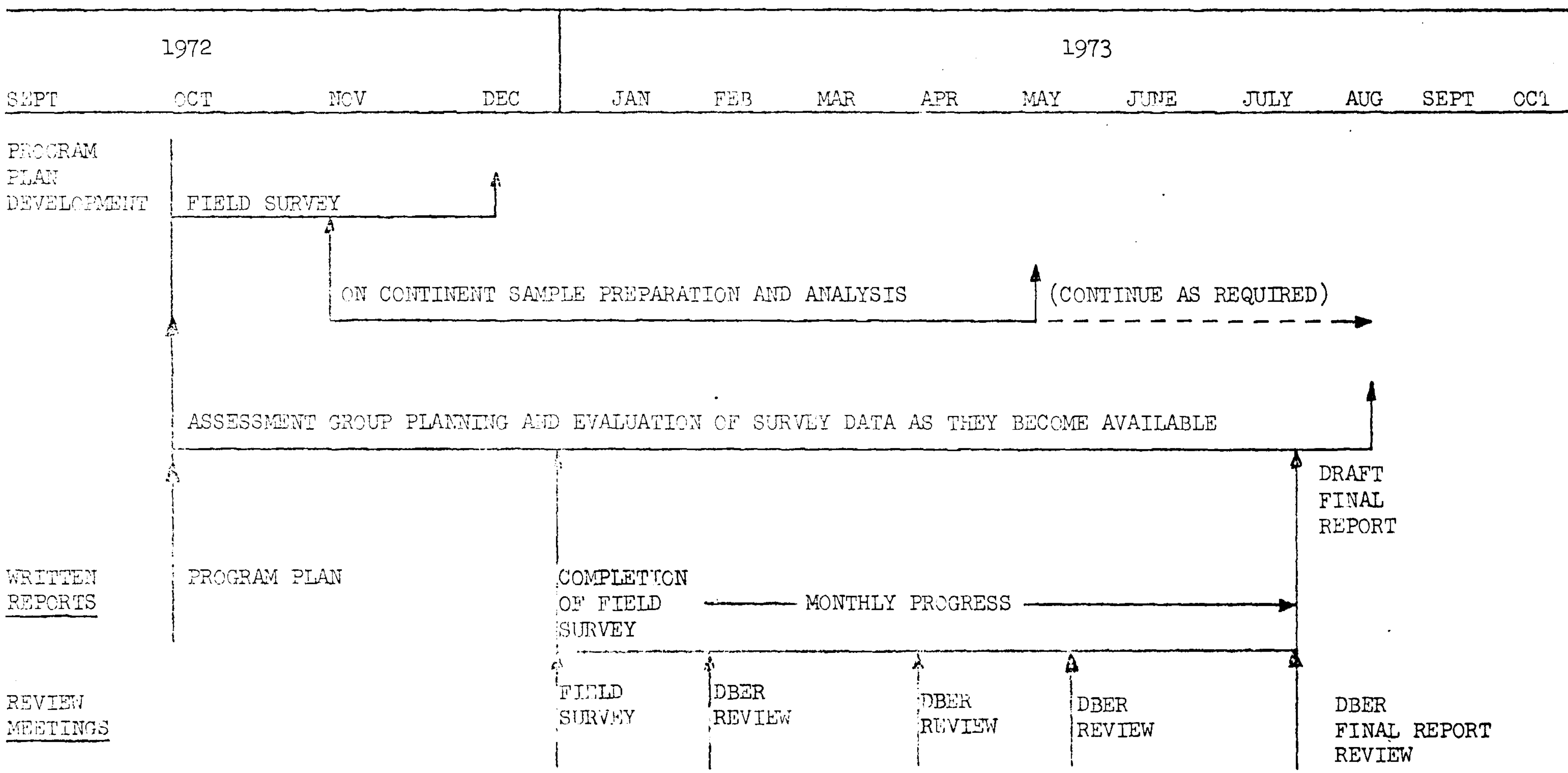
We now expect that the field survey group will depart for Eniwetok on or about October 12, 1972 and that the work on Eniwetok will take approximately eight weeks. Samples taken in the field are to be returned to Livermore on weekly scheduled flights. Processing and analysis will begin as soon as the first samples arrive at LLL.

The first data that are expected to be available are those taken in the field (sample types and locations, survey instrument readings, etc.). These should be in reportable form by January 1, at which time a review meeting may be scheduled to discuss the status of the program.

Considering all available laboratory capabilities, sample preparation and analysis will certainly take a number of months to complete. Samples will be processed on a priority basis according to the needs of the Radiological Assessment Group, so that the DBER assessment and review can proceed on a continuous schedule rather than wait for all data to become final. The DBER review schedule shown in Fig.5 is a very tentative one. Every attempt will be made to speed up the process, without compromising on quality or completeness, of course, but no one should be under the impression that gathering this much experimental data and interpreting it will be accomplished overnight.

FIGURE 5

SCHEDULE FOR THE ENIWETOK RADIOLOGICAL SURVEY PROGRAM



APPENDIX B

R 132155Z SEPT 72

FM USAEC FRANK A CAMM WASHDC

TO: USAEC M E GATES LAS VEGAS NEV

INFO: LT GEN C H DUNN DNA WASHDC

UNCLAS SUBJECT: RADIOLOGICAL SURVEY OF ENIWETOK

PARA. AS A RESULT OF COMMITMENTS MADE BY AMBASSADOR WILLIAMS AND INITIAL AGREEMENTS REACHED DURING AN INTERAGENCY MEETING HELD ON SEPTEMBER 7,1972, IT IS THE OVERALL AEC PURPOSE TO GAIN A SUFFICIENT UNDERSTANDING OF THE TOTAL RADIOLOGICAL ENVIRONMENT OF ENIWETOK ATOLL TO PERMIT JUDGMENTS AS TO WHETHER ALL OR ANY PART OF THE ATOLL CAN SAFELY BE REINHABITED AND, IF SO, WHAT STEPS TOWARD CLEANUP SHOULD BE TAKEN BEFOREHAND AND WHAT POST-REHABILITATION CONSTRAINTS MUST BE IMPOSED. IT IS NECESSARY TO THOROUGHLY EXAMINE AND EVALUATE RADIOLOGICAL CONDITIONS ON ALL ISLANDS OF THE ATOLL AND IN THE LOCAL MARINE ENVIRONMENT PRIOR TO COMMENCEMENT OF CLEANUP ACTIVITIES IN ORDER TO OBTAIN SUFFICIENT RADIOLOGICAL INTELLIGENCE TO DEVELOP AN APPROPRIATE CLEANUP PROGRAM. SPECIFICALLY, IT IS NECESSARY:

1. TO LOCATE AND IDENTIFY CONTAMINATED AND ACTIVATED TEST DEBRIS,
2. TO LOCATE AND EVALUATE ANY SIGNIFICANT RADIOLOGICAL HAZARDS WHICH MAY COMPLICATE CLEANUP ACTIVITIES, AND
3. TO IDENTIFY SOURCES OF DIRECT RADIATION AND FOOD CHAIN-TO-MAN PATHS HAVING RADIOLOGICAL IMPLICATIONS.

PARA. YOU ARE DIRECTED TO PLAN, ORGANIZE, AND CONDUCT A RADIOLOGICAL FIELD SURVEY TO DEVELOP SUFFICIENT DATA ON THE TOTAL RADIOLOGICAL ENVIRONMENT OF ENIWETOK ATOLL TO PERMIT THE ASSESSMENTS ON WHICH THE JUDGMENTS DESCRIBED ABOVE CAN BE MADE. THIS

SURVEY SHOULD BE ACCOMPLISHED AS SOON AS POSSIBLE UPON COMPLETION OF THE NECESSARY PLANNING AND COORDINATION. IT SHOULD CONSIDER THE TOTAL ENVIRONMENT PERTINENT TO REHABILITATION INCLUDING BOTH EXTERNAL RADIATION DOSAGE AND BIOLOGICAL FOOD-CHAIN CONSIDERATIONS. IT IS ANTICIPATED THAT TECHNICAL STANDARDS AND REQUIREMENTS WILL BE PROVIDED BY RESPONSIBLE DIVISIONS WITHIN AEC HEADQUARTERS. IT IS UNDERSTOOD THAT PLANNING HAS BEEN INITIATED BY DOS AND DBER IN COOPERATION WITH FIELD ORGANIZATIONS AND SUCH PLANNING WILL SERVE AS THE BASIS FOR A COMPREHENSIVE SURVEY PLAN.

PARA. IN IMPLEMENTATING THE ABOVE OBJECTIVE YOU ARE DIRECTED TO:

1. PREPARE A PLAN FOR THE CONDUCT OF RADIOLOGICAL FIELD SURVEY AND ANALYSIS OF SAMPLES OBTAINED UTILIZING NECESSARY LABORATORY AND CONTRACTOR SUPPORT.
2. SELECT PERSONNEL NECESSARY TO CONDUCT THE FIELD SURVEY.
3. SELECT LABORATORIES AND PERSONNEL TO ACCOMPLISH THE NECESSARY LABORATORY WORK FOR ANALYSIS OF SAMPLES. THIS TASK INCLUDES ESTABLISHMENT OF PROCEDURES, STANDARDS, AND METHODS FOR CORRELATION OF DATA BETWEEN LABORATORIES. IN THIS CONTEXT YOU SHOULD PROVIDE FOR REVIEW AND REPORTING OF DATA.
4. SUPPORT PATHWAY AND DOSE ASSESSMENT ACTIONS WHICH WILL COME UNDER OVERALL TECHNICAL DIRECTION OF THE DBER, SUPPORTED BY THE DOS.
5. ARRANGE FOR NECESSARY LOGISTIC SUPPORT
6. COORDINATE LOGISTIC SUPPORT REQUIREMENTS WITH THOSE OF THE ENGINEERING SURVEY TO BE CONDUCTED CONCURRENTLY BY DNA.
7. DIRECT LIAISON WITH DNA IS AUTHORIZED, AS REQUIRED, KEEPING COGNIZANT AEC HEADQUARTERS DIVISIONS ADVISED.

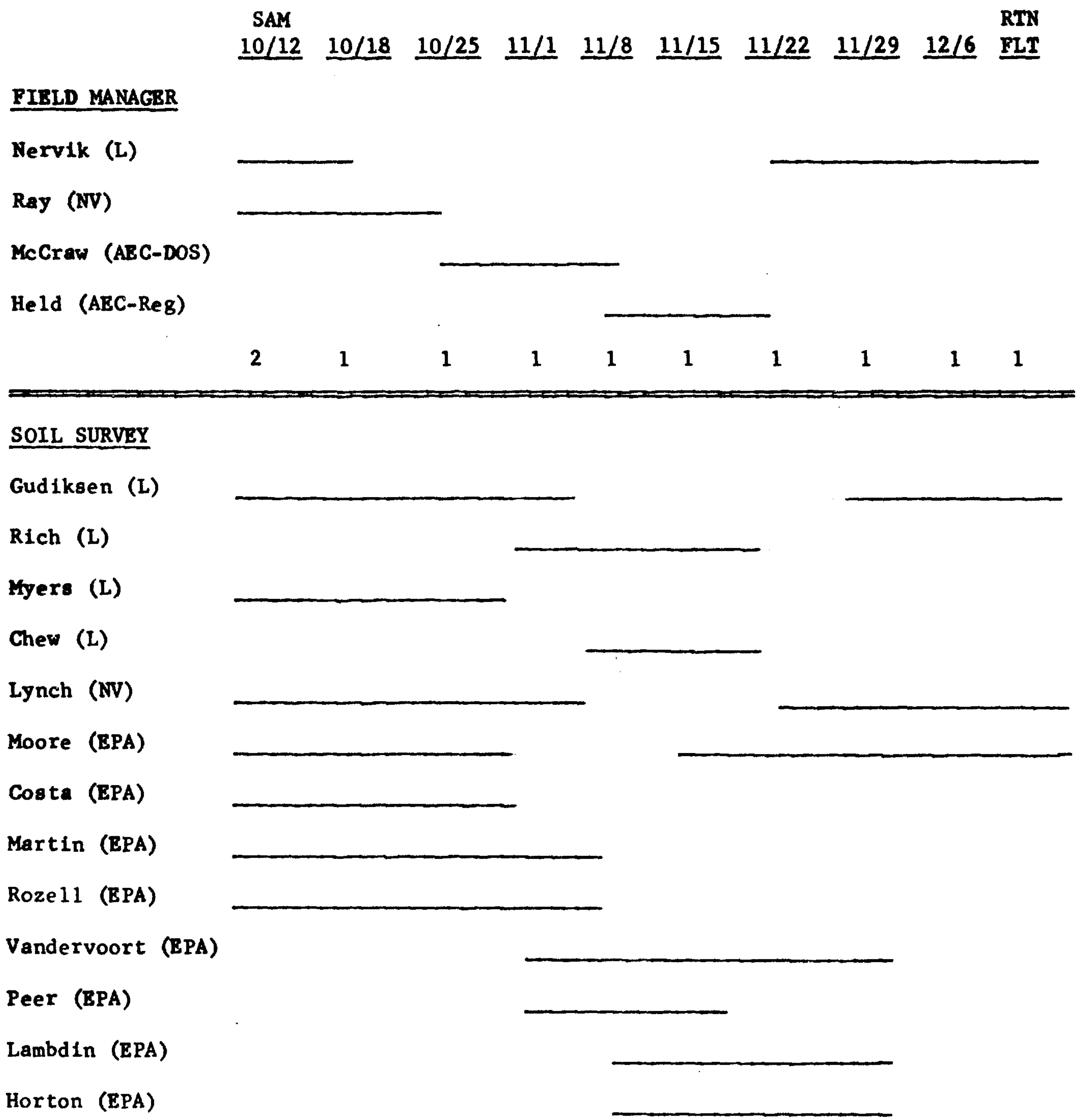
8. PENDING FURTHER GUIDANCE YOU ARE DIRECTED TO ADDRESS CONSIDERATIONS OF PRIORITY IN PLANNING FOR SAMPLE ANALYSIS AND FOR BIOLOGICAL PATHWAY AND DOSE ASSESSMENT PORTIONS OF THIS TASK. IT IS ANTICIPATED THAT A REVIEW OF THE SURVEY WILL BE CONDUCTED UPON COMPLETION OF THE FIELD EFFORT AND BY THAT TIME MORE DEFINITIVE GUIDANCE WILL BE FORTHCOMING ON PRIORITIES IN THE AREAS OF ANALYSIS AND ASSESSMENT.

PARA. YOU ARE AUTHORIZED TO EXPEND $150 K IN THE INITIAL PLANNING AND ORGANIZATION OF THIS SURVEY. INITIALLY THE COST OF PERFORMING THIS EFFORT SHOULD BE CHARGED TO THE ON-CONTINENT PROGRAM. FOR YOUR INFORMATION, THE GENERAL MANAGER HAS APPROVED ALTERNATIVE 2 OUTLINED IN THE CONTROLLER'S MEMORANDUM DATED AUGUST 28, 1972, AND WE CURRENTLY WORKING OUT FUNDING ARRANGEMENTS FOR THE ENTIRE SURVEY. YOU WILL BE KEPT ADVISED.

MA:T:WWG:265-1.

APPENDIX C

Tentative Schedule for Field Survey Personnel:



SOIL SURVEY (Cont'd)

	SAM 10/12	10/18	10/25	11/1	11/8	11/15	11/22	11/29	12/6	RTN FLT
Phillips (EIC)	—	—	—	—	—	—	—	—	—	—
Parker (EIC)	—	—	—	—	—	—	—	—	—	—
Price (EIC)	—	—	—	—	—	—	—	—	—	—
Young (EIC)	—	—	—	—	—	—	—	—	—	—
Sammons (H&N)	—	—	—	—	—	—	—	—	—	—
Chambers (H&N)	—	—	—	—	—	—	—	—	—	—
	13	13	13	13	12	12	11	9	9	9

MARINE

	SAM 10/12	10/18	10/25	11/1	11/8	11/15	11/22	11/29	12/6	RTN FLT
Noshkin (L)	—	←	—	—	—	PALUMBO	—	—	—	—
Nelson (UW)	—	—	—	—	—	—	—			
Seymour (UW)							—	—		
Eagle (UW)		←	—	—	—	PALUMBO	—	—	—	—
Johnson (UW)		—	—	—	—	—	—	—	—	—
Fowler (L)				—	—	—	—			
Holladay (L)	—	—	—	—						
Schell (UW)	—	←	—	—	—	PALUMBO	—			
Chapman (L)	—	—	—	—						
Dawson (L)				—	—	—	—			
Lusk (UW)	—	—	—	—	—	—	—			
	6	5	5	5	5	5	5	2	1	

	SAM 10/12	10/18	10/25	11/1	11/8	11/15	11/22	11/29	12/6	RTN FLT
BIOTA & AIR										
Potter (L)	—	—	—	—	—					
Koranda (L)	—	—	—	—	—					
McIntyre (L)	—	—	—	—	—					
Thompson (L)				—	—	—	—			
Stuart (L)				—	—	—	—			
J. Martin (L)				—	—	—	—			
Clegg (L)	—	—	—	—	—					
	4	4	4	7	3	3	3	3		
ELECTRONICS										
Newbold (L)	—	—	—	—	—					
Bishop (L)	—	—								
Breshears (L)					—	—	—			
Jones (L)	—							—	—	—
Hoeger (L)	—	—	—	—						
Cate (L)				—	—	—	—			
Thrall (EPA)	—	—	—					—	—	—
Lawson (EPA)				—	—	—	—			
	5	3	3	3	3	2	2	2		
CLEANUP TECHNIQUE ASSESS.										
Yoder (1)	—					—	—	—	—	—
	1					1	1	1	1	

	SAM 10/12	10/18	10/25	11/1	11/8	11/15	11/22	11/19	12/6	RTN FLT
SAMPLE PREP										
Phillips (L)	—	—	—	—	—					
W. Martin (L)						—	—	—	—	—
Qualheim (L)	—	—	—	—						
Mendoza (L)				—	—	—	—			
Wilson (L)							—	—	—	—
Schweiger (L)	—	—								
Landrum (L)			—	—	—					
LLL (Hoff)?						—	—	—	—	—
	3	3	3	3	3	3	3	3	3	
FIELD OPERATIONS										
Stewart (NV)	—	—	—			—	—	—	—	—
Lease (NV)			—	—	—					
Warren (L)	—	—	—	—	—					
Button (L)					—	—	—	—	—	—
	2	2	3	2	2	2	2	2	2	
DOCUMENTARY PHOTO										
Wilson ? (L)				—	—					
Tyner (Pan Am)				—	—					
				2	2					
EG&G										
NaI Det. Survey										
Total + EG&G	36	31	32	37	31	29	28	23	17	Average 29