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Briefing on Cleanup of TRU Contaminated Soil
January 17, 1984
Planning Phase
Enewetak Atoll Cleanup
T. McCraw

This summary reviews actions during the period 1972-77 by AEC-ERDA-DOE to conduct radiological surveys, to develop radiological cleanup criteria, and to assist in obtaining approval and funding for cleanup and rehabilitation of Enewetak, an Atoll used for U.S. nuclear tests from 1948 to 1958. These criteria are compared with current EPA draft criteria. Mr. Bruce Church will cover Enewetak cleanup field operations. This presentation highlights those aspects of criteria development and planning that are different from and/or incompatible with EPA's draft criteria.

Figure 1 is a chronological outline of the events leading to cleanup field operations at Enewetak. Following the announcement of the U.S. commitment to return this Atoll to the Trust Territory, and without waiting for a final agreement on AEC, DOD, and DOI responsibilities, an AEC task group began development of recommendations on cleanup concurrently with the radiological survey phase of the project. The first draft dose estimates from the 1972-73 radiological survey of Enewetak began to be available during the period of task group deliberations.

As the task group members formed their opinions, a number of ideas were considered and rejected that might have misdirected cleanup planning. Among these were proposals that radiological criteria were not needed and that the amount of cleanup performed would automatically be determined by the amount of funding provided by Congress, or that cleanup criteria should be derived through a consideration of risk estimates, or that dose criteria should be equivalent to the highest doses being received by any population such as those living in high natural radiation areas in Brazil. There was also the idea that the benefits to the Enewetak people of return to their homeland transcended any risk from radiation. The task group chose instead to derive its recommendations on cleanup criteria through a conservative application of current national and international standards for individuals in the population, and considering a wide range of land use and soil cleanup options.

The task group sought to recommend soil criteria that were practical in their application and expressed as a flexible guideline, not a limit. Its recommendations were considered to be site-specific for Enewetak. There was a consensus within the group that if its recommendations were to be technically defensible and useful, site-specific soil cleanup criteria must be developed that were related to current radiation standards, and expressed in units that could be compared with measurements made in the field. The task group recommended use of 50 percent of the annual doses for individuals and 80 percent of the 30 year dose for populations issued by the FRC, for cleanup and resettlement planning for fission product doses. Soil cleanup

was recommended for TRU contamination only. The soil levels recommended were associated with 10 percent to 100 percent of the ICRP lung values for individuals. Enjebi Island was to be cleaned up for TRU but not resettled at this time due to high fission product doses. Runit, the island for disposal of contaminated soil and debris, was to remain quarantined.

From the outset, the task group's recommendations were the subject of controversy. On occasion, a strong technical defense of their validity was needed. Agreement on the final draft criteria was a fragile product. Some NV staff did not support the recommendations. DNA staff preferred to establish their own cleanup criteria. EPA staff agreed that they would not disagree, but were looking toward developing their own TRU cleanup criteria. The Enewetak people and their legal council sought cleanup that would achieve zero risk for their return. The task group's recommendations were the subject of an AEC staff paper that was approved by the Commission.

The remaining figures identify agency responsibilities, the task group members, the basis for their judgments and recommendations, options considered, their conclusions, the position taken on risk, the features of the EIS related to Task Group recommendations, and some of the obvious differences between the Enewetak criteria and current EPA draft dose limits.

The role of those who performed the early work to develop Enewetak cleanup criteria largely ended with the issuance of the task group's report. Cleanup planning, field operations, and participants were documented in DOE and DNA reports. However, no overall post-mortem evaluation of this project has been conducted and little effort made to learn from all aspects of this unique experience. So far as I know, this meeting is the first time that the Enewetak project has been reviewed since DOE's report on field operations was issued. In that context I would like to acknowledge the important contributions made toward the success of this effort by the task group members and particularly Walter Nervik of LLNL. Jack Healy of LANL and Lyn Anspaugh of LLNL provided the critical relationship between TRU soil concentrations, air concentrations, and dose to lung. Harold Beck and Jim McLaughlin of HASL, Paul Gudiksen of LLNL, and Oliver Lynch of NVO provided input for external doses. Vic Nelson of the University of Washington and Vic Noshkin of LLNL provided marine data. Bill Robinson of LLNL provided the many dose estimates needed for a matrix of land use and cleanup alternatives.

The reason for citing these contributions is to emphasize that development of site-specific criteria and options for cleanup of a contaminated environment requires a large amount of detailed environmental information that has been evaluated for use in cleanup planning. Mandatory cleanup dose limits derived from extremely low risk values such as those in the EPA draft, had they been in existence in 1973, may well have made Enewetak cleanup appear to be an impossible task with a price tag that was out of the

question, and with so much soil requiring disposal that the only option would have been ocean disposal, an action EPA advised was not acceptable. The removal of soil from much larger land areas,an action that would have been required by the EPA limits, would have accomplished only a small increment of additional dose and risk reduction. How the EPA screening level would have been interpreted in planning Enewetak cleanup is a matter for guesswork. It may have been a liability because of the potential for misuse and misinterpretation.

I do recall several matters that may be relevant. The task group had little faith in use of air sampling data to determine that significant levels of TRU contamination were not present in the soil. Also, they considered but did not recommend plowing to dilute TRU concentrations below the levels to be considered for soil removal. In retrospect, use of EPA dose limits to plan soil cleanup at Enewetak appears incompatible with the need to prepare a complete spectrum of cleanup alternatives that would give OMB and Congress some choice as to the magnitude of the Enewetak cleanup effort.

The task group recommended a conservative application of existing standards for use at Enewetak. In recommending use of dose limits based upon an extremely conservative risk value, EPA ignores these standards. Viewed from the prospective of the Enewetak experience, EPA's development of yet another set of numerical dose values significantly lower than Federal standards and described as limits, restricts rather than promotes flexibility in cleanup decision-making.

For Enewetak there where significant areas of land contaminated with TRU elements and fission products, high visibility and public interest and concern, the involvement of land owners and their legal advisors, and concern for the cost of cleanup. Under such circumstances, AEC acting on its own judgment may have found it impossible to justify conduct of soil cleanup not meeting Federal dose limits even with advice from EPA that these limits are not to be interpreted as absolute values to be met in every instance. If available in 1973, dose limits that need not always be applied as absolute values, would have been a new and confusing concept in radiation prediction and I suggest this is true today as well.

Though permitted by the EPA criteria, development of cleanup recommendations that present a justification for exceeding a dose limit that is some fraction of the FRC standards for use at Enewetak, would have created a problem for those planning cleanup. Almost any advice that was not supported by existing standards would have resulted in disagreement on technical and legal issues. This could have made cleanup a more controversal political issue than it was.

A justification for exceeding EPA's dose limits would have focussed attention away from the fact that basic radiation standards could be (and were) met at Enewetak through a combination of cleanup actions and land restrictions.

In terms of the total cleanup effort, 1 year was required to develop Enewetak cleanup criteria, the time from the announcement until funding was more than 4 years, and the time from the announcement until the end of cleanup was 8 years. Since the fission product doses on some cleaned-up islands are likely to be higher than the EPA draft dose limits for TRU elements in soil for a number of years, one could now argue that Enewetak cleanup was not adequate. This is one of the problems avoided by use of a conservative application of basic standards for both fission products and TRU contamination.

Enewetak planning experience would seem to support the idea that as much advice and as many recommendations on soil cleanup as can be agreed upon should be issued as Federal criteria. However, such guidance must not close off the possibility for consideration of a range of cleanup options wherein dose to the public is only one of several considerations.

One final point, compared to the task group's recommendations, EPA's draft criteria commit that agency to very little in terms of agreements on acceptable methods for dealing with the practical problems incurred in planning and conduct of soil cleanup, many of which are ameniable to generic guidelines. The possibilities for such guidelines can be derived from the published records of Enewetak cleanup.

AGENCY RESPONSIBILITIES
ENEWETAK CLEANUP AND REHABILITATION

DOD — Precleanup Engineering Survey

Monitoring to Insure Safety of Cleanup Personnel

Radiological and Nonradiological Cleanup

Reimburse AEC Support of Cleanup in Field

AEC — Precleanup Radiological Survey

Development of Radiological Criteria and Recommendations

Monitoring Support for Cleanup Field Operations

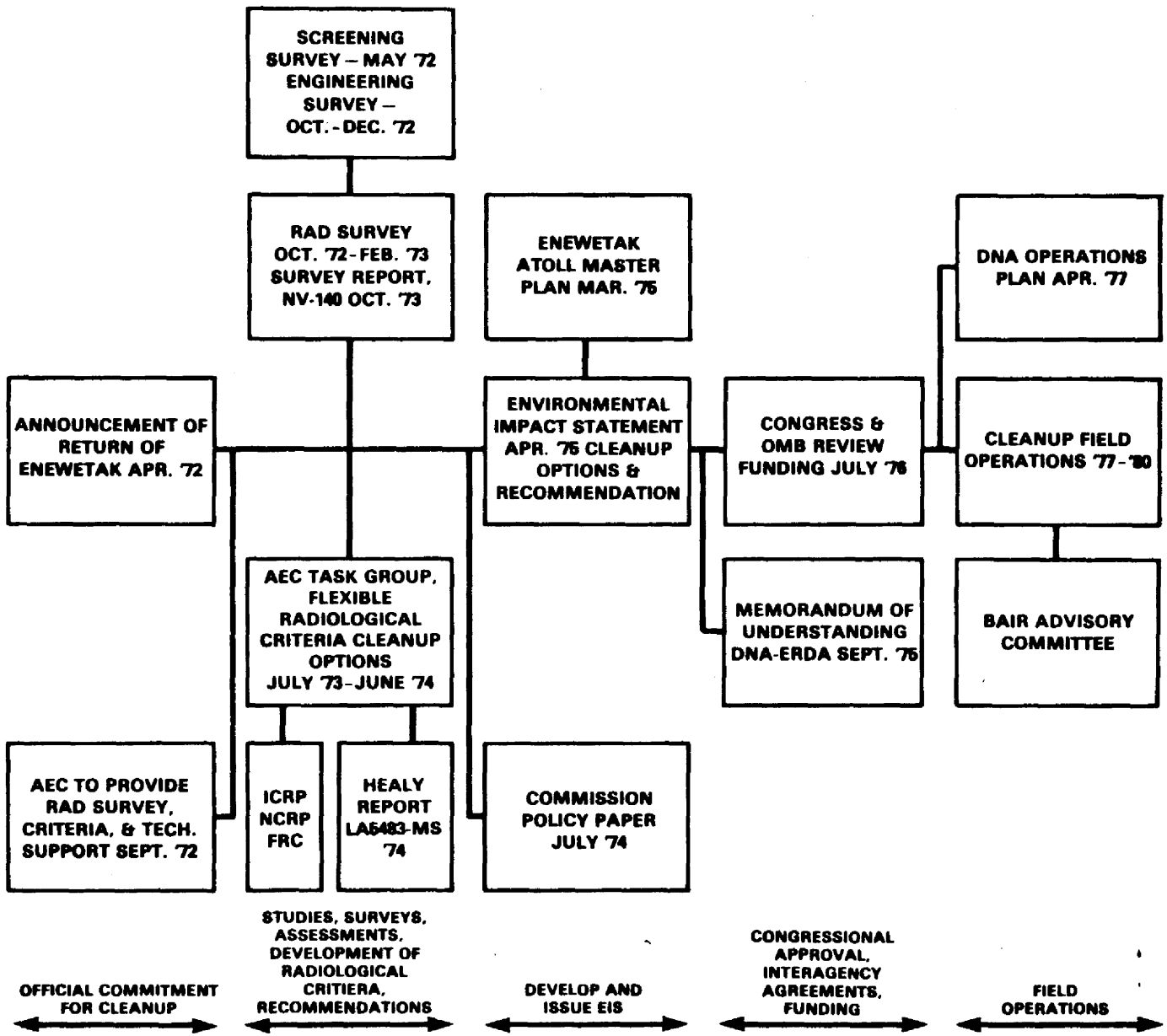
Certification of Completion

Followup Radiological Monitoring After Cleanup

DOI — Rehabilitation

Resettlement

ENEWETAK ATOLL CLEANUP — SEQUENCE OF EVENTS



AEC TASK GROUP ON RECOMMENDATIONS FOR CLEANUP AND REHABILITATION OF ENEWETAK ATOLL

Members:

T. McCraw	AEC/OS
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W. Nervik	LLL
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Liaison:

C. Palmiter	EPA
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ALTERNATIVES CONSIDERED

The Task Group Evaluated:

- **A Five by Six Matrix of Cleanup Degrees and Food Production Locations vs Living Patterns**
- **Five Cleanup Options Ranging from no Radiological Cleanup and no Return, to Extensive Soil Removal and Some Soil Replacement on Certain Northern Islands**
- **Six Options for Disposal of TRU Contaminated Soil and Scrap**

TASK GROUP POSITION ON RISK

"Most of the exposure to whole body, at Enewetak, and in fact to all organs will come from internal emitters. The shape of the dose-effect curve for exposure from internal emitters is most uncertain because of lack of experience and lack of confidence in extrapolation of high dose and dose rate effects into the very low dose and low dose rate situation. A lack of confidence in the statistic and risk estimate drawn therefrom has therefore led the Task Group to have serious reservations about their validity. The Task Group holds the opinion that such estimates cannot be used in any definitive way to draw conclusions on whether current radiation standards are too high or too low or as a basis for decision-making relative to resettlement of Enewetak Atoll."*

*Report by AEC Task Group on recommendations for cleanup and rehabilitation of Enewetak Atoll, June 18, 1974

TASK GROUP CONCLUSIONS

- Cleanup and Rehabilitation of Enewetak Atoll is Feasible
- Doses from Fission Products will Predominate
- The Degree of Cleanup of the Atoll Should be Dictated by the Requirement to Keep Exposure within Acceptable Standards
- National and International Standards Apply
- A Fraction of FRC's, RPG's for Individuals Should be Utilized to Evaluate Cleanup and Land Use Options Involving Fission Product Doses
- A Fraction of ICRP Standards for Lung for Individuals Should be Utilized to Develop Flexible Soil Cleanup Criteria Expressed as a Concentration of TRU Elements in Soil, i.e., pCi/gm*

TASK GROUP CONCLUSIONS (CONT'D)

- A Group of Experts Should Support Cleanup Operations with Advice on Application of Task Group Criteria to Specific Situations

- Land Use Restrictions, as Opposed to Soil Removal, are the Recommended Method for Controlling Exposure from Fission Products

- Removal and Disposal of Soil, or a Permanent Quarantive, are the Only Effective Measure Against Soil TRU Concentrations Exceeding Task Group Criteria

*The Task Group believed that site-specific criteria could be developed on a case-by-case basis using conservative assumptions and a safety factor, but that biological and environmental information is not adequate to establish general cleanup guidance.

TASK GROUP JUDGEMENTS AND RECOMMENDATIONS

"The Task Group approach for development of judgements and recommendations for the radiological cleanup and rehabilitation of Enewetak was to consider a number of alternatives for exposure reduction that may be feasible. Basically the procedure involved four steps."

- **Assessment of doses for current conditions**
- **Assessment of dose reductions by modifying the diet**
- **Assessment of dose reductions by removing contaminated soil**
- **Comparison of dose assessment matrices with Task Group guidelines**

TASK GROUP CRITERIA AND THEIR CONTEXT

TRU IN SOIL

>400 pCi/g, Corrective Action Required
1,500 m Rem/yr, Lung (150 m Rad/yr)

<40 pCi/g, Corrective Action Not Required
150 m Rem/yr, Lung (15 m Rad/yr)

40 to 400 pCi/g, Corrective Action Determined on Case-by-Case Basis

FISSION PRODUCTS*

250 m Rem/yr, Whole Body and Bone Marrow

750 m Rem/yr, Thyroid

750 m Rem/yr, Bone

4,000 m Rem/30 yrs, Gonads

*50% of Federal Radiation Council (FRC) Radiation Protections Enider (RPG's) for Annual Doses for Individuals and 80% of the 30-year Criterion for a Population

ENEWETAK CLEANUP EIS

- Presents AEC Task Group Recommendations as Conservative Guidelines that are Necessary Because of Uncertainties in Exposure Predictions
- For TRU Contaminated Soil Removal Stresses Need for a Team of Experts to Advise on Cleanup Actions
- Presents Five Cases (Options) for Land Use and Degree of Cleanup and a Matrix Showing a Range of Alternatives Detailing Dose Reduction, Health Effects, Cost, and General Acceptability
- Recommends Case 3 as Offering the Best Combination of Features

EPA DOSE LIMITS AND THEIR CONTEXT

1 Millirad Per Year to Lung*

3 Millirad Per Year to Bone*

".....while the recommendations are expressed in terms of numerical limits.....these are not to be interpreted as absolute values which must be met in every instance. Rather, Federal Radiation Guidance relies on the judgement of the implementing agency, and only specifies that the general objectives are to be met and deviations must be justified."

"Suggestions that higher dose rate limits should be used were rejected because the Agency had shown that the proposed limits were reasonable and achievable."

*Risk is less than 10^{-6} per year to critical segment of population.

GUIDANCE RECOMMENDATIONS (REVISED)

In order to assure the protection of persons in the general population by limiting the radiation doses that an individual in a critical segment of the population may receive from concentrations of transuranium elements present above average background levels in the general environment, the following recommendations shall apply for the guidance of Federal agencies:

1. Dose rates to persons in the general population for continuing exposure to transuranium elements should not exceed the recommendations provided in Federal Radiation Guidance No. 1, and reasonable efforts should be made to keep all exposures as low as reasonably achievable.

2. Contamination levels in the general environment should be limited to assure that the annual alpha radiation dose rate to members of the critical segment of the exposed population as the result of exposure to transuranium elements not exceed either:

   a. 1 millirad per year to the pulmonary lung, or
   b. 3 millirad per year to the bone or 40 millirad per year to the bone surfaces.

3. For newly contaminated areas, the Federal agency responsible for implementation of these recommendations should take immediate action to minimize both the residual levels of transuranium elements in the general environment and the radiation exposure of the general public. Determination and implementation of further appropriate measures, to ensure that projected dose rates to persons in the general population are as low as reasonably achievable and in full compliance with the above recommendations, should begin as promptly as possible and should be completed within a reasonable period of time.

4. The recommendations are to be used only as radiation protection guidance for presently existing cases of environmental contamination by transuranium elements and for possible future cases of environmental contamination from unplanned releases of transuranium elements. Federal agencies are not to use them as limits for planned releases of transuranium elements into the general environment.

5. Remedial actions for contaminated sites should be planned to provide maximum protection of the public health at reasonable cost, and should be implemented with the objective of minimizing adverse impacts on the environment.

6. The relationship between the projected dose rates to persons in a "critical segment of the population" and the ambient concentration of transuranium elements in air, soil and food is to be determined on a site-specific basis, taking into account all possible environmental pathways. For purposes only of eliminating certain lands from further more detailed evaluation, a soil "screening level" of 0.2 uCi/m^2 of alpha-emitting transuranium elements, for samples collected at the surface to a depth of 1 cm and for particle sizes less than 2 mm, may be used under most circumstances. Areas which do not exceed the "screening level" generally may be considered in compliance with the recommendations; those that exceed it would require further evaluation to determine the actual dose rates to exposed persons. The "screening level" is not to be used by Federal agencies as a soil concentration limit for purposes of implementing these recommendations.

DOSE COMPARISONS

EPA Dose Limit is:

$\frac{1}{15}$ **Enewetak Level where No Action Required**

$\frac{1}{150}$ **Enewetak Level where Action Required**

COMPARISON OF MAJOR FEATURES

AEC Task Group	EPA Draft
Site-specific Soil Criteria Recommendations Developed with Knowledge of Rad Survey Data Base	General Criteria to be Applied to Current Situations or Future Accidents on Site-specific Basis
Conservative Application of Existing Radiation Standards	Selection of 10^{-6} Risk, Derivation of Associated Doses Expressed as Limits not to Interpret as Absolute Values, Limits Shown by EPA to be Reasonable and Achievable.
Cleanup and Land Use Options Evaluated Against Dose and Soil TRU Concentration Criteria	Dose Limits to be Applied on Site-specific Basis, Explicit Guidance not Given in Order to Allow Flexibility, No Examples Cited
Anticipates Need for Full Spectrum of Cleanup Options in EIS and that Final Decisions on Cleanup to be Made at Higher Level Such as OMB and Congress	Recommendations Anticipate Decision Point for Flexible Implementation of Dose Limit Lies within Implementing Agency, Application Relies on Judgement of this Agency
No Equivalent	Screening Levels

DATA FOR ENJEBI ISLAND*

Maximum Annual Dose

m Rem/y

Bone Marrow	293/718**
Whole Body	245/540**

Transuranium Soil Contamination

pCi/g Top 15 cm

0.08 to 170

* AEC Task Group Report, June 19, 1974. Note: The Task Group recommended Enjebi not be resettled until test food crops showed acceptable low levels.

** Imports available/Imports unavailable average dose primary from Cs-137, Sn-90, and external radiation. TRU dose smaller by comparison.

DWK

Technical Evaluation of the Proposed "Screening" Level Using the Critical Organ Methodology and ICRP-26

J. W. Healy

Los Alamos National Laboratory

The EPA provides two screening levels, one for soil and one for air. We will discuss the soil screening level first then the air screening level and finally some perceived problems in the application of the EPA Guidance.

A mass loading approach is used to define the resuspension leading to inhalation. The EPA first refers to a study by Anspaugh in which concentration data for various radionuclides was compared with air concentrations. (Slide 1.) In this comparison he used an air concentration of 100 $\mu g/m^3$ for the dust. It may be noted that the agreement is good for resuspension data and covers a wide variety of areas. This method seems to be more a correlation using a fixed value of the mass loading in the air than a true mass loading approach. The EPA, however, seemed to be enamoured with some correction for particle size and derived the method for correcting for particle size in the soil and air given in the next slide (Slide 2) even though the Anspaugh correlation provided conservative results for the variety of areas included. It should be noted that the EPA approach requires considerable additional measurements on size fractions in the soil and air. Although they claim that representative areas could be used, they do not indicate how these are selected nor how many are required so that a true estimate of the increased costs cannot be made. However, it is important to note that this method has never been tested to prove its applicability to estimating resuspension. The assumptions used in calculating the soil

screening level are given in the next slide (Slide 3). They claim that the use of the dust storm data is appropriate because two other studies gave the same results.

In estimating doses to the lung and bone they used the organ weights in the next slide (Slide 4). The chief discrepancy is in the lung weight where the EPA tried to describe the tissues irradiated more closely than most. Of course, the new ICRP calculations used the dose to the bone surface assumed to weigh 120 grams rather than the average bone dose. These ICRP bone surface calculations are given in the next slide (Slide 5). It is of some interest that this calculation gives a factor of 10 over the average bone dose while the older calculation uses a factor of 5 as derived from early animal experiments.

The air screening level is given in the next slide (Slide 6). It is based on a particle size of 0.1 μm presumably because it is intended to apply to effluents from a facility. As such, it does not really apply to the resuspended component where particle sizes are typically on the order of a few micrometers. However, the difference between the EPA air value and that for several micrometers is only about a factor of two to three.

The EPA insists that the primary guidance of 1 mrad/yr to the lungs and 3 mrads/yr to the bone should take precedent. However, there are problems with this in terms of the data needed to predict the dose and the need to use models to determine the dose. The next slide (Slide 7) shows the distribution of plutonium in the bone and liver as obtained from the autopsy data of both public and workers. The wide distribution is apparent so that it will be

difficult to assure that any guidance is met for an individual or a group of individuals. The ICRP cautions on the use of their models for an individual because a number of uncertainties are present. All of this leads to the conclusion that it will be difficult to obtain a calculation that will be acceptable to all parties, particularly if opposition groups develop. For these reasons, it is my belief that the screening levels may play a large role in any future accident cleanup and may, in fact, become the de facto standard. If an accident occurs in a foreign country, there is little doubt in my mind that they will consider the screening level as the primary standard.

ANSPAUGH MASS LOADING PREDICTIONS - 100 $\mu g/M^3$ DUST

LOCATION, ETC.	RADIONUCLIDE	AIR CONCENTRATION PREDICTED	AIR CONCENTRATION MEASURED	RATIO
GMX SITE, USAEC NEVADA TEST SITE				
NE, 1971-1972	^{239}Pu	7200 aCi/M^3	6600 aCi/M^3	1.09
CZ, 1972, 2 WEEKS	^{239}Pu	120 fCi/M^3	23 fCi/M^3	5.22
LAWRENCE LIVERMORE LABORATORY				
1971	^{238}U	150 pg/M^3	52 pg/M^3	2.88
1972	^{238}U	150 pg/M^3	100 pg/M^3	1.50
1973	^{238}U	150 pg/M^3	86 pg/M^3	1.74
1973	^{40}K	1000 aCi/M^3	980 aCi/M^3	1.02
ARGONNE NATIONAL LABORATORY				
1972	^{232}Th	320 pg/M^3	240 pg/M^3	1.33
1972	^{NAT}U	215 pg/M^3	170 pg/M^3	1.26
SUTTON, ENGLAND				
1967-1968	^{NAT}U	110 pg/M^3	62 pg/M^3	1.77

EPA "ENRICHMENT FACTOR"

$$C \simeq AML \times SC \times \Sigma F_I G_I$$

AML - AIR MASS LOADING

SC - SOIL CONCENTRATION

F_I - FRACT. AIRBORNE MASS IN EACH SIZE INCREMENT

G_I - RATIO OF TOTAL ACTIVITY IN EACH SOIL PARTICLE SIZE INCREMENT TO FRACTION OF TOTAL MASS WITHIN THE INCREMENT.

SOIL SCREENING LEVEL ASSUMPTIONS

1. MASS LOADING - $100\,\mu g/m^3$

2. PARTICLE SIZE DISTRIBUTION IN AIR
   - CHEPIL DATA FROM DUST STORMS

3. SOIL ENRICHMENT - ROCKY FLATS DATA
   ($\Sigma F_I G_I = 1.06 - 2.34$)

4. INFINITE AREA

5. NO RESTRICTIONS ON LAND USE

6. CONC. $\approx$ 1 MRAD/YR $\simeq 2.6 \times 10^{-15}$ Ci/m^3

ORGAN WEIGHTS

LUNG

EPA	530 g
ICRP-2	1000 g
ICRP-30	1000 g

(PUL, LYMPH, TB CONTENTS)

BONES

EPA	5000 g
ICRP-2	7000 g
ICRP-30	5000 g

(BONE SURFACES - 120 g)

BONE WEIGHT 5000 g

BONE SURFACE WEIGHT 120

25% ENERGY ABSORBED IN SURFACE

$$\text{RATIO } \frac{\text{BONE SURFACE DOSE}}{\text{BONE DOSE}} = \frac{120}{0.25 \times 5000} = 0.096 \approx 0.1$$

ICRP-2 N FACTOR = 5

RATIO = 0.2

AIR SCREENING LEVEL

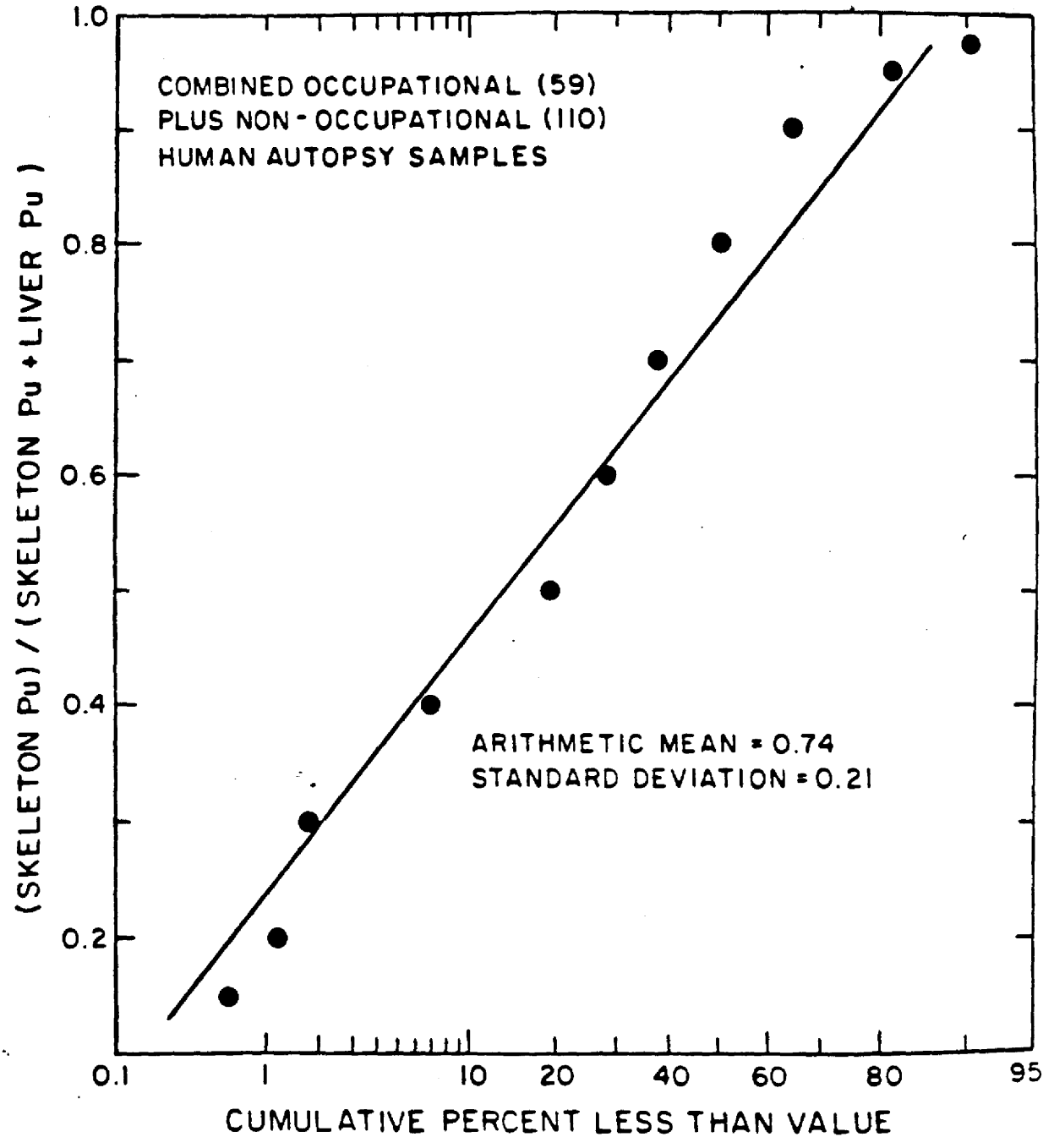
ASSUMPTION

0.1 μM AMAD PARTICLE

LEVEL

1 fCi/m^3 (10^{-15} Ci/m^3)

ICRP-2 (PUBLIC) 6×10^{-14} Ci/m^3


COMBINED OCCUPATIONAL (59)
PLUS NON-OCCUPATIONAL (110)
HUMAN AUTOPSY SAMPLES
ARITHMETIC MEAN = 0.74
STANDARD DEVIATION = 0.21
(SKELETON Pu) / (SKELETON Pu + LIVER Pu)
1.0
0.8
0.6
0.4
0.2
0.1
1
10
20
40
60
80
95
CUMULATIVE PERCENT LESS THAN VALUE

510

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JAN 13 1984

T. D. Pflaum, HQ, Chief of Envir., Safety & Health (DP-226.1) GTN

COMMENTS ON EPA-PROPOSED "DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT"

The Nevada Operations Office (NV) submitted comments on the subject dose limits via our letter, Church to Pflaum, dated October 19, 1983. For convenience a copy is enclosed.

Although much can be said on this subject I wish to take this opportunity to discuss the following points.

1. EPA Objective of Reducing Risk to 10^{-6} Ultra Conservative

EPA states that they believe it appropriate to limit the risk for a cancer fatality from a single radiation source to a person in the population to 10^{-6} per year. We contend that the proposed standards in reality impose a risk limit much more conservative and could be as low as 10^{-8}.

There is considerable uncertainty in developing risk estimates from observable health effect data, and there is considerable uncertainty in estimating environmental organ doses through pathway modeling because of the assumptions made and variability of individuals (i.e., lifestyles, ingestion, uptake and growth rates, etc.).

If the maximizing assumptions are always taken, the predicted risk to a population for leaving a contaminated area undisturbed could be several orders of magnitude less than the real risk encountered during cleanup operations.

One risk not considered by EPA is the risk benefit to personnel involved in the cleanup which approximates 10^{-4}. The criteria and consideration for cleanups should include the risk of death and injury resulting from the cleanup itself.

During the course of the Enewetak cleanup, two men died in work-related accidents; six others died from a variety of causes. It is well documented that construction activities have higher fatality rates than most industries.

The following table summarizes some selected fatality rates and risks.

Activity	Fatality Rate*	Risk
All industries (1976)	14	1.4×10^{-4}
Construction (1976)	57	5.7×10^{-4}
At work (1980) State of Nevada	4.9	4.9×10^{-5}
DOE & Contractors (1978-82 average)	5.6	5.6×10^{-5}
NTS (1965-1981 average)	27	2.7×10^{-4}
Enewetak cleanup	70	7.0×10^{-4}

*Per 100,000 worker-years.

Because of the great variability in the data, and the requirement to interpolate and extrapolate, it is essential that a careful uncertainty analysis be made by EPA. This analysis is necessary to ensure confidence that the risk of cleanup does not exceed the 10^{-8} risk from leaving the contamination undisturbed; which may be as low as 10^{-8} or lower.

2. Imaginary Versus Real Deaths!

The models used to assess the health effects (i.e. radiation-induced cancer fatalities) on the Enewetak people during the planning phase estimated $\leq$ 3 health effects (cancer deaths) over 30 years with no cleanup and no restrictions on island or food usage.

An analysis of the total radiation dose to the returning people of Enewetak after the cleanup leads to the conclusion that there might be an additional 0.026 deaths in 30 years from cancer caused by radiation. This is compared to the two persons who died in course of the three-year cleanup.

The uncertainty which is inherent in cancer-risk estimates is graphically illustrated in Table V-4, page 147 in the 1980 BEIR report in which the expected number from continuous exposure of one rad per year to a population of 1,000,000 ranges from zero to 568.

The risk estimates of cancer deaths as required by the proposed EPA standard (maximizing risk estimates) give hypothetical, or imaginary deaths as compared to the real deaths which do occur in construction projects. The fact is that no increase in cancer rate has been, nor can be, identified at the dose levels comparable to background radiation levels.

Therefore, until the technology is developed to perform TRU cleanups where workers do not take substantially higher risks (which are real) to achieve a condition where the risks (which are hypothetical) are substantially lower than daily risks, guidance should be limited to reflect the greatest savings of life.

The Enewetak cleanup, which was designed to conform with the proposed EPA guidance is the epitome of the above discussion. According to risk analyses published in the planning documents, the islands could have been turned over to the people without a radiological TRU cleanup and saved lives. Ultraconservatism costs more than just time and dollars, it can cost real lives.

3. Cost Versus Benefit

Reasonable alternatives should be evaluated when decisions are made affecting the expenditure of resources. The radiological cleanup at Enewetak cost approximately $100 million and resulted in the potential of averting less than one cancer death from radiation in 30 years in the Enewetak population. How many premature deaths from disease and illness might have been averted in the Enewetak population by directing $100 million into improving health care knowledge, facilities, and capability? We may not have the information available to answer this question, but it is not unreasonable to consider this alternative. Similar logic should be applied in considering any radiological cleanup.

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OCT 19 1983

T. D. Pflaum, HQ, Chief of Envir., Safety & Health (DP-226.1) GTN
ATTN: R. H. Wank, HQ (DP-226.1) GTN

COMMENTS ON EPA-PROPOSED "DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT"

The Nevada Operations Office (NV), Health Physics Division (HPD), has obtained comments from the scientific laboratories, appropriate contractors, and staff on the subject document. A brief summary of those comments is provided below.

Because the maximum measured Pu concentration outside of the Nellis Bombing and Gunnery Range (observed during sampling approximately 10 years ago) is less than a half of the screening level, we believe the recommendations of the report probably will not impact significantly on NTS activities. Even so, the recommendations are not considered reasonable. However, because there is great variability between locations of samples and aliquots of the same soil sample (i.e., the hot particle problem), it is conceivable that someone could find off-site locations which would exceed the screening level. In addition, we have substantial areas contaminated above these limits on the Nellis range, but off the NTS, as well as substantial areas above the limits on the NTS. It appears that the real basis for these recommendations is "as low as can be tolerated without heavily consuming agency budgets," and is not based on any cost-benefit analysis. Any number of approaches could be used to assign a value to a life and thereby calculate a dollar value for dose reduction which could be balanced against cleanup costs. Instead, the report lists an absolute risk of 10^{-5} to 10^{-6} deaths per year as reasonable and then turns around and selects 10^{-6} (not 5×10^{-6} or 3×10^{-6}) without considering cost or benefit.

The guidance levels of 1 mR/yr to the pulmonary lung, 3 mR/yr to bone, or 40 mR/yr to the bone surface are not directly measurable quantities and therefore are of little practical use. Complex and questionable calculations would be required to transform measured contamination levels to doses. Any such calculations contain judgmental factors concerning dietary habits and personal preferences which could be challenged and the responsible agency could find itself in endless court battles regarding compliance. The only certain way to assure compliance would be prohibitive for routine operations.

Costs of cleanup, if it should be required, are estimated in the EPA document at upwards of $40,000 per acre, which exceeds the intrinsic land value around the NTS by more than ten times. This kind of cost relative to the estimated potential benefit of much less than one one-millionth of a "health effect" seems grossly excessive.

We would be very happy to work with Military Application in developing any further response to EPA on this matter.

Original Signed By
BRUCE W. CHURCH

Bruce W. Church, Director
Health Physics Division

HPD-ER:FM

cc:
T. F. McCraw, HQ (SP-32) GTN

Briefing on Cleanup of TRU Contaminated Soil

ENEWETAK CLEANUP PROJECT

Jan. 17, 1984

Bruce W. Church
Nevada Operations Office

- UNITED STATES BORROWED ENEWETAK ATOLL IN 1947 FOR NUCLEAR TESTING.
- NATIVE POPULATION DISPLACED TO SMALLER ATOLL.
- TESTING PROGRAM:
  - DESTROYED VEGETATION VITAL TO SUSTENANCE OF NATIVE INHABITANTS.
  - GENERATED THOUSANDS OF TONS OF DEBRIS WHICH WAS LEFT IN PLACE.
  - INTRODUCED RADIOACTIVE CONTAMINATION TO NORTHERN HALF OF ATOLL.
- UNITED STATES PROMISED IN 1972 RETURN OF THE ATOLL TO DISPLACED OWNERS.
- CLEANUP AND REHABILITATION WAS ACCOMPLISHED DURING 1977-80.
- ENTIRE PROJECT INVOLVED:
  - REMOVAL OF DEBRIS FROM ISLANDS.
  - CONSOLIDATION OF SOIL CONTAMINATED ABOVE CLEANUP CRITERIA.
  - RESTORATION OF VEGETATION FOR AGRICULTURAL PURPOSES.
  - CONSTRUCTION OF 116 NEW DWELLINGS AND TWO COMMUNITY CENTERS.
- DNA WAS RESPONSIBLE FOR CLEANUP WITH DOE IN ADVISORY AND SUPPORT ROLES. CLEANUP WORK DONE BY MILITARY PERSONNEL.

TABLE 5-6: ESTIMATED 30-YEAR INTEGRATED DOSES TO INDIVIDUALS[a] (REM)

HABITATION PLANS / CLEANUP ACTIONS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED[b]	C LIVE ON SOUTHERN ISLANDS; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS[c]	D LIVE ON SOUTHERN ISLANDS; VISIT ON SOUTHERN ISLANDS; USE FOOD GROWN ON ONLY SOUTHERN ISLANDS.
I. NO CLEANUP.	CASE 1 WB = 6 B = 60 L = 0.1	WB = 3 (6 ON ENJEBI) B = 10 (20 ON ENJEBI) L = 0.06 (0.1 ON ENJEBI)	WB = 1 B = 5 L = 0.04	CASE 2 WB = BACKGROUND[d] B = BACKGROUND L = BACKGROUND
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	WB = 6 B = 60 L = BACKGROUND	CASE 4 WB = 3 (6 ON ENJEBI) B = 10 (20 ON ENJEBI) L = BACKGROUND	CASE 3 WB = 1 B = 5 L = BACKGROUND	SAME AS CASE 2
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	CASE 5 WB = BACKGROUND B = BACKGROUND L = BACKGROUND	HABITATION RESTRICTION NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5

LEGEND

WB = WHOLE BODY DOSE
B = BONE DOSE
L = LUNG DOSE

[a] DOSES CALCULATED TO ONE SIGNIFICANT FIGURE BASED ON DATA FROM NVO-140 AND AEC TASK GROUP REPORT.

[b] DOSES CALCULATED FROM AN ASSUMED POPULATION DISTRIBUTION OF 44 PERCENT OF THE ATOLL POPULATION ON ENJEBI AND THE BALANCE OF THE POPULATION ON THE SOUTHERN ISLANDS.

[c] DOSES CALCULATED FROM ISLAND AREA WEIGHTED DISTRIBUTION OF COCONUTS: 40 PERCENT FROM MIJIKADREK TO BILLAE AND BIKEN, AND 60 PERCENT FROM THE SOUTHERN ISLANDS.

[d] BACKGROUND MEANS THAT THE DOSE IS ESTIMATED TO BE NO GREATER THAN WOULD BE ABSORBED FROM NATURALLY OCCURRING SOURCES, EITHER EXTERNALLY OR INTERNALLY. ESTIMATES FOR BACKGROUND 30-YEAR DOSES ARE: WB = 1 rem, B = 4 rem, AND L = 0.0009 rem.

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975 VOL I.

TABLE 5-7: ESTIMATED MAXIMUM ANNUAL DOSES TO INDIVIDUALS[a] (REM)

HABITATION PLANS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED.	C LIVE ON SOUTHERN ISLANDS; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS	D LIVE ON SOUTHERN ISLANDS; VISIT ON SOUTHERN ISLANDS; USE FOOD GROWN ON ONLY SOUTHERN ISLANDS.
I. NO CLEANUP.	CASE 1 WB = 0.3 B = 2 L = 0.004	WB = 0.1 (0.3 ON ENJEBI) B = 0.5 (1 ON ENJEBI) L = 0.002 (0.004 ON ENJEBI)	WB = 0.05 B = 0.2 L = 0.001	CASE 2 WB BACKGROUND[b] B BACKGROUND L BACKGROUND
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	WB = 0.3 B = 2 L = BACKGROUND	CASE 4 WB = 0.1 (0.3 ON ENJEBI) B = 0.5 (1 ON ENJEBI) L = BACKGROUND	CASE 3 WB = 0.05 B = 0.2 L = BACKGROUND	SAME AS CASE 2
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	CASE 5 WB = BACKGROUND B = BACKGROUND L = BACKGROUND	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5

LEGEND

WB = WHOLE BODY DOSE
B = BONE DOSE
L = LUNG DOSE

[a] DOSES CALCULATED TO ONE SIGNIFICANT FIGURE BASED ON DATA FROM NVO-140 AND AEC TASK GROUP REPORT. AEC GUIDELINES FOR MAXIMUM ANNUAL DOSE ARE: WB = 0.25, B = 0.75. SEE TABLE 5-6 FOR ASSUMPTIONS USED IN DOSE CALCULATIONS FOR COLUMNS B AND C.

[b] BACKGROUND MEANS THAT THE DOSE IS ESTIMATED TO BE NO GREATER THAN WOULD BE ABSORBED FROM NATURALLY OCCURRING SOURCES, EITHER EXTERNALLY OR INTERNALLY. ESTIMATES FOR ANNUAL BACKGROUND DOSE ARE: WB = 0.04 rem, B = 0.1 rem, and L = 3×10^{-4} rem.

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975, VOL. I.

TABLE 5-8: RATIOS OF ESTIMATED MAXIMUM ANNUAL DOSES TO RECOMMENDED ANNUAL DOSE GUIDELINES FOR INDIVIDUALS[a]

HABITATION PLANS / CLEANUP ACTIONS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED[b]	C LIVE ON SOUTHERN ISLANDS; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS	D LIVE ON SOUTHERN ISLANDS; VISIT ON SOUTHERN ISLANDS; USE FOOD GROWN ON ONLY SOUTHERN ISLANDS
I. NO CLEANUP.	CASE 1 RWB = 1.2 RB = 2.7	RWB = 0.4 (1.2 ON ENJEBI) RB = 0.7 (1.3 ON ENJEBI)	RWB = 0.2 RB = 0.3	CASE 2 b
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	RWB = 1.2 RB = 2.7	CASE 4 RWB = 0.4 (1.2 ON ENJEBI) RB = 0.7 (1.3 ON ENJEBI)	CASE 3 RWB = 0.2 RB = 0.3	b
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	CASE 5 b	b	b	b

LEGEND

RWB = RATIO OF MAXIMUM ANNUAL DOSE TO RECOMMENDED LIMIT FOR WHOLE BODY DOSE (0.25 rem/yr).
RB = RATIO OF MAXIMUM ANNUAL DOSE TO RECOMMENDED LIMIT FOR BONE DOSE (0.75 rem/yr).

[a] APPLICABLE TO AVERAGE INDIVIDUAL ON ENTIRE ATOLL, EXCEPT WHERE NOTED. PEOPLE SHOULD NOT RETURN IF THE RATIO IS GREATER THAN UNITY.

[b] THE RATIOS ARE EFFECTIVELY LESS THAN OR EQUAL TO THE RATIO OF BACKGROUND DOSE TO RECOMMENDED GUIDELINE WHERE RWB≤0.16 AND RB≤0.13.

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975, VOL. I.

TABLE 5-12: ESTIMATED NUMBER OF HEALTH EFFECTS[a] FROM 30-YEAR DOSES TO POPULATION OF 1,000

HABITATION PLANS / CLEANUP ACTIONS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED.	C LIVE ON SOUTHERN ISLANDS; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS	D LIVE ON SOUTHERN ISLANDS; VISIT ON SOUTHERN ISLANDS; USE FOOD GROWN ON ONLY SOUTHERN ISLANDS.
I. NO CLEANUP.	H(WB)≤ 0.3 TO 1 H(B)≤ 2 H(L)≤ 0.003 H(TOTAL)≤ 3	H(WB)≤ 0.2 TO 0.5 H(B)≤ 0.3 H(L)≤ 0.002 H(TOTAL)≤ 0.8	H(WB)≤ 0.05 TO 0.2 H(B)≤ 0.1 H(L)≤ 0.001 H(TOTAL)≤ 0.3	CASE 2 BACKGROUND[b]
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	H(WB)≤ 0.3 TO 1 H(B)≤ 2 H(L)≤ BACKGROUND[b] H(TOTAL)≤ 3	CASE 4 H(WB)≤ 0.2 TO 0.5 H(B)≤ 0.3 H(L)≤ BACKGROUND[b] H(TOTAL)≤ 0.8	CASE 3 H(WB)< 0.05 TO 0.2 H(B)< 0.1 H(L)< BACKGROUND H(TOTAL)< 0.3	SAME AS CASE 2
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	BACKGROUND[b]	SAME AS CASE 5	SAME AS CASE 5	SAME AS CASE 5

LEGEND

H(WB) = MAXIMUM EXPECTED WHOLE BODY HEALTH EFFECTS
H(B) = MAXIMUM EXPECTED BONE HEALTH EFFECTS
H(L) = MAXIMUM EXPECTED LUNG HEALTH EFFECTS
H(TOTAL) = MAXIMUM EXPECTED TOTAL HEALTH EFFECTS

[a] HEALTH EFFECTS MEAN SOMATIC CANCER INDUCTIONS THAT RESULT IN FATALITY, CALCULATED TO ONE SIGNIFICANT FIGURE. THE NUMBER OF FATAL AND NONFATAL CASES IS ESTIMATED TO BE TWICE THE NUMBER OF FATAL CASES. SEE TABLE 5-1 FOR DOSE RESPONSE RATES USED TO ESTIMATE HEALTH EFFECTS. THESE EFFECTS WOULD BE IN ADDITION TO THOSE FROM BACKGROUND RADIATION.

[b] HEALTH EFFECTS FOR 30-YEAR BACKGROUND DOSES OF WB = 1 rem, B = 4 rem, and L = 0.0009 rem ARE: H(WB)≤ 0.05 TO 0.2
H(B)≤ 0.1
H(L)≤ 0.00002
H(TOTAL)≤ 0.3

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975, VOL. I.

DEVELOPMENT OF CLEANUP CRITERIA

1974 TASK GROUP REPORT

DOSE BASED ON FEDERAL RADIATION COUNCIL LIMITS
— TO INDIVIDUALS, 50 PERCENT OF FRC ANNUAL RATE LIMIT
— TO POPULATION, 80 PERCENT OF FRC 30-YEAR GENETIC LIMIT

RESULTING GUIDANCE APPLICABLE TO PLUTONIUM CONCENTRATION IN SOIL:
— OVER 400 pCi/g, REMOVE SOIL
— UNDER 40 pCi/g, LEAVE IN PLACE
— BETWEEN 40 AND 400, CASE-BY-CASE DECISION

1977 SERIES OF FALL MEETINGS BETWEEN DOE AND DNA

— CRITERIA TO INCLUDE ALL TRANSURANICS, NOT JUST PLUTONIUM
— CLEANUP CRITERIA LINKED TO INTENDED ISLAND USE
— AGRICULTURAL ISLAND TO MEET CRITERIA OF 100 pCi/g
— CRITERIA INTENDED TO COMPLY WITH EPA PROPOSED GUIDELINES

DEVELOPMENT OF CLEANUP CRITERIA (CON'T)

1978 SERIES OF SPRING MEETINGS BETWEEN DOE AND DNA

PRELIMINARY DOSE ESTIMATES BY LLL INDICATED CLEANUP SHOULD BE ACCOMPLISHED TO THE FOLLOWING LEVELS TO MEET PROPOSED EPA CRITERIA:

- RESIDENCE ISLAND 10 pCi/g
- AGRICULTURAL ISLAND 20 pCi/g
- FOOD GATHERING ISLAND 40 pCi/g

1978 BAIR COMMITTEE RECOMMENDATIONS:

1st PRIORITY - CLEANUP TRANSURANICS ON RESIDENTIAL ISLANDS TO AVERAGE LESS THAN 40 pCi/g FOR EACH QUARTER-HECTARE AREA

2nd PRIORITY - CLEAN TRANSURANICS ON AGRICULTURAL ISLANDS TO AVERAGE LESS THAN 80 pCi/g FOR EACH HALF-HECTARE AREA

3rd PRIORITY - CLEAN TRANSURANICS ON FOOD GATHERING ISLANDS TO AVERAGE LESS THAN 160 pCi/g FOR EACH HALF-HECTARE AREA

1978 MAY DECISION CONFERENCE AT DNA/HQ

DIRECTOR, DNA, AGREED TO ACCEPT THE CRITERIA RECOMMENDED BY THE BAIR COMMITTEE.

IN ALL OF THE ABOVE, DIFFERENT CRITERIA FOR ISLANDS OF DIFFERENT INTENDED USE WAS ABOVE ON ESTIMATES OF THE TIME SPENT ON EACH ISLAND.

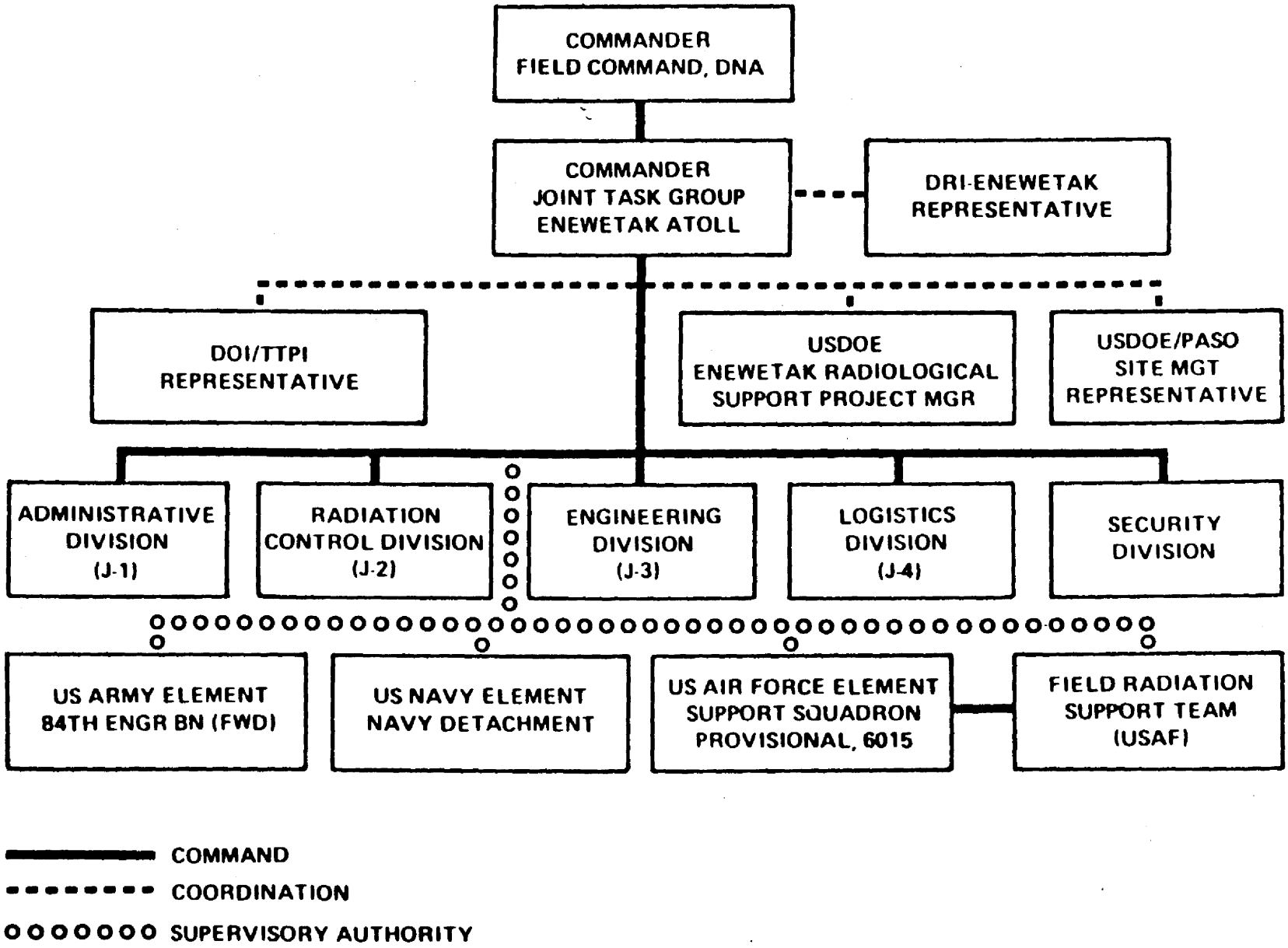


FIGURE 3-12. JOINT TASK GROUP ORGANIZATION.

TYPICAL ATOLL POPULATION DURING ENEWETAK CLEANUP

U.S. ARMY	270
NAVY	220
AIR FORCE	75
DOE & CONTRACTORS	130
DOE/TTPI	100
DNA/JTG	25
VISITORS/MARSHALLESE	75
TOTAL	900

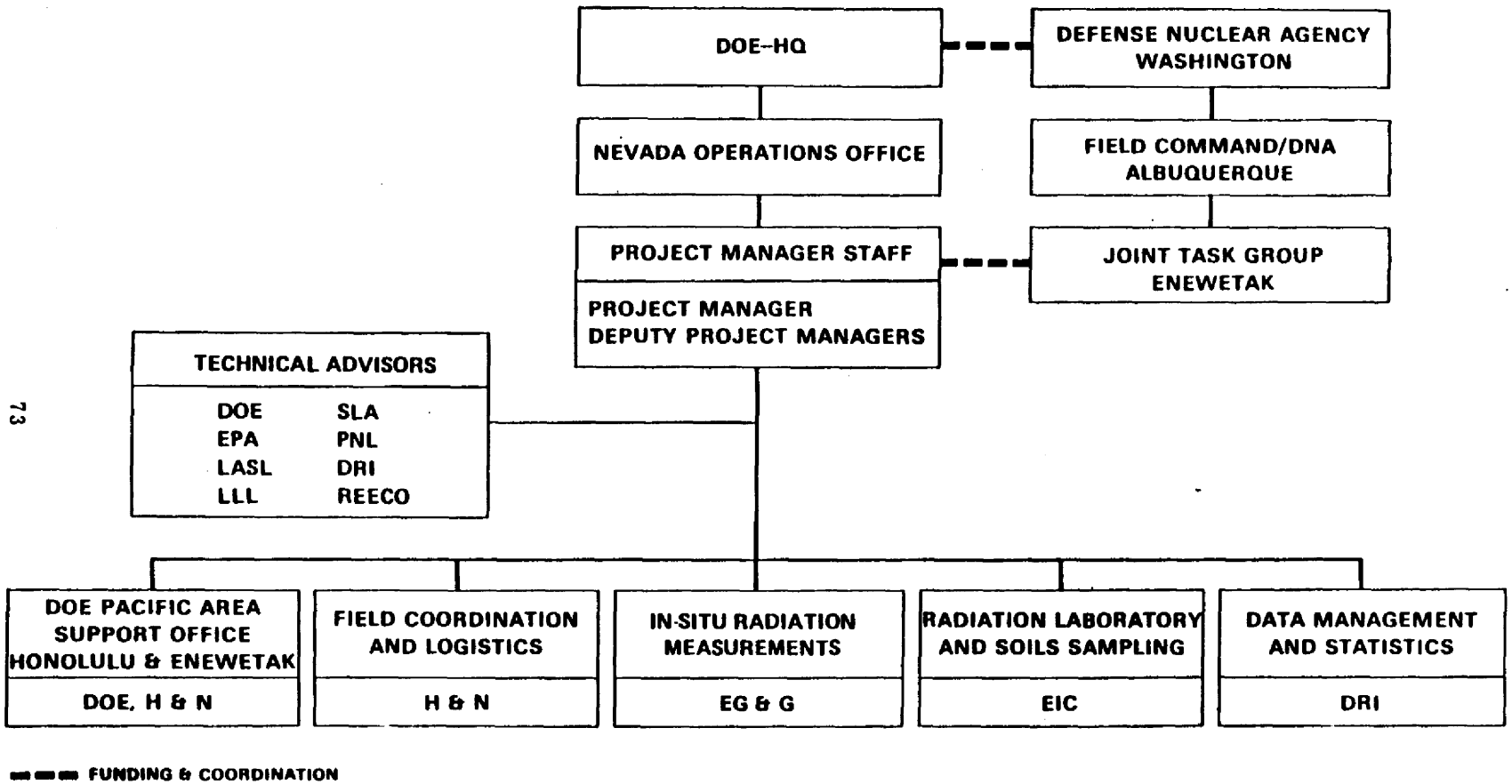


FIGURE 2-5
ENEWETAK RADIOLOGICAL SUPPORT PROJECT (ERSP)

DOE/ERSP ON-ISLAND STAFF (NORMAL OPERATIONS)

MANAGEMENT	
PROJECT MANAGER OR DEPUTY	1
TECHNICAL ADVISOR	1
STAFF ASSISTANT	1
IN-SITU MEASUREMENT SYSTEMS	
SCIENTIST	1
TECHNICIAN	2
DRIVER/MECHANIC (AIR FORCE)	2
RADIATION/SOILS LABORATORY	
MANAGER	1
CHEMIST	1
ELECTRONIC TECHNICIAN	1
FIELD SUPERVISOR	1
SOIL SAMPLER (NAVY)	7
STATISTICS/DATA MANAGEMENT	
STATISTICIAN	1
DATA TECH (NAVY)	1
TOTAL	21

VARIATIONS IN FIELD EXPERIENCE AT ENEWETAK

PRE- AND POST-CLEANUP DATA ARE NOT ABSOLUTELY COMPARABLE FOR VARIOUS REASONS, BUT REPRESENT THE BEST ESTIMATES AVAILABLE DURING CLEANUP.

IRENE CLEANUP WAS DIRECTED TOWARD REMOVAL OF SUBSURFACE POCKETS OF TRU ABOVE CRITERIA, RATHER THAN REMOVAL TO MEET SURFACE CRITERIA. THERE ARE NO COMPARABLE PRE- POST TRU DATA.

JANET CLEANUP WAS CONDUCTED IN 1/4 ha BLOCKS IN "WORST FIRST" ORDER WHERE EVER THE BLOCKS OCCURED.

PEARL CLEANUP WAS DONE AS (ESSENTIALLY) ONE LARGE BLOCK WITH 2 SMALL AREAS REQUIRING A SECOND "LIFT".

SALLY CLEANUP CONSISTED OF 3 SMALL AREAS WHERE AS MANY AS 5 ITERATIONS OR "LIFTS" WERE REQUIRED; ESSENTIALLY A COMBINATION OF SURFACE AND SUBSURFACE EXCISION.

YVONNE CLEANUP WAS QUITE COMPLEX AND NO COMPARABLE DATA EXIST FOR VALID PRE- AND POST-CLEANUP COMPARISON.

CLEANUP OF TRANSURANICS AT ENEWETAK ATOLL

Northern Islands*	Code	Approx. Island Area, ha	Radiological Cleanup Project			Final Surface Area Exceeding	
			Soil Excision Area, ha	Excised Soil**, m^3	Final Surface TRU pCi/g	Screening Level 20 pCi/g, ha	40pCi/g, ha
ALICE	FG	9			76	9	8.8
BELLE	FG	12			95	12	11.2
CLARA	A	3			40	3	0.6
DAISY	A	8.5			43	8.5	2.8
EDNA	R	4			33	4	--
EDNA'S DAU	FG	0.5			103	0.5	0.5
IRENE	A	18	0.6	3775	32	11	3.3
JANET	R	118	15.5	40525	20	36	4
KATE	R	6.5			20	3.5	0.4
LUCY	A	8			35	5.5	3
PERCY	R	0.8			6	--	--
MARY	R	5			19	1.5	0.1
MARY'S DAU	FG	0.5			54	0.5	0.3
NANCY	A	4.5			34	4	0.6
OLIVE	A	16.5			20	4	1
PEARL	A	22	9.7	11415	36	14	6.5
PEARL'S DAU	FG	0.5			123	0.5	0.5
RUBY	R	1.5			8	--	--
SALLY	R	40	1.8	8100***	8	4	0.4
SALLY'S CHILD	R	0.8			21	0.5	--
TILDA	R	21			7	--	--
URSULA	R	16			2	--	--
VERA	R	15.5			7	--	--
WILMA	R	6.5			3	--	--
SO. YVONNE	Q	15.5			8	3.5	0.2
NO. YVONNE	Q	21.5	5.0	8210	41	19.5	5.5
TOTALS		375.6	32.8	72025		145	49.7

Code: FG = Food Gathering; A = Agricultural; R = Residence; Q = Quarantined

*Northern Islands were more contaminated than Southern Islands, which had an average of less than 1 pCi TRU per gram of soil.

**Includes subsurface pockets excised to depths exceeding 1 meter.

***Does not include 7500 m^3 excised from subsurface repository to depth of 7 meters.

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

TRU = 238,239,240 Pu + 241 Am

ISLAND	% OF ISLAND CLEANED	TRU pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3			
JANET	13	26	20	-24
PEARL	44	72	36	-50
SALLY	4.5	11	8	-27

* TOP 15 cm.

RESULTS BY ISLAND FOR FISSION PRODUCTS

Island	^{137}Cs IN 0-15 cm SOIL SAMPLES 1979 Fission Product Data Base Program			^{90}Sr IN 0-15 cm SOIL SAMPLES 1979 Fission Product Data Base Program		
	No. of Locations Sampled	Range of Activity, all depths, (pCi/g)	0-15cm Mean (pCi/g)	No. of Locations Sampled	Range of Activity, all depths, (pCi/g)	0-15cm Mean (pCi/g)
Alice	26	<0.4 - 114	39.9	7	1.3 - 347	85.9
Belle	40	<0.4 - 204	61.0	11	3.5 - 339	107.4
Clara	8	0.3 - 105	22.4	4	1.4 - 243	42.8
Daisy	26	<0.4 - 34	6.8	8	1.9 - 144	34.8
Edna	5	<0.4 - 7	2.9	3	4.3 - 48	21.7
Irene	53	<0.4 - 54	6.1	15	0.6 - 136	31.0
Janet	364	<0.4 - 142	16.4	99	<0.1 - 244	31.9
Kate	18	<0.4 - 35	7.8	6	1.0 - 31	13.3
Lucy	22	<0.4 - 40	11.7	8	1.0 - 94	21.9
Percy	2	<0.4 - 2	0.6	2	2.0 - 7	5.4
Mary	12	<0.4 - 18	6.0	4	1.1 - 46	14.2
Mary's Dau.	3	<0.4 - 72	12.3	1	5.2 - 107	41.9
Nancy	11	<0.4 - 60	10.8	6	<0.15 - 82	20.1
Olive	50	<0.4 - 60	7.5	12	<0.12 - 83	16.2
Pearl	72	<0.4 - 43	7.2	17	0.4 - 38	11.4
Pearl's Dau.	2	<0.4 - 7	5.6	1	1.3 - 28	18.0
Ruby	3	1.1 - 11	2.0	1	5.5 - 9	5.8
Sally	137	<0.4 - 43	3.5	39	<0.10 - 25	4.4
Sally's Ch.	4	<0.4 - 13	6.9	4	1.0 - 60	16.7
Tilda	48	<0.4 - 20	3.2	15	<0.12 - 25	5.6
Ursula	15	<0.4 - 4	1.2	15	<0.08 - 70	3.0
Vera	48	<0.4 - 20	3.0	13	0.2 - 29	4.8
Wilma	17	<0.4 - 5	1.3	5	0.2 - 19	2.9
Yvonne+	14	<0.4 - 11	1.5	5	<0.13 - 5	1.1

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

CS—137

ISLAND	% OF ISLAND CLEANED	CS-137 pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3	10	6	-40
JANET	13	31	16	-48
PEARL	44	15	7	-53
SALLY	4.5	7	3.5	-50

*TOP 15 cm.

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

SR—90

ISLAND	% OF ISLAND CLEANED	SR-90 pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3	47	31	-33
JANET	13	69	32	-54
PEARL	44	28	11	-61
SALLY	4.5	12	4	-67

* TOP 15 cm.

ENEWETAK CLEANUP PROJECT COSTS (000)

DNA-MILCON	$18,177.4
DNA-BASE CAMP EXPANSION	1,362.8
DNA-OPERATION & MAINTENANCE	19,692.0
SERVICES-AIR FORCE	3,877.1
-ARMY	33,797.5
-NAVY	7,863.8
DOE-RADIOLOGICAL SUPPORT*	3,371.0
DOI-REHABILITATION	14,100.0
	$102,241.6

*AN ADDITIONAL $1.5 MILION DOE COST WAS REIMBURSED FROM DNA-MILCON FUNDS.

SOME COST RATIO APPROXIMATIONS

TOTAL COST OF CLEANUP AND REHABILITATION: $102,240,000.

COST PER:	UNITS	COST
HECTARE*	33	$3,100,000
ACRE*	81	1,262,000
CUBIC METER SOIL	79,500	1,285
CURIE	14.7	6,955,000
FATALITY	2	51,120,000
LIFE SAVED	0.025	4,089,664,000

*INCLUDES ONLY THAT AREA FROM WHICH SOIL WAS REMOVED.

CLEANUP YARDSTICKS

SOIL MOVED TO CACTUS CRATER, yd^3	104,097
TRU IN MOVED SOIL, CURIES	14.7
DEBRIS — UNCONTAMINATED - TO LAGOON, yd^3	122,810
— UNCONTAMINATED - TO SALVAGE, yd^3	54,500
— CONCRETE RUBBLE - SHORE PROTECTION, yd^3	76,340
— CONTAMINATED - TO CACTUS CRATER, yd^3	5,883
SOIL SAMPLES ARCHIVED	11,455
AIR SAMPLED, m^3	866,227
AIR FILTERS ANALYZED	5,204
GAMMA SPECTROMETRY - IN LAB	11,553
- IN-SITU	6,000 +
COCONUT TREES PLANTED	30,333
DOCUMENTATION GENERATED, LINEAR FT	200 +

FATALITIES DURING ENEWETAK RADIOLOGICAL CLEANUP

MILITARY

19 AUG 77*	USN WELDER, EXPLOSION WHILE WELDING ON LANDING CRAFT.
17 NOV 77	USA PVT, CARDIAC ARREST WHILE PLAYING BASKETBALL.
14 AUG 78*	USA NCO, CARDIAC ARREST WHILE PINNED BETWEEN D8 DOZER AND DUMP TRUCK.
29 DEC 78	USAF CPT, LOST WHILE SAILBOATING FOR RECREATION.
29 DEC 78	USA PFC, LOST WHILE SAILBOATING FOR RECREATION.
06 JAN 80	USA SPEC 4, ASPIRATION OF THE LUNGS ON HIS OWN VOMITUS, THEN SUFFOCATION.

* SATISFIES NATIONAL SAFETY COUNCIL CRITERIA FOR INCLUSION IN DATA TABLES FOR REPORTING ACCIDENT STATISTICS

DOE & CONTRACTORS

JUL 79	EIC FIELD SUPERVISOR, DEPARTED ATOLL FOLLOWING INCIDENCE OF CHEST PAINS, AND CHECKED INTO HOSPITAL IN HONOLULU, DIED SEVERAL DAYS LATER OF HEART PROBLEMS.
79	H&N BARBER, DIED IN HIS SLEEP OF NATURAL CAUSES. (?)

TOP CAUSES OF DEATH IN U.S. POPULATION, 1976

CAUSE	DEATH RATE*	EXPECTED DEATHS IN 30 YR IN POPULATION OF 500
ALL CAUSES	888	133
HEART DISEASE	336	50
CANCER	171	26
STROKE	91	14
ACCIDENTS	48	7

*DEATHS PER 100,000 POPULATION (FROM ACCIDENT FACTS, 1977)

WORK ACCIDENTS

INDUSTRY GROUP	WORKERS (000) [a]	DEATHS [a]	DEATH RATES [b] 1976	1981
ALL INDUSTRIES	87,800	12,500	14	12
TRADE	20,300	1,300	16	5
MANUF. & SERVICE	39,800	3,500	19	7
GOVERNMENT	14,900	1,700	11	10
TRANSP. & UTILITIES	4,800	1,500	31	31
AGRICULTURE	3,500	1,900	54	54
CONSTRUCTION	3,700	2,100	57	40
MINING	800	500	63	55
ENEWETAK CLEANUP	1	0.7	70	

[a] IN 1976

[b] PER 100,000 WORKERS IN EACH GROUP.

[c] TOTAL OF 8033 INDIVIDUALS INVOLVED IN 3 YEAR PROJECT WITH NO MORE THAN 1000 INVOLVED AT ONE TIME.

BASIC DATA FROM ACCIDENT FACTS, 1977 AND 1982.

AT-WORK ACCIDENTAL DEATHS, 1980

	AT WORK	
	DEATHS	RATE[a]
TOTAL U.S.	13,000	5.7
HIGHEST STATE - WYOMING	63	13.3
- NEVADA	39	4.9
LOWEST STATE - NEW YORK	174	1.0
DOE & CONTRACTORS		5.6[b]
NTS AVERAGE 1965-81	1.35	27.0[c]

a. DEATHS PER 100,000 WORKER YEARS. (FROM ACCIDENT FACTS, 1981)

b. 1978-82 AVERAGE (FROM INJURY AND PROPERTY DAMAGE SUMMARY, JAN-JUN 1983, USDOE)

c. BASED ON NTS AVERAGE MONTHLY WORK FORCE.

SUMMARY OF AT-WORK FATALITY RATES

ACTIVITY	FATALITY RATE*	RISK
ALL INDUSTRIES (1976)	14	1.4×10^{-4}
CONSTRUCTION (1976)	57	5.7×10^{-4}
ALL AT WORK, STATE OF NEV. (1980)	4.9	4.9×10^{-5}
DOE & CONTRACTORS (1978-82 AVG.)	5.6	5.6×10^{-5}
NTS (1965-81 AVG.)	27	2.7×10^{-4}
ENEWETAK CLEANUP	70	7.0×10^{-4}

*DEATHS PER 100,000 WORKER YEARS

INFORMATION THAT HAS BEEN OBTAINED

IF PEOPLE WILL LIVE ON ENEWETAK, JAPTAN, AND MEDREN;
IF THEY WILL EAT FOOD FROM THEIR ATOLL ALONG WITH FOOD FROM OUTSIDE;
IF THEY DO GATHER COCONUTS FROM BILLAE TO MIJIKADREK;

THE LARGEST AMOUNT OF RADIATION ONE PERSON MIGHT RECEIVE DURING 1 YEAR.		28 millirem
AVERAGE AMOUNT OF RADIATION A PERSON MIGHT RECEIVE DURING 30 YEARS.	(WHOLE BODY)	200 millirem
	(BONE MARROW)	250 millirem
THE INCREASE OF CANCERS THAT MIGHT OCCUR WITHIN THE NEXT 30 YEARS.		0.10%
THE POSSIBLE INCREASE OF CHILDREN BORN WITH HEALTH DEFECTS WITHIN THE NEXT 30 YEARS.		0.04%

THIS MEANS THAT IF THERE WOULD BE 10,000 PEOPLE DIE WITHIN THE NEXT 30 YEARS FROM ANY CANCER OTHER THAN THAT CAUSED BY RADIAITON LEFT FROM ATOMIC BOMBS, THERE MIGHT BE AN ADDITIONAL 10 WHO DIE FROM CANCER THAT IS CAUSED BY RADIATION LEFT FROM ATOMIC BOMBS

THIS MEANS THAT IF THERE WERE 10,000 CHILDREN BORN WITH HEALTH DEFECTS OCCURING FROM ANY CAUSE OTHER THAN RADIATION LEFT FROM ATOMIC BOMBS, WITHIN THE NEXT 30 YEARS, THERE MIGHT BE AN ADDITIONAL 4 CHILDREN BORN WITH DEFECTS CAUSED BY RADIATION LEFT FROM ATOMIC BOMBS.

ESTIMATES OF TRU DOSE TO RETURNING ENEWETAK PEOPLE

	30 YEARS	50 YEARS	AVERAGE*
PRE-CLEANUP			
ESTIMATES OF POST-CLEANUP WORST CASE	7,800 mrem	13,000 mrem	13.0 mrad/yr.
POST-CLEANUP			
ENJEBI (100% OF TIME, IMPORTS UNAVAILABLE)	394 mrem	1,080 mrem	1.0 mrad/yr.
SOUTHERN ISLANDS (95% OF TIME, IMPORTS)	60 mrem	163 mrem	0.2 mrad/yr.

*AVERAGE ANNUAL BONE DOSE (RAD) USING 50 YEAR TOTAL AND ALPHA QUALITY FACTOR OF 20.

TRU CONTRIBUTION IS A SMALL PART OF TOTAL DOSE DURING INITIAL 30 YEARS.

RADIATION-INDUCED CANCER IN THE ENEWETAK POPULATION

ENEWETAK PEOPLE WERE TOLD IF THERE WERE 10,000 DEATHS FROM CANCER NOT RELATED TO RADIATION, THERE MIGHT BE AN ADDITIONAL 10 PEOPLE DIE OF CANCER DURING THE NEXT 20 YEARS AS A RESULT OF THE RADIATION REMAINING ON THE ISLANDS, ASSUMING LIVING AND EATING PATTERNS IN CONFORMANCE WITH CASE 3 CLEANUP.

ASSUME THE FOLLOWING CONDITIONS:

- **DURING THE NEXT 30 YEARS, AN AVERAGE OF 500 PEOPLE RESIDE ON ATOLL, WITH THE HELP OF IMPORTED FOOD. (15,000 PERSON-YEARS)**
- **CAUSES OF DEATH ARE THE SAME AS FOR THE U.S. POPULATION IN 1976 (FOR LACK OF BETTER DATA).**

THEN, THERE MIGHT BE AN ADDITIONAL 0.026 DEATH FROM CANCER CAUSED BY THE RADIATION.

(NOTE: DOSE ESTIMATES INCLUDED INTAKE OF CESIUM AND STRONTIUM WHICH WERE EXCLUDED FROM CONSIDERATION IN THE CLEANUP CRITERIA.)

RISK OF RADIATION-INDUCED CANCER DEATH AT ENEWETAK

NUMBER RESIDENTS, AVERAGE/YEAR, 30 YEARS	500
ADDITIONAL RADIATION-INDUCED CANCER DEATHS, 30 YEARS	0.026
ADDITIONAL CANCER DEATHS PER YEAR, PER 500 RESIDENTS	0.0009
RATE PER 1,000,000	1.7
APPROXIMATE RISK TO FUTURE RESIDENTS	1.7×10^{-6}
APPROXIMATE RISK TO CLEANUP WORKERS	7.0×10^{-4}

THE GAME ISN'T OVER 'TIL THE LAST OUT

THE ENEWETAK CLEANUP PROJECT OFFICIALLY ENDED APRIL 15, 1980. ACTIVITIES SINCE THEN INCLUDE:

REPORT TO ENEWETAK PEOPLE, DOE	25 PGS	1979
ISLAND CERTIFICATION BY DOE,	92 PGS	1980
DOSE ASSESSMENT, LLNL	92 PGS	1980
PROJECT REPORT, DNA	700 PGS	1981
PROJECT REPORT, DOE	712 PGS	1982
SOIL SAMPLES IN ARCHIVE AT NTS UNTIL		?
MONITORING OF CACTUS DOME UNTIL		?
BEGIN RADIONUCLIDE MONITORING OF COCONUTS		1986
MONITOR COCONUTS UNTIL		?
SAVE DATA BASE TAPES UNTIL		?

OVERVIEW OF RADIATION DOSE STANDARDS AND RELEVANCE TO REMEDIAL ACTION CRITERIA (DOE/OMA)

Battelle

JANUARY 1984

J.P. CORLEY
RADIOLOGICAL SCIENCES DEPARTMENT

RADIATION PROTECTION STANDARDS ORGANIZATIONS

Advisory

- ICRP — International Commission on Radiological Protection
- NCRP — National Council on Radiation Protection and Measurements

---

- Others — Nuclear Energy Agency
  International Atomic Energy Agency

Regulatory

- EPA — Environmental Protection Agency (Superseded FRC-Federal Radiation Council)

- NRC — Nuclear Regulatory Commission
- OSHA — Occupational Safety and Health Administration
- Others — Department of Transportation
  Bureau of Radiological Health
  American National Standards Institute
  American Society for Testing and Materials

BASES FOR RADIATION LIMITS

- RISK
- DOSE LIMIT
- ALARA
- MULTIPLE OF "BACKGROUND"
- MEASUREMENT CAPABILITY

RELATIONSHIPS OF STANDARDS CRITERIA

STAGE	PERTINENT FACTORS	STANDARDS CRITERIA
EFFLUENT RELEASES		RELEASE GUIDES, OPERATING LIMITS
(A)	METEOROLOGY, BIOLOGY, HYDROLOGY, PHYSICAL AND CHEMICAL FORMS, CONCENTRATION FACTORS	
DISPERSION AND/OR RECONCENTRATION		CONCENTRATION GUIDES, CONTAMINATION LIMITS
(B)	EXPOSURE PERIODS, CONSUMPTION RATES	
INTAKE AND EXPOSURE		INTAKE RANGES -- FRC; ANNUAL LIMITS OF INTAKE -- ICRP
(C)	UPTAKE AND ABSORPTION FACTORS, DISTRIBUTIONS IN BODY, BIOLOGICAL HALF-LIVES, BODY DIMENSIONS, RADIATION TYPES AND ENERGIES	
DOSE		DOSE LIMITS --ICRP AND NCRP PUBLICATIONS DOE ORDER 5480.1A NRC (10 CFR 20 etc.) EPA (40 CFR 190 etc.)
(D)	DOSE/RESPONSE RELATIONSHIPS, INDIVIDUAL VARIATIONS	
HEALTH EFFECTS		RISK/PROBABILITY (ICRP NO. 26) (EPA - TRU IN SOIL)

REVIEW OF STANDARDS

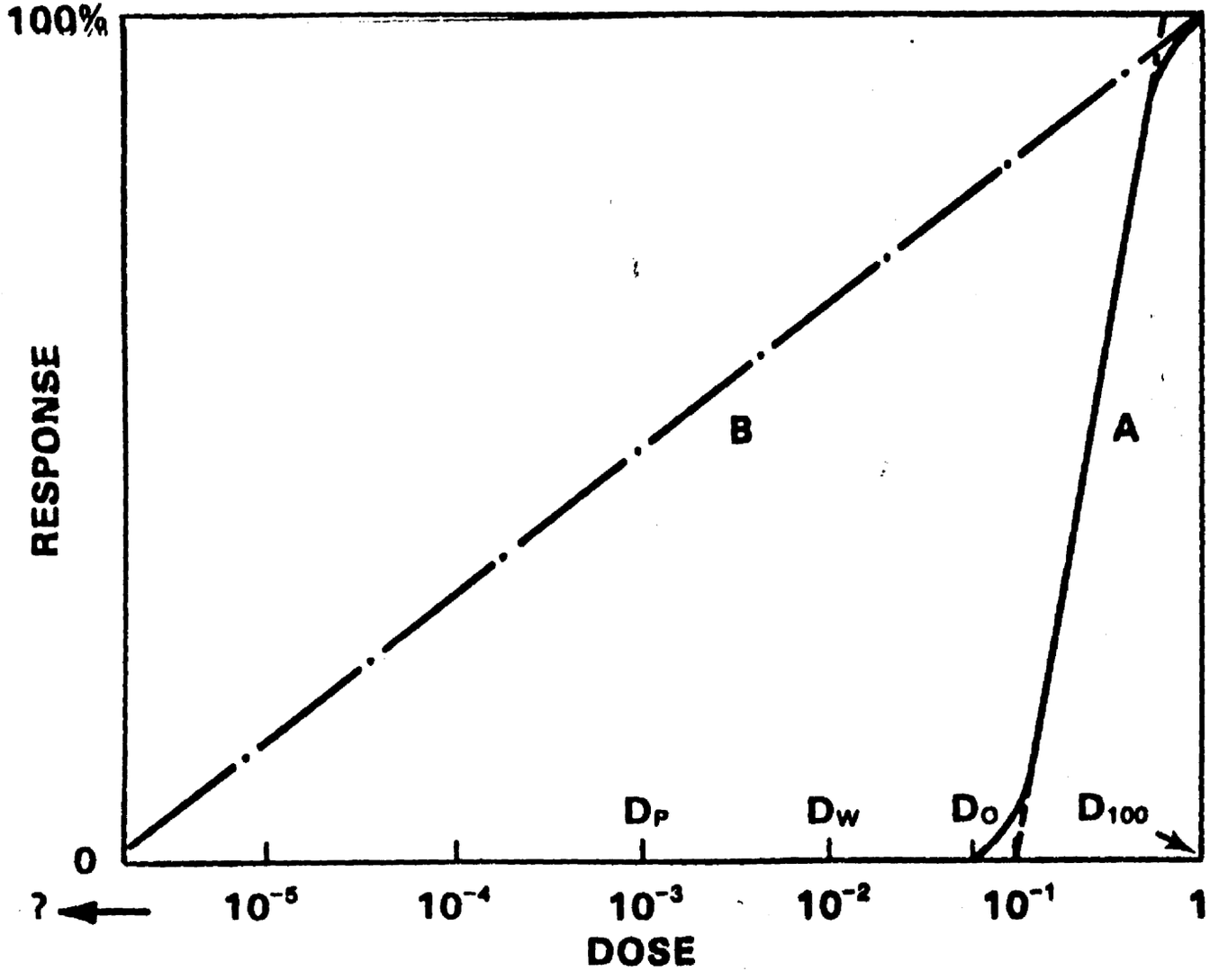
HISTORICAL

1. FRACTION OF DOSE FOR OBSERVABLE RESPONSE (e.g. ERYTHEMA, BLOOD COUNTS)
   - GENERALLY SHORT-TERM
   - NON-STOCHASTIC

2. GENETIC EFFECTS
   - AGE PRO-RATION; 5 (n-18)

3. ALARA (ALAP)
   - JUSTIFICATION

4. TOTAL RISK OF HEALTH EFFECTS
   - RISK ≡ PROBABILITY
   - STOCHASTIC RISKS CONTROLLING


100%
RESPONSE
0
B
A
D_P
D_W
D_O
D_{100}
?
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
DOSE

REVIEW OF TERMINOLOGY

DOSE (DOSE RATE)

UNIT	CONCEPT
rad	ABSORBED DOSE
rem	DOSE EQUIVALENT
rem	DOSE EQUIVALENT COMMITMENT (∞)
rem	COMMITTED DOSE EQUIVALENT (t)
rem	COMMITTED EFFECTIVE (WHOLE BODY) DOSE EQUIVALENT (WEIGHTING FACTORS FOR RISK)

REVIEW OF TERMINOLOGY

EXPOSURE (EXPOSURE RATE)

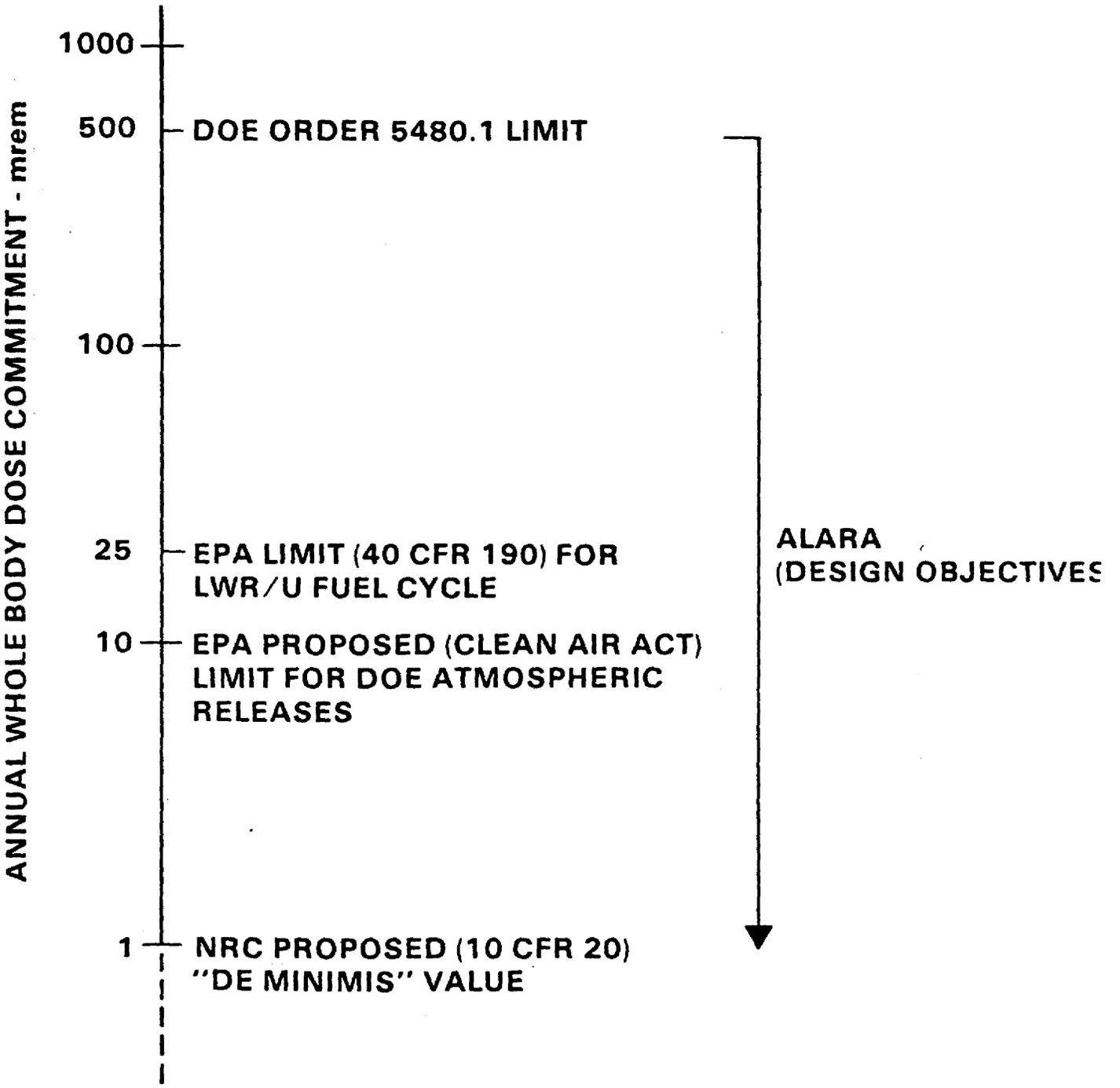
UNIT	CONCEPT
ROENTGEN	EXTERNAL GAMMA OR X RADIATION
CURIES PER CUBIC METER CURIES PER KILOGRAM	RADIONUCLIDE CONCENTRATION IN AIR, WATER, FOOD
CURIES PER SQUARE METER	CONTAMINATION OR EMANATION (RADON)
CURIES (PER UNIT TIME)	RADIONUCLIDE INTAKE QUANTITY

REVIEW OF TERMINOLOGY

REGULATION AND MANAGEMENT

- LIMITS
- ACTION (INTEREST) LEVELS/WORKING LIMITS
- SCREENING LEVELS
- ACCEPTABLE LEVELS
- ALARA
- LESS THAN REGULATORY CONCERN (de minimis)

DOSE COMMITMENT SCALE



MAJOR CHANGES IN ENVIRONMENTAL RADIATION PROTECTION CRITERIA

ICRP No. 26

- Committed vs. Annual dose equivalent
- Summation of Risk - Use of Weighting Factors
- Assumptions as to Distribution of Dose (Risk) in Exposed Population

EPA

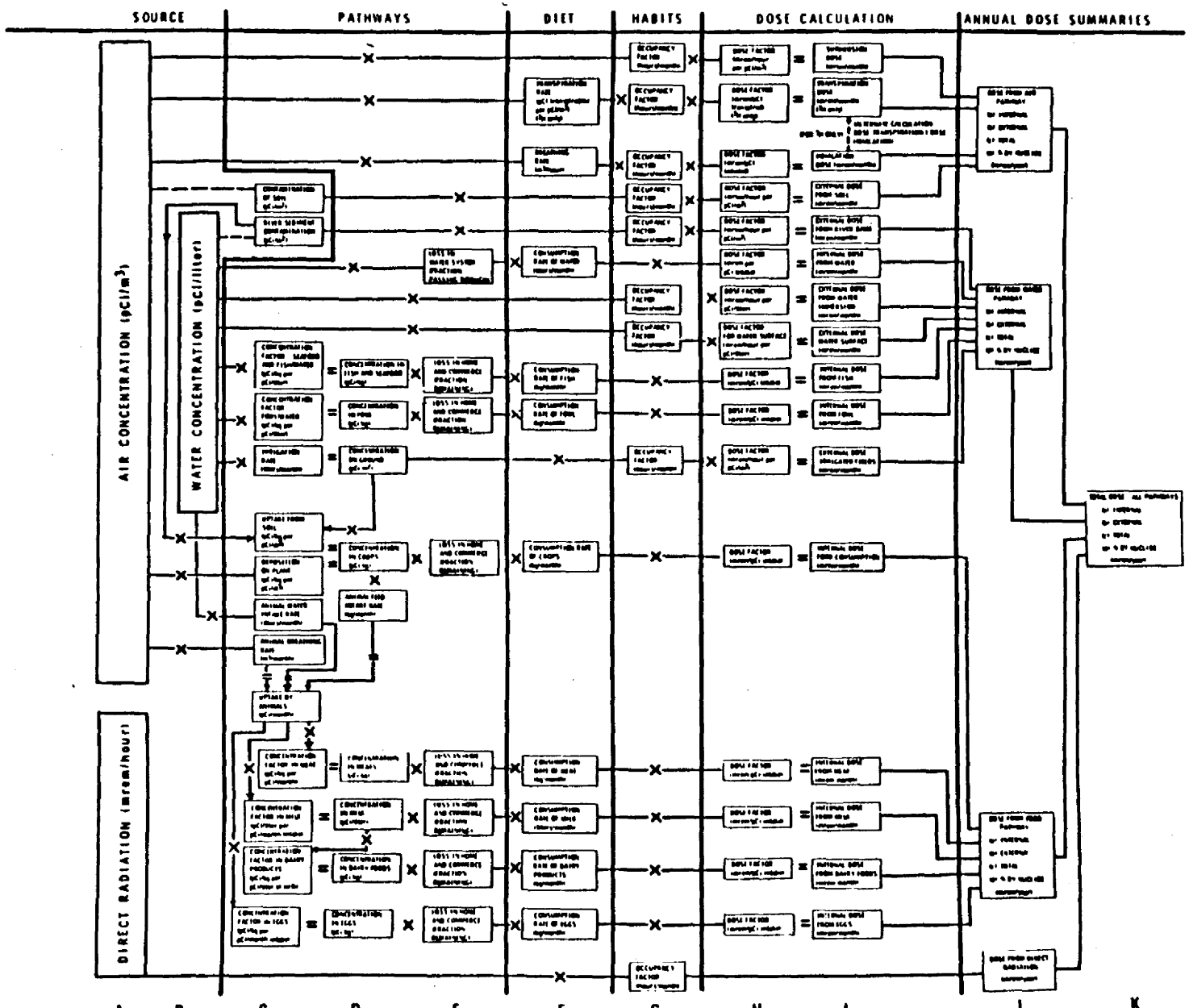
- Multiple Time Periods - Years of Committed Dose
  - Years of Continuing Exposure
  - Years of Environmental Buildup
- Quantification of ALARA

PROPOSED EPA REGULATIONS
WHOLE BODY (EFFECTIVE) RADIATION DOSE LIMITS

High level & TRU Waste Disposal (40CFR191)	25 mrem/yr
DOE Facilities - Clean Air Act (40CFR61)	10 mrem/yr
Phosphorus Plants - Clean Air Act	2 mrem/yr

EXISTING EPA REGULATIONS
WHOLE BODY (ANNUAL) RADIATION DOSE LIMITS

Safe Drinking Water Act (40CFR141)	4 mrem/yr
Nuclear Power Operations (40CFR190)	25 mrem/yr


SOURCE
PATHWAYS
DIET
HABITS
DOSE CALCULATION
ANNUAL DOSE SUMMARIES
AIR CONCENTRATION (pCi/m³)
WATER CONCENTRATION (pCi/liter)
DIRECT RADIATION (mrem/hour)
A
B
C
D
E
F
G
H
I
J
K

COMPARISON OF LIMITING AIR CONCENTRATIONS (μCi/ML)
MAXIMUM INDIVIDUAL IN UNCONTROLLED AREA

RADIONUCLIDE	DOE ORDER 5480.1A TABLE II (AIR) CG	ICRP No. 30[A]
^{3}H (AS HTO)	2×10^{-7}	1×10^{-6}
^{90}Sr	3×10^{-11}	3×10^{-11}
^{238}U	5×10^{-12}	7×10^{-13}
^{239}Pu	6×10^{-14}	7×10^{-14}

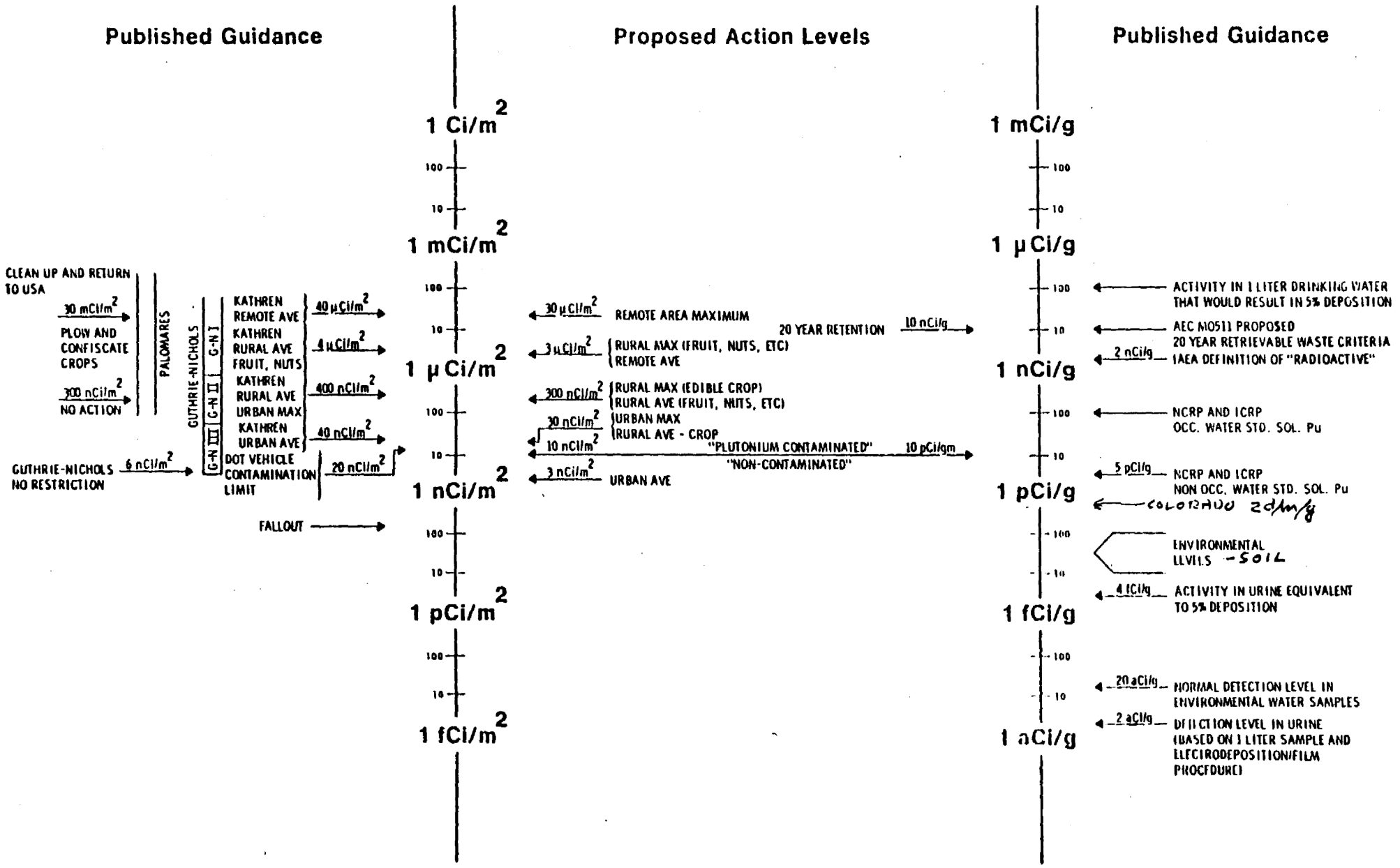
TABLE 1. Ratio of the Committed Dose Equivalent to the Annual Dose Equivalent for Inhalation

Radionuclide	Whole Body	Bone	Lung	GI-LLI	Thyroid
^{3}H	1.0	1.0	1.0	1.0	1.0
^{14}C	1.0	1.0	1.0	1.0	1.0
^{65}Zn	1.2	1.2	1.1	1.0	1.0
^{85}Kr	1.0	1.0	1.0	1.0	1.0
$^{90}Sr+D$	14	15	1.8	1.0	1.0
^{131}I	1.0	1.0	1.0	1.0	1.0
^{129}I	1.1	1.0	1.0	1.0	1.1
$^{137}Cs+D$	1.0	1.1	1.1	1.0	1.0
^{226}Ra	18	24	1.9	1.0	1.0
^{234}U	7.6	15	4.6	1.2	1.0
^{238}U	7.6	15	4.6	1.2	1.0
^{239}Pu	33	30	2.5	1.0	1.0

TABLE 2. Ratio of the Committed Dose Equivalent to the Annual Dose Equivalent for Ingestion

Radionuclide	Whole Body	Bone	Lung	GI-LLI	Thyroid
^{3}H	1.0	1.0	1.0	1.0	1.0
^{14}C	1.0	1.0	1.0	1.0	1.0
^{65}Zn	2.3	2.4	1.0	3.2	1.0
^{85}Kr	1.0	1.0	1.0	1.0	1.0
$^{90}Sr+D$	40	45	1.0	1.0	1.0
^{131}I	1.0	1.0	1.0	1.0	1.0
^{129}I	1.6	1.1	1.0	1.0	1.6
$^{137}Cs+D$	1.7	1.8	1.9	1.0	1.0
^{226}Ra	50	70	1.0	1.0	1.0
^{234}U	1.6	3.2	1.0	1.0	1.0
^{238}U	1.5	3.1	1.0	1.0	1.0
^{239}Pu	90	90	1.0	1.0	1.0

PLUTONIUM ACTION LEVELS



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JAN 25 10 37 AM '81

RBBU1IFX RHEGLAF0737 0242228 MTMS-UUUU--RHEGNVF.

ZNR UUUUU

R 242228Z JAN 84

FM J W HEALY MS-P228 LOS ALAMOS NATIONAL LABORATORY

LOS ALAMOS NM 87545

TO RHEGGTF/TOMMY MCGRAW EP-342 USDOE WASHINGTON DC

RHEGRLF/JACK CORLEY BATTELLE NORTHWEST LABORATORY PO BOX 999

RICHLAND WA

RHEGRLF/KEN HEID BATTELLE NORTHWEST LABORATORY PO BOX 999

RICHLAND WA

RHEGORF/C R RICHMOND ORNL PO BOX X OAK RIDGE TN

RHEGRFF/ROBERT YODER ROCKWELL INTERNATIONAL ATOMICS INTERNATIONAL

DIVISION ROCKY FLATS PLANT PO BOX 464 GOLDEN CO

RHEGNVF/BRUCE CHURCH DOE PO BOX 14100 LAS VEGAS NV — 0961

AE-XNAE

UNCLAS/NONWD/F A X

THIS TRANSMITTAL CONSIST OF 5 PAGES

BT

JAN 25 1984

DRAFT

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

January 24, 1984
JG-84-5

Mr. Tommy McGraw
EP-842
U. S. Dept. of Energy
Washington, DC 20545

Dear Mr. Cannon:

The Department of Energy has conducted the review of the proposed guidance for transuranium elements in the environment by a technical committee as promised in our letter of November 15, 1983. The following comments and recommendations arose from this review.

In our letter of July 8, 1981, we indicated that we had no objections to the basic dose equivalent limits proposed as guidance. There were also many additional comments on the draft guidance as then proposed including a reference to the nearly 300 pages of technical comments provided earlier. In our current review, we felt that there have been many developments since this letter was written which caused us to change our position on these numerical values in the guidance. These include the recent developments in risk based control of exposure by the ICRP and, more recently, the proposed risk system of the NCRP. The obsolescence of the detailed guidance now proposed by the EPA is an important factor. This guidance was developed in accord with a request from the State of Colorado to provide guidance for control of the Rocky Flats contamination. This situation now seems to be under control and other existing sites of contamination with transuranium elements appear to present little or no problems. Thus, the primary use of the guidance appears to be future weapons accidents or accidents in launching a nuclear power

(1)

DRAFT

source. It seems that the information used in developing the guidance was primarily for existing sites of contamination and little real attention has been paid to what now seems to be the primary usefulness of the guidance. This guidance has been in preparation for about ten years and there have been changes in policy in the EPA that should be considered before these numbers are accepted. A noteworthy example is the talk by Mr. Ruckelshaus before the National Academy of Sciences proclaiming the policy of the EPA to use the best science available in providing their regulations. We do not believe that the present limiting numbers represent a truly scientific approach to generally applicable standards. Perhaps the results of the recently appointed subcommittee of the EPA Scientific Advisory Board will be applicable to this guidance.

We do have a number of objections to this draft guidance. The DOE questions the wide range of limits in recently issued or proposed EPA regulations for the protection of the public from radiation. This draft guidance adds another set of values to the various ones accepted by the EPA. In fact, the use of mrads rather than mrems, as in the other standards, sets this one apart from the others leading to inconsistency in units as well as in risk values. Earlier we referred to a shift in the probable application of this guidance from present sites to future accidents. However, the background studies leading to this guidance have paid little attention to this aspect of its use. There are, for example, no analyses of the cost and practicality of the values given. In particular, the potential political problems caused by these low values if the accident occurs on foreign soil have not been addressed. The current guidance is now about seven years old. Much has

happened in that time, including added experience in the cleanup of areas contaminated with transuranium elements. Thus, we can only regard the present draft as obsolescent. Some of the later concepts and experience should be studied with respect to this guidance. In particular, the question of flexibility in application of the guidance should be considered. Since DOE will undoubtedly be a technical advisor to DOD or NASA in event of another accident, we are concerned that many options will be foreclosed by the present lack of flexibility. In this respect, there are words giving flexibility in the document, but not in the recommendations section. In fact, this section reflects the view that the guidance must be followed. Since we do not know what portion of this document will be signed by the President, if approved, this lack of flexibility in the recommendations could lead to serious problems in implementation. Finally, a number of statements in the present (and past) draft leads to belief that EPA was attempting to incorporate ALARA into their considerations but appropriate analyses for the present use in future accidents are not included.

As a result of this review, the DOE has several recommendations for the revision of this guidance and for development of future regulations and guidance.

(1) The EPA should issue generally applicable radiation standards in the form of a limiting risk.

(2) The scope of the generally applicable guidance should be broadened to cover all radionuclides in the environment. This would provide

guidance applicable to present decontamination and cleanup work and would not overemphasize the transuranium elements.

(3) The guidance should not be based on ALARA but rather on the EPA's version of a reasonable risk considering other risks. The use of ALARA should be in addition to meeting the standards and an applicable level of ALARA should be defined by the responsible agency that has knowledge of the details of the given situation.

(4) DOE has changed their former position on having EPA provide a screening level. We now believe that the EPA should provide the generally applicable guidance and that DOE, DOD, NASA, and other Agencies as needed, cooperate to produce any screening level required. As we now envision it, there are two levels that need to be defined: (a) a screening level below which action is not needed; and (b) an action level above which cleanup could be started without further studies. This would satisfy the need of the operator who needs a number to work with while other studies define the actions needed in the intermediate zone.

(5) The DOE recommends that EPA take a consistent approach to the setting of environmental standards and guidance so that these standards represent a coherent whole rather than a fragmented group of inconsistent standards.

DRAFT

(6) A general problem that has existed in the past, and is still present, is the lack of strong interagency working groups that allow involved people to talk to each other on policy, technical problems, and implementation. The DOE strongly recommends that EPA avail themselves of the help that can be obtained from other agencies in such working groups. The present system is not working because problems of mutual interest do not seem to arise at the infrequent meetings of the present interagency working group.

Copies Faxed to the following:

Jack Corley, Battelle NW
Ken Heid, Battelle NW
B. Church, NVOO
Chet Richmond, ORNL
Robert Yoder, Rocky Flats

Summary of
Radiological Guidelines for the
DOE FUSRAP Program
for
DOE Conference on EPA Transuranic Guides

Wayne R. Hansen
Los Alamos National Laboratory

The Department of Energy (DOE) programs for Surplus Facilities and Formerly Utilized Sites Remedial Action Program (FUSRAP) has prepared some draft criteria for residual radiation levels. This paper summarizes a joint effort by Los Alamos National Laboratory, Argonne National Laboratory, Oak Ridge Operations, and Bechtel National, Inc., to prepare a background document for such criteria.

The FUSRAP sites in the DOE program involve a wide range of radioactive contamination in soils, building wastes, sludges, and chemical residues. The majority of site contaminants involve higher than normal, naturally occurring radionuclides and three sites involve fission products and transuranics. Before remedial action decisions on these sites were possible, some basis for decision regarding completion of remedial action was necessary.

In 1981, the DOE Inspector General stated that decisions regarding the need for remedial actions should be based on site specific health effects assessments and a cost/benefit analysis. To meet the needs of the program, ORO-831 was prepared based on DOE Standards for Radiation Protection of the Public.

The methods of analysis and the source to dose conversion factors needed to derive soil concentration guidelines from radiation protection standards are presented; the health risk studies that provide a basis for the radiation protection standards are discussed; radiological guidelines for remedial action based on the previous discussions are presented; and considerations in applications of the guides are presented.

The translation of the ORO-831 guidance into DOE criteria for FUSRAP and Surplus Facility program guidance reflect some changes due to EPA guides. Changes in the Ra-226 guidance reflect the influence of the EPA standards for inactive uranium mill tailings. The limits for transuranics in soil have not been changed to reflect the EPA guidance.

Radiological Guidelines For the DOE FUSRAP Program

for
DOE Conference on Transuranic Guidance
January 17–18, 1984

Wayne R. Hansen
Environmental Surveillance Group
Los Alamos National Laboratory

Los Alamos

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Argonne National Laboratory

Robert Rudolph
R. Daniel Glenn
Edward Walker
Bechtel National, Inc.

Los Alamos

Discussion to cover:

- Need for FUSRAP Guides
- Summary of Work on FUSRAP Guides
- Comparison with EPA Guides

Inspector General, DOE, 1981

Questioned expenditures on Remedial Actions Without

...site-specific health effects assessments...
...cost/benefit analyses...

Los Alamos

Purpose

Provide Guidance for Estimates of:

- Health Effects
- Dose Assessment
- Methods for Field Use

Los Alamos

Approach

Attempt to provide brief guidance on:

- o Environmental Pathways Methods
- o Dose Estimation
- o Health Effects Estimation
- o Derived Clean-up Guides
- o Applications of Guides

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Starting Point

DOE Orders based on Acceptable Levels
of Risk as Stated By ICRP and NCRP

500 mrem/yr Maximum Individual Whole Body
1500 mrem/yr Maximum Individual Organ Dose

Assumption that ALARA Applied in
Field Implementation of Site Evaluation

ORO – 831

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Health Effects Estimators

Based on BIER III

Exception - Radon + Daughters

Based on Value From International Workshop on Radon Risks

Published by Evans et al

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Derived Guides

1. What is Acceptable Risk?

   ICRP - 1 chance in 100,000 to
   1,000,000 per year
   EPA - 1 chance in 1000,000 per year

2. What is Dose Limit Corresponding
   to that Level of Risk?
   500 mrem/yr to Max. Individual
   170 mrem/yr to Segment of Population

3. What Levels of Contamination Corresponds
   to Dose Limit ?

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Soil Remedial Action Guidelines

Radionuclide	Surface Soil Guideline (pCi/g above background)	Reference
Am–241	20	Healy 1977
Pu–241	800	Healy 1977
Pu–239,–240	100	Healy 1977
Pu–238	100	Healy 1977
Natural uranium	75	Gilbert et al. 1983
U–238	75	Gilbert et al. 1983
Th–230	300	Gilbert et al. 1983
Ra–226	15	Gilbert et al. 1983
Cs–137	80	Healy et al. 1979
Sr–90	100	Healy et al. 1979
H–3 (pCi/ml Soil moisture)	5,200	Appendix B of ORO–831

RADIUM-226 AND RADON-222 REMEDIAL ACTION GUIDES

(ABOVE BACKGROUND)

RADIONUCLIDE	GUIDE	ACTION	CONDITION
RADON-222	>0.03	REQUIRED ACTION	STRUCTURES
+DAUGHTERS	<0.02	NO ACTION	
RADON-222	>3PCI/1	REQUIRED ACTION	BOUNDARY OF CONTROLLED PROPERTY
	>30PCI/1	REQUIRED ACTION	OVER SURFACE OF CONTROLLED PROPERTY
RADIUM-226	>15PCI/G	REQUIRED ACTION	10 CM OR LESS SOIL THICKNESS
	>5PCI/1	REQUIRED ACTION	SURFACE WATER OR GROUND WATER
GAMMA DOSE	>0.02 MREM/HR	REQUIRED ACTION	EXTERNAL RADIATION

Radon + Daughters
Lung Cancer Mortality

Inhaled Daughters	Population Risk	Individual Risk
1 WLM	10 cancers in 100,000	1 chance in 10,000
BKG 1pCi/ℓ (0.25 WLM indoors) (0.005–0.01 WL)	2.5 cancers in 100,000	2.5 chances in 100,000
0.03 WL	7.5 cancers in 100,000	7.5 chances in 100,000

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Approximate Absolute Risks of Cancer Mortality (BEIR III)

Dose	Cancer Deaths	Percent of Normal Cancer Mortality
1 mrad/yr alpha to lung	0.1 in 100,000	0.03
3 mrad/yr alpha to bone	0.3 in 100,000	0.10
40 mrad/yr alpha to bone surface	0.1 in 100,000	0.03
Normal Annual Risk of Cancer Death	300 in 100,000	
500 mrem/yr whole body (low LET)	4 in 100,000	1.3
170 mrem/yr whole body low LET (0.02 mrem/hr)	1.5 in 100,000	0.5

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Approximate Absolute Risks of Cancer Mortality (BEIR III)

Dose	Cancer Deaths	Percent of Normal Cancer Mortality
1500 mrem/yr bone surface (high LET)	0.2 in 100,000	0.7
1500 mrem/yr lung (high LET)	7.5 in 100,000	2.5
Natural Background of 100 mrem/yr whole body (low LET)	0.9 in 100,000	0.3
Congressional Aide's Suggested Start of Disability Payments Due to Radiation Cause		10

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Application of Guides

Derived guides based on maximum individual

Modify based on considering:

- o present and future land use
- o occupancy factors
- o distribution of contamination
- o quantities of contaminated material
- o costs in dollars and health
- o socioeconomics

Department of Energy
Nevada Operations Office
P. O. Box 14100
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JAN 13 1984

T. D. Pflaum, HQ, Chief of Envir., Safety & Health (DP-226.1) GTN

COMMENTS ON EPA-PROPOSED "DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT"

The Nevada Operations Office (NV) submitted comments on the subject dose limits via our letter, Church to Pflaum, dated October 19, 1983. For convenience a copy is enclosed.

Although much can be said on this subject I wish to take this opportunity to discuss the following points.

1. EPA Objective of Reducing Risk to 10^{-6} Ultra Conservative

EPA states that they believe it appropriate to limit the risk for a cancer fatality from a single radiation source to a person in the population to 10^{-6} per year. We contend that the proposed standards in reality impose a risk limit much more conservative and could be as low as 10^{-8}.

There is considerable uncertainty in developing risk estimates from observable health effect data, and there is considerable uncertainty in estimating environmental organ doses through pathway modeling because of the assumptions made and variability of individuals (i.e., lifestyles, ingestion, uptake and growth rates, etc.).

If the maximizing assumptions are always taken, the predicted risk to a population for leaving a contaminated area undisturbed could be several orders of magnitude less than the real risk encountered during cleanup operations.

One risk not considered by EPA is the risk benefit to personnel involved in the cleanup which approximates 10^{-4}. The criteria and consideration for cleanups should include the risk of death and injury resulting from the cleanup itself.

During the course of the Enewetak cleanup, two men died in work-related accidents; six others died from a variety of causes. It is well documented that construction activities have higher fatality rates than most industries.

Because of uneven distribution (re: Hot Particle Problem) there is Room for Mischief (e.g. Rocky Flats Experience)

The following table summarizes some selected fatality rates and risks.

Activity	Fatality Rate*	Risk
All industries (1976)	14	1.4×10^{-4}
Construction (1976)	57	5.7×10^{-4}
At work (1980) State of Nevada	4.9	4.9×10^{-5}
DOE & Contractors (1978-82 average)	5.6	5.6×10^{-5}
NTS (1965-1981 average)	27	2.7×10^{-4}
Enewetak cleanup	70	7.0×10^{-4}

*Per 100,000 worker-years.

Because of the great variability in the data, and the requirement to interpolate and extrapolate, it is essential that a careful uncertainty analysis be made by EPA. This analysis is necessary to ensure confidence that the risk of cleanup does not exceed the risk from leaving the contamination undisturbed; which may be as low as 10^{-8} or lower.

2. Imaginary Versus Real Deaths!

The models used to assess the health effects (i.e. radiation-induced cancer fatalities) on the Enewetak people during the planning phase estimated $\leq$ 3 health effects (cancer deaths) over 30 years with no cleanup and no restrictions on island or food usage.

An analysis of the total radiation dose to the returning people of Enewetak after the cleanup leads to the conclusion that there might be an additional 0.026 deaths in 30 years from cancer caused by radiation. This is compared to the two persons who died in course of the three-year cleanup.

The uncertainty which is inherent in cancer-risk estimates is graphically illustrated in Table V-4, page 147 in the 1980 BEIR report in which the expected number from continuous exposure of one rad per year to a population of 1,000,000 ranges from zero to 568.

The risk estimates of cancer deaths as required by the proposed EPA standard (maximizing risk estimates) give hypothetical, or imaginary deaths as compared to the real deaths which do occur in construction projects. The fact is that no increase in cancer rate has been, nor can be, identified at the dose levels comparable to background radiation levels.

Therefore, until the technology is developed to perform TRU cleanups where workers do not take substantially higher risks (which are real) to achieve a condition where the risks (which are hypothetical) are substantially lower than daily risks, guidance should be limited to reflect the greatest savings of life.

The Enewetak cleanup, which was designed to conform with the proposed EPA guidance is the epitome of the above discussion. According to risk analyses published in the planning documents, the islands could have been turned over to the people without a radiological TRU cleanup and saved lives. Ultraconservatism costs more than just time and dollars, it can cost real lives.

3. Cost Versus Benefit

Reasonable alternatives should be evaluated when decisions are made affecting the expenditure of resources. The radiological cleanup at Enewetak cost approximately $100 million and resulted in the potential of averting less than one cancer death from radiation in 30 years in the Enewetak population. How many premature deaths from disease and illness might have been averted in the Enewetak population by directing $100 million into improving health care knowledge, facilities, and capability? We may not have the information available to answer this question, but it is not unreasonable to consider this alternative. Similar logic should be applied in considering any radiological cleanup.

Bruce W. Church, Director
Health Physics Division

HPD:DLW

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COMMENTS ON EPA-PROPOSED "DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT"

The Nevada Operations Office (NV), Health Physics Division (HPD), has obtained comments from the scientific laboratories, appropriate contractors, and staff on the subject document. A brief summary of those comments is provided below.

Because the maximum measured Pu concentration outside of the Nellis Bombing and Gunnery Range (observed during sampling approximately 10 years ago) is less than a half of the screening level, we believe the recommendations of the report probably will not impact significantly on NTS activities. Even so, the recommendations are not considered reasonable. However, because there is great variability between locations of samples and aliquots of the same soil sample (i.e., the hot particle problem), it is conceivable that someone could find off-site locations which would exceed the screening level. In addition, we have substantial areas contaminated above those limits on the Nellis range, but off the NTS, as well as substantial areas above the limits on the NTS. It appears that the real basis for these recommendations is "as low as can be tolerated without heavily consuming agency budgets," and is not based on any cost-benefit analysis. Any number of approaches could be used to assign a value to a life and thereby calculate a dollar value for dose reduction which could be balanced against cleanup costs. Instead, the report lists an absolute risk of 10^{-5} to 10^{-6} deaths per year as reasonable and then turns around and selects 10^{-6} (not 5×10^{-6} or 3×10^{-6}) without considering cost or benefit.

The guidance levels of 1 mR/yr to the pulmonary lung, 3 mR/yr to bone, or 30 mR/yr to the bone surface are not directly measurable quantities and therefore are of little practical use. Complex and questionable calculations would be required to transform measured contamination levels to doses. Any such calculations contain judgmental factors concerning dietary habits and personal preferences which could be challenged and the responsible agency could find itself in endless court battles regarding compliance. The only certain way to assure compliance would be prohibitive for routine operations.

Costs of cleanup, if it should be required, are estimated in the EPA document at upwards of $50,000 per acre, which exceeds the intrinsic land value around the NTS by more than ten times. This kind of cost relative to the estimated potential benefit of such less than one one-millionth of a "health effect" seems grossly excessive.

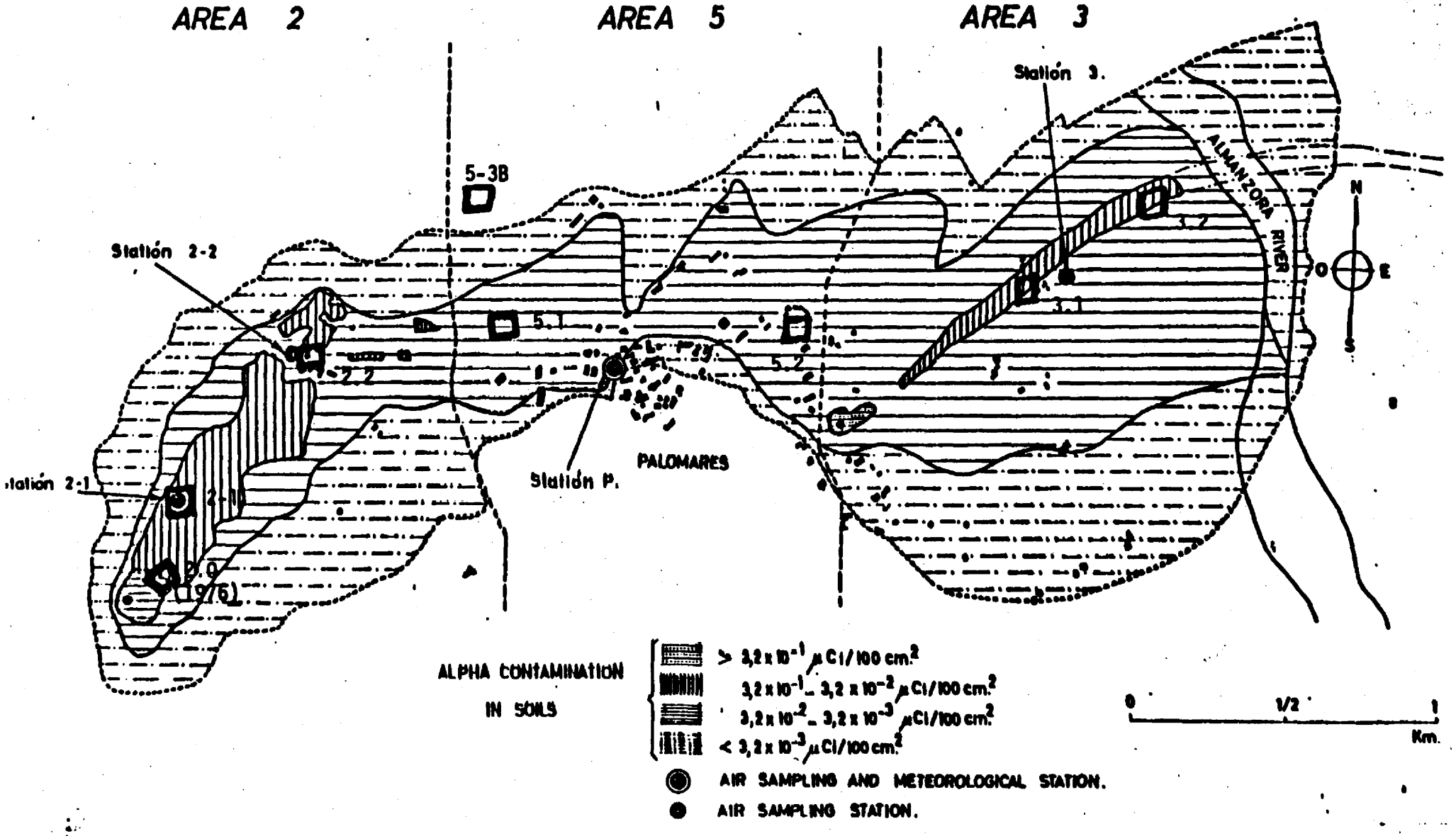
[illegible] would be very happy to work with military installations to coordinate [illegible] response to EPA on this matter.

[illegible]

Bruce W. Church, Director
Health Physics Division

WPD-EP:EP

cc:
T. F. McGraw, WP (EP-22) CTN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ALPHA CONTAMINATION
IN SOILS
> 3,2 x 10⁻¹ μCi/100 cm²
3,2 x 10⁻¹ - 3,2 x 10⁻² μCi/100 cm²
3,2 x 10⁻² - 3,2 x 10⁻³ μCi/100 cm²
< 3,2 x 10⁻³ μCi/100 cm²
AIR SAMPLING AND METEOROLOGICAL STATION.
AIR SAMPLING STATION.
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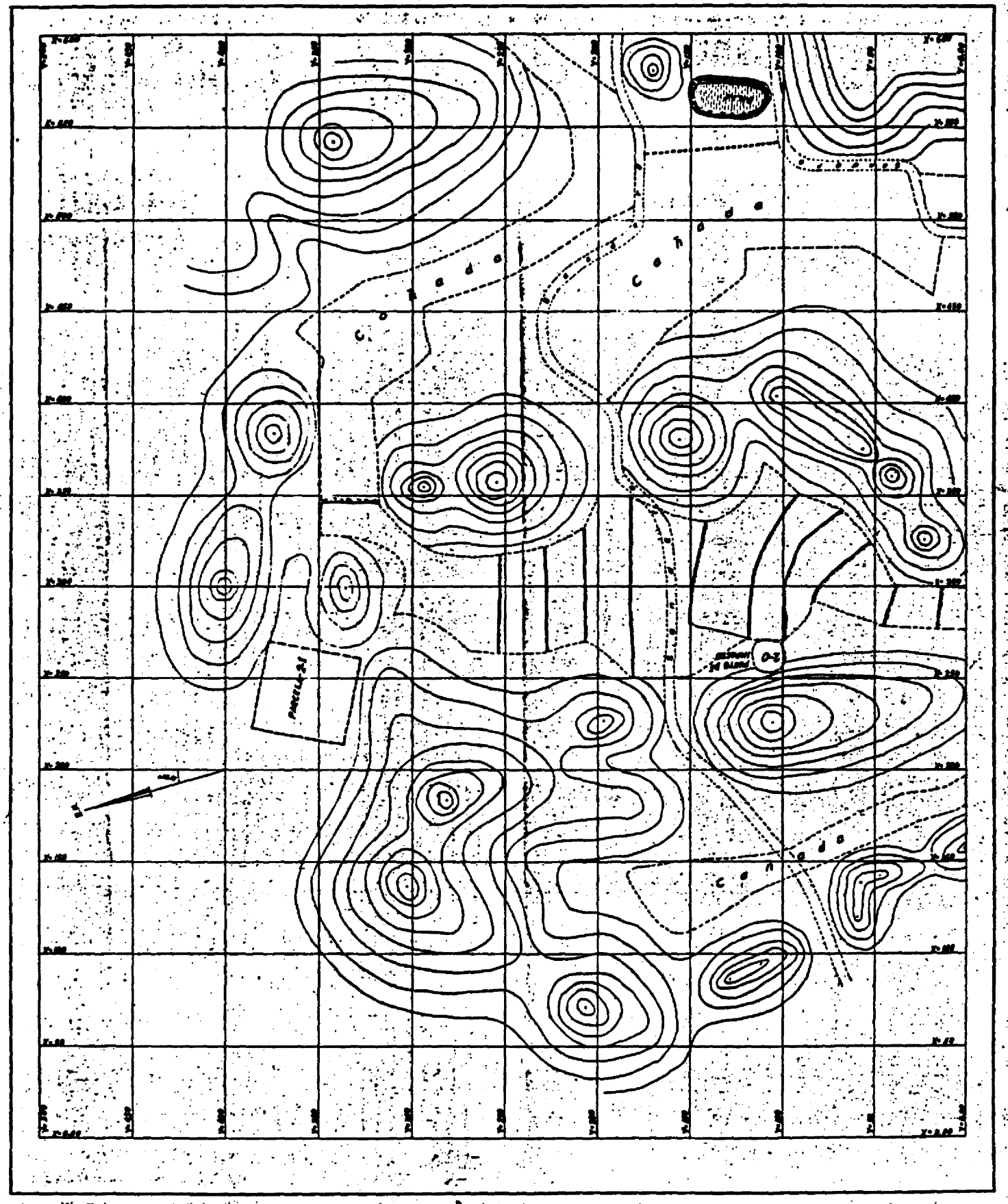
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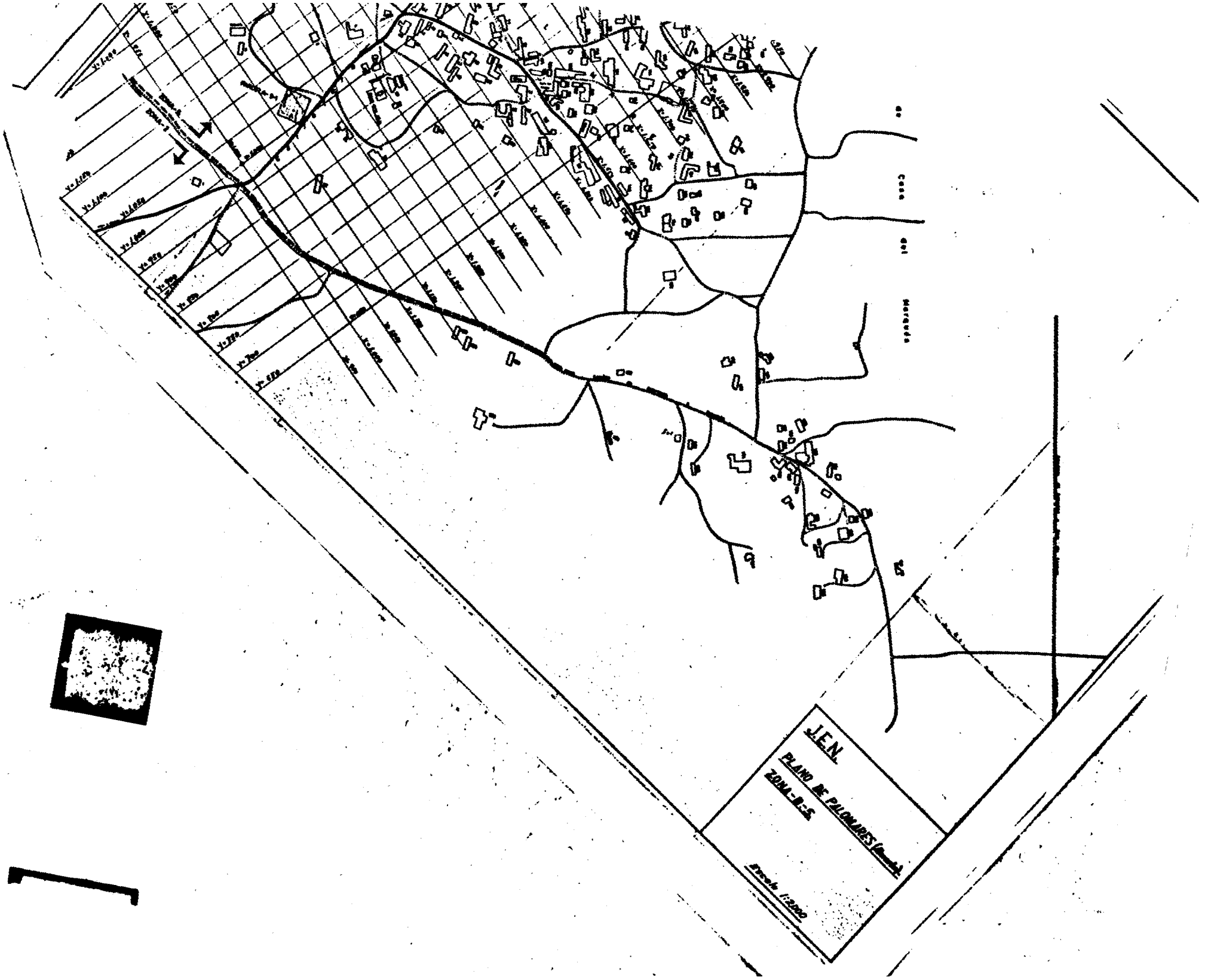
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PLANO DE PALOMARES
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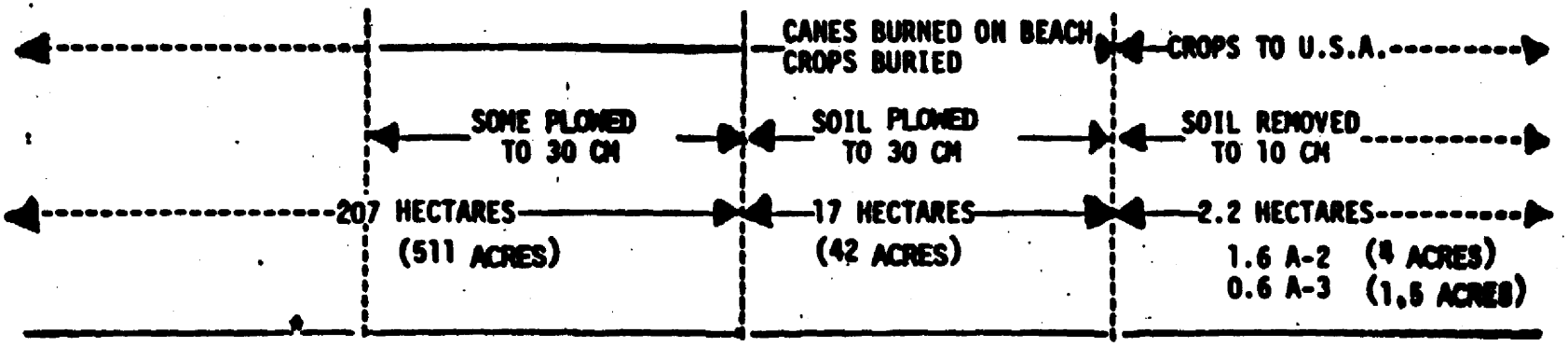
REMEDIAL ACTIONS TAKEN AT PALOMARES FOLLOWING ACCIDENT IN JANUARY 1966



μCi/m²	.32**	3.2	32
μg/m²	5.0	50.0	500
dpm/100cm²	7000.0	70,000.0	700,000
Bq/m²	1.18×10^4	1.18×10^5	1.18×10^6

* EPA Screening Level of 0.2 μCi Pu/m² ~ 4,400 dpm/100 cm² ~ 3.1 μg/m²

** ~ 1.3×10^{10} 1 μm particles/m²

MEAN ANNUAL Pu-239 AND Pu-240 CONCENTRATIONS IN BREATHABLE AIR DURING THE PERIOD 1966 - 1980

YEAR	CONCENTRATIONS AT STATION ($pCi \times m^{-3} \times 10^{-3}$)			
	2-1	2-2	P	3-1
1966	1.13	1.21	0.4	0.74
1967	0.41	11.94	0.11	0.35
1968	0.19	0.59	0.07	0.09
1969	4.35	3.84	0.07	0.38
1970		0.16	0.06	
1971		0.06	0.09	
1972		0.28	0.05	
1973		0.08	0.06	
1974		0.22	0.11	
1975		0.44	0.05	
1976		0.12	0.05	
1977		0.32	0.15	
1978		0.45	0.06	
1979		0.52	0.15	
1980		0.89	0.76	

POPULATION GROUPS CONSIDERED FOR CALCULATING THE DOSE EQUIVALENT

(YEARS OF INHALATION)

GROUP	BABY	CHILD	YOUTH	ADULT	TOTAL	AGE AT THE TIME OF THE ACCIDENT
1	0	10	5	0	15	1
2	0	0	6	9	15	11
3	0	0	0	15	15	18

DOSE RECEIVED (REM) BY INHALING Pu—239 THROUGH 12—31—1980 STATION IN PALOMARES

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	1.926—04	4.427—03	2.896—06	2.778—03	1.390—02	7.262—04
2	1.503—04	3.456—03	2.635—06	2.654—03	1.289—02	7.206—04
3	1.810—04	4.164—03	2.614—06	3.188—03	1.254—02	8.679—04

Particle size: 0.3 micron

DOSE RECEIVED (REM) BY INHALING Pu-239 THROUGH 12-31-2015(+)

STATION IN PALOMARES

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	6.870-04	1.591-02	2.900-06	1.040-02	2.350-02	3.085-03
2	9.620-04	2.232-02	2.639-06	1.501-02	2.508-02	4.592-03
3	1.089-03	2.528-02	2.618-06	1.690-02	2.564-02	5.197-03

(+)It is assumed that the Pu-239 concentration is nil after 12-31-1980

Particle size: 0.3 micron

DOSE RECEIVED (REM) BY INHALING Pu-239 THROUGH 12-31-1980

STATION 2-2

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	3.632-03	8.352-02	2.974-05	5.101-02	2.036-01	1.319-02
2	2.540-03	5.844-02	2.562-05	4.450-02	1.868-01	1.218-02
3	3.260-03	7.502-02	2.513-05	5.701-02	1.831-01	1.563-02

Particle size: 0.3 micron

DOSE RECEIVED (REM) BY INHALING Pu-239 THROUGH 12-31-1980

STATION 2-2

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	3.632-03	8.352-02	2.974-05	5.101-02	2.036-01	1.319-02
2	2.540-03	5.844-02	2.562-05	4.450-02	1.868-01	1.218-02
3	3.260-03	7.502-02	2.513-05	5.701-02	1.831-01	1.563-02

Particle size: 0.3 micron

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR THE URBAN AREA THROUGH THE YEAR 2015 AS A RESULT OF INHALATION DURING THE PERIOD 1966-1980, AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	23.5	7.2	10.4	4.4	15.9	6.7
2	25.1	7.7	15.0	6.4	22.3	9.5
3	25.6	7.9	16.9	7.2	25.3	10.7

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	3.1	1.3	0.006	0.003	0.69	0.29
2	4.6	2.0	0.005	0.003	0.96	0.41
3	5.2	2.2	0.005	0.003	1.09	0.46

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR THE URBAN AREA DURING THE PERIOD 1966-1980 AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	13.9	4.2	2.8	1.2	4.4	1.9
2	12.9	3.9	2.7	1.1	3.5	1.5
3	12.5	3.8	3.2	1.4	4.2	1.8

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	0.73	0.31	0.006	0.003	0.19	0.08
2	0.72	0.31	0.005	0.003	0.15	0.06
3	0.87	0.37	0.005	0.003	0.18	0.08

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR STATION 2-2

DURING THE PERIOD 1966-1980 AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	203.6	63.0	51.0	21.6	83.5	35.4
2	186.8	57.6	44.5	18.9	58.4	24.8
3	183.1	56.0	57.0	24.1	75.0	31.8

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	13.2	5.7	0.060	0.030	3.6	1.5
2	12.2	5.2	0.052	0.026	2.5	1.1
3	15.6	6.7	0.051	0.025	3.3	1.4

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR STATION 2-2
UP TO THE YEAR 2015, FROM INHALATION DURING THE PERIOD 1966-1980,
AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	240.0	73.2	99.6	42.2	161.4	68.4
2	244.0	75.0	132.5	56.1	200.8	85.1
3	255.1	78.5	177.0	74.9	270.2	114.4

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	29.1	12.5	0.060	0.030	7.0	3.0
2	41.2	17.8	0.052	0.026	8.6	3.7
3	55.4	23.8	0.051	0.025	11.6	4.9

PLUTONIUM CONTAMINATION AT THULE

Summary of Notes for Talk
Given at DOE Meeting on Proposed
EPA Guidelines for Transuranium
Elements in the Environment

January 17, 1984

David S. Myers
Lawrence Livermore National Laboratory

PLUTONIUM CONTAMINATION AT THULE

On January 21, 1968, a B-52 carrying 4 nuclear weapons crashed and burned on the ice near Thule, Greenland. The 7 crew members bailed out before the crash and 6 survived. At the time of the crash, the plane was carrying about 225,000 pounds of JP-4 jet fuel. The resultant fire produced a blackened area on the ice of about 500 feet wide by 2100 feet long. The ice was cracked for about 100 yards in all directions from the point of the impact.

At the time of the crash, the temperature was -24°F and a 7 knot wind reduced this to an equivalent -53°F reading. It would be about 3 weeks yet until the sun made its first appearance after the long Artic night. During the next few weeks, several storms swept the area. The combination of darkness, storms, severe cold, and the remote location would make recovery operations extremely difficult.

Within a few days, members of the U.S. Air Force, scientific experts from LASL and Livermore, and Danish scientists were assembled at Thule to assess the accident situation. It quickly became clear that there was plutonium contamination around the crash site, but there was no evidenace of any nuclear yield. Also, it was determined that the ice at the crash site was 2 to 4 feet thick and sufficient to support vehicles and structures as long as adequate spacing was maintained.

One of the first priorities was to establish the extent of the contamination around the crash site and determine a zero line outside of which no contamination was detectible. The most valuable instrument for mapping the contamination level was the FIDLER detector developed at Livermore. This instrument is designed to detect the low energy x-rays (14 keV to 20 keV) from plutonium and the 60 keV photon from Am-241. Because of the snow cover, the 60 keV photons from ^{241}Am produced better sensitivity and were used for contamination contour mapping and hot-spot identification.

Thorough surveys of the contaminated area produced the isocontamination contour map shown in Figure 1. It was estimated that there were about 3150 g ($\pm$ 20%) of plutonium on the surface of the ice. About 99% of the contamination was confined to the blackened crust where the fuel had burned. The edge of the blackened crust was closely coincident with the 0.9 mg/m^2 isocontour line. This level is about 400 times greater than the proposed EPA "screening level" of 0.2 uCi/m^2 for transuranic contamination in soil.

Snow samples were taken by Danish scientists at numerous locations (primarily to the south and west) away from the immediate crash site. The maximum contamination level observed was 0.4 uCi/m^2. The geometric mean of all the samples was about 0.004 uCi/m^2.

One of the major constraints in the clean up operation was that whatever actions that were going to be taken on the ice had to be finished by the later part of April when the ice would become unsafe to work on. Whatever plutonium

contamination remained on or in the ice at that time would disappear into the bay.

It was decided to remove all of the snow inside of the blackened zone which included an area of about 60,000 m^2. With an average snow depth of 10 cm, this would produce a volume of 6000 m^3. Assuming that the volume ratio of packed snow to water would be about 2.5, this would produce about 6×10^5 gallons of water. After all of the aircraft debris had been removed from the ice, the snow in the blackened area was scraped into rows, picked up and transferred into sixty-seven 25,000 gallon tanks.

In the area of the aircraft impact, the ice had been broken, melted, and refrozen. To assess the level of contamination in the ice, 85 core samples were taken in the fractured area. There was plutonium contamination associated with black bands distributed in the ice which were produced by burned fuel. It was estimated that about 350 g of plutonium were contained in the roughly 2000 tons of ice. Studies showed that when samples of the ice were melted, essentially all of the plutonium contamination sank to the bottom. Another 48 core samples were taken outside the fractured area. They disclosed no contamination in or under the ice.

A decision was made to let the contaminated ice melt in place for three reasons. First, even if the plutonium were to stay suspended in water, it would rapidly be reduced to non-hazardous levels by dispersion. Second, it was likely that the plutonium would settle into the sediment layer on the

bottom of the bay and become effectively isolated from the inhabitants in the area. And third, the clean-up operations which had already taken place were not completed until the end of March, which left only a few weeks before the ice would become unsafe to work on.

Many environmental surveys have been conducted by Danish scientists in the years since the accident. These surveys have focused on determining the levels and distribution of plutonium contamination in the marine environment and investigating the possible impact that might be transmitted through the food chain to the Greenlanders (see Figure 2). The surveys have produced the following major conclusions:

1. The inventory of plutonium in the sediment on the bottom of the bay is about 30 Ci. The maximum concentration under the crash site is about 50 pCi/g (see Figure 3). The vertical displacement of the plutonium is about 7-8 mm/y which indicates that it will become increasingly unavailable to the biota in the sediments.

2. Plutonium has been found in increased quantities (up to 6 pCi/g) in the organisms (mussels, starfish, and shrimp) that live in the sediment, but the concentrations are decreasing with time.

3. Certain seaplants have been found to concentrate plutonium by a factor of about 13,000.

4. In 1979, seawater did not contain measurable amounts of plutonium from the accident, except in particles just above the seabed at the point of impact.

5. In the most recent environmental survey completed in 1979, plutonium from the accident was not detected in any of the higher animals (birds, fish, mammals) with any certainty. The contamination has been confined to the sediment and those organisms that live in or on the sediment.

The only direct link between the Greenlanders and the portion of the foodchain with detectable plutonium contamination is through the mussels (bivalves). In 1974, the average concentration of plutonium in the soft parts of the mussels found within a radius of 20 km of the crash site was about 20 pCi/kg. If we asume that a Greenlander eats 100 grams of mussels a day from this region for 70 years, the estimated annual dose rate to the bone at the end of 70 years would be .075 mrad (from EPA 520/-77-016, Table A3-6). Even with this extremely conservative scenario, the projected maximum annual dose rate is less than 3% of the proposed EPA limit.

I was unable to find any cost estimates for the clean up operation at Thule. It involved the resources and people of many organizations and would be difficult to reconstruct. However, since the clean up operations apparently were sufficient to meet the requirements for limiting exposures to individuals as currently proposed by the EPA, it is my opinion that the clean up costs wouldn't be appreciably different today than they were then, save the adjustment for inflation.

REFERENCES

1. "Project Crested Ice", USAF Nuclear Safety, Volume 65 (Part 2) Special Edition, Jan/Feb/Mar 1970.

2. Aarkrog, A, "Environmental Behavior of Plutonium Accidentally Released at Thule, Greenland", Health Physics, Volume 32, No. 4, April 1977.

3. Aarkrog, A, et al., "Radioecological Investigations of an Environmental Contamination with Transuranic Elements", 1980 Progress Report, Radiation Protection, Commission of European Communities.

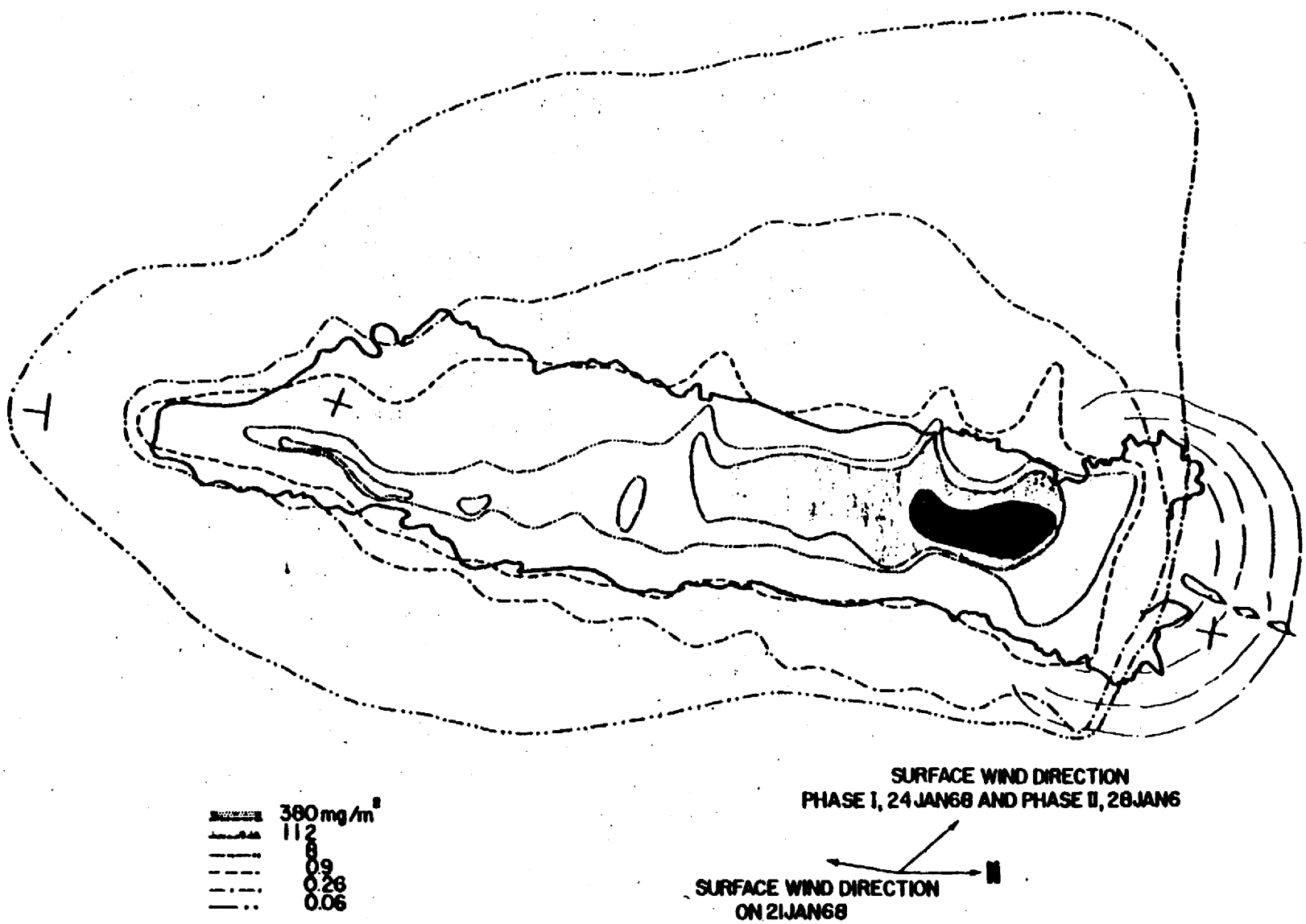


Figure 1 Plutonium contamination levels observed.

Taken from reference 1

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

CS—137

ISLAND	% OF ISLAND CLEANED	CS-137 pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3	10	6	-40
JANET	13	31	16	-48
PEARL	44	15	7	-53
SALLY	4.5	7	3.5	-50

*TOP 15 cm.

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

SR—90

ISLAND	% OF ISLAND CLEANED	SR-90 pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3	47	31	-33
JANET	13	69	32	-54
PEARL	44	28	11	-61
SALLY	4.5	12	4	-67

* TOP 15 cm.

ENEWETAK CLEANUP PROJECT COSTS (000)

DNA-MILCON	$18,177.4
DNA-BASE CAMP EXPANSION	1,362.8
DNA-OPERATION & MAINTENANCE	19,692.0
SERVICES-AIR FORCE	3,877.1
-ARMY	33,797.5
-NAVY	7,863.8
DOE-RADIOLOGICAL SUPPORT*	3,371.0
DOI-REHABILITATION	14,100.0
	$102,241.6

*AN ADDITIONAL $1.5 MILION DOE COST WAS REIMBURSED FROM DNA-MILCON FUNDS.

SOME COST RATIO APPROXIMATIONS

TOTAL COST OF CLEANUP AND REHABILITATION: $102,240,000.

COST PER:	UNITS	COST
HECTARE*	33	$3,100,000
ACRE*	81	1,262,000
CUBIC METER SOIL	79,500	1,285
CURIE	14.7	6,955,000
FATALITY	2	51,120,000
LIFE SAVED	0.025	4,089,664,000

*INCLUDES ONLY THAT AREA FROM WHICH SOIL WAS REMOVED.

CLEANUP YARDSTICKS

SOIL MOVED TO CACTUS CRATER, yd^3	104,097
TRU IN MOVED SOIL, CURIES	14.7
DEBRIS — UNCONTAMINATED - TO LAGOON, yd^3	122,810
— UNCONTAMINATED - TO SALVAGE, yd^3	54,500
— CONCRETE RUBBLE - SHORE PROTECTION, yd^3	76,340
— CONTAMINATED - TO CACTUS CRATER, yd^3	5,883
SOIL SAMPLES ARCHIVED	11,455
AIR SAMPLED, m^3	866,227
AIR FILTERS ANALYZED	5,204
GAMMA SPECTROMETRY - IN LAB	11,553
- IN-SITU	6,000 +
COCONUT TREES PLANTED	30,333
DOCUMENTATION GENERATED, LINEAR FT	200 +

FATALITIES DURING ENEWETAK RADIOLOGICAL CLEANUP

MILITARY

19 AUG 77*	USN WELDER, EXPLOSION WHILE WELDING ON LANDING CRAFT.
17 NOV 77	USA PVT, CARDIAC ARREST WHILE PLAYING BASKETBALL.
14 AUG 78*	USA NCO, CARDIAC ARREST WHILE PINNED BETWEEN D8 DOZER AND DUMP TRUCK.
29 DEC 78	USAF CPT, LOST WHILE SAILBOATING FOR RECREATION.
29 DEC 78	USA PFC, LOST WHILE SAILBOATING FOR RECREATION.
06 JAN 80	USA SPEC 4, ASPIRATION OF THE LUNGS ON HIS OWN VOMITUS, THEN SUFFOCATION.

* SATISFIES NATIONAL SAFETY COUNCIL CRITERIA FOR INCLUSION IN DATA TABLES FOR REPORTING ACCIDENT STATISTICS

DOE & CONTRACTORS

JUL 79	EIC FIELD SUPERVISOR, DEPARTED ATOLL FOLLOWING INCIDENCE OF CHEST PAINS, AND CHECKED INTO HOSPITAL IN HONOLULU, DIED SEVERAL DAYS LATER OF HEART PROBLEMS.
79	H&N BARBER, DIED IN HIS SLEEP OF NATURAL CAUSES. (?)

TOP CAUSES OF DEATH IN U.S. POPULATION, 1976

CAUSE	DEATH RATE*	EXPECTED DEATHS IN 30 YR IN POPULATION OF 500
ALL CAUSES	888	133
HEART DISEASE	336	50
CANCER	171	26
STROKE	91	14
ACCIDENTS	48	7

*DEATHS PER 100,000 POPULATION (FROM ACCIDENT FACTS, 1977)

WORK ACCIDENTS

INDUSTRY GROUP	WORKERS (000) [a]	DEATHS [a]	DEATH RATES [b] 1976	1981
ALL INDUSTRIES	87,800	12,500	14	12
TRADE	20,300	1,300	16	5
MANUF. & SERVICE	39,800	3,500	19	7
GOVERNMENT	14,900	1,700	11	10
TRANSP. & UTILITIES	4,800	1,500	31	31
AGRICULTURE	3,500	1,900	54	54
CONSTRUCTION	3,700	2,100	57	40
MINING	800	500	63	55
ENEWETAK CLEANUP	1	0.7	70	

[a] IN 1976

[b] PER 100,000 WORKERS IN EACH GROUP.

[c] TOTAL OF 8033 INDIVIDUALS INVOLVED IN 3 YEAR PROJECT WITH NO MORE THAN 1000 INVOLVED AT ONE TIME.

BASIC DATA FROM ACCIDENT FACTS, 1977 AND 1982.

AT-WORK ACCIDENTAL DEATHS, 1980

	AT WORK	
	DEATHS	RATE[a]
TOTAL U.S.	13,000	5.7
HIGHEST STATE - WYOMING	63	13.3
- NEVADA	39	4.9
LOWEST STATE - NEW YORK	174	1.0
DOE & CONTRACTORS		5.6[b]
NTS AVERAGE 1965-81	1.35	27.0[c]

a. DEATHS PER 100,000 WORKER YEARS. (FROM ACCIDENT FACTS, 1981)

b. 1978-82 AVERAGE (FROM INJURY AND PROPERTY DAMAGE SUMMARY, JAN-JUN 1983, USDOE)

c. BASED ON NTS AVERAGE MONTHLY WORK FORCE.

SUMMARY OF AT-WORK FATALITY RATES

ACTIVITY	FATALITY RATE*	RISK
ALL INDUSTRIES (1976)	14	1.4×10^{-4}
CONSTRUCTION (1976)	57	5.7×10^{-4}
ALL AT WORK, STATE OF NEV. (1980)	4.9	4.9×10^{-5}
DOE & CONTRACTORS (1978-82 AVG.)	5.6	5.6×10^{-5}
NTS (1965-81 AVG.)	27	2.7×10^{-4}
ENEWETAK CLEANUP	70	7.0×10^{-4}

*DEATHS PER 100,000 WORKER YEARS

INFORMATION THAT HAS BEEN OBTAINED

IF PEOPLE WILL LIVE ON ENEWETAK, JAPTAN, AND MEDREN;
IF THEY WILL EAT FOOD FROM THEIR ATOLL ALONG WITH FOOD FROM OUTSIDE;
IF THEY DO GATHER COCONUTS FROM BILLAE TO MIJIKADREK;

THE LARGEST AMOUNT OF RADIATION ONE PERSON MIGHT RECEIVE DURING 1 YEAR.		28 millirem
AVERAGE AMOUNT OF RADIATION A PERSON MIGHT RECEIVE DURING 30 YEARS.	(WHOLE BODY)	200 millirem
	(BONE MARROW)	250 millirem
THE INCREASE OF CANCERS THAT MIGHT OCCUR WITHIN THE NEXT 30 YEARS.		0.10%
THE POSSIBLE INCREASE OF CHILDREN BORN WITH HEALTH DEFECTS WITHIN THE NEXT 30 YEARS.		0.04%

THIS MEANS THAT IF THERE WOULD BE 10,000 PEOPLE DIE WITHIN THE NEXT 30 YEARS FROM ANY CANCER OTHER THAN THAT CAUSED BY RADIAITON LEFT FROM ATOMIC BOMBS, THERE MIGHT BE AN ADDITIONAL 10 WHO DIE FROM CANCER THAT IS CAUSED BY RADIATION LEFT FROM ATOMIC BOMBS

THIS MEANS THAT IF THERE WERE 10,000 CHILDREN BORN WITH HEALTH DEFECTS OCCURING FROM ANY CAUSE OTHER THAN RADIATION LEFT FROM ATOMIC BOMBS, WITHIN THE NEXT 30 YEARS, THERE MIGHT BE AN ADDITIONAL 4 CHILDREN BORN WITH DEFECTS CAUSED BY RADIATION LEFT FROM ATOMIC BOMBS.

ESTIMATES OF TRU DOSE TO RETURNING ENEWETAK PEOPLE

	30 YEARS	50 YEARS	AVERAGE*
PRE-CLEANUP			
ESTIMATES OF POST-CLEANUP WORST CASE	7,800 mrem	13,000 mrem	13.0 mrad/yr.
POST-CLEANUP			
ENJEBI (100% OF TIME, IMPORTS UNAVAILABLE)	394 mrem	1,080 mrem	1.0 mrad/yr.
SOUTHERN ISLANDS (95% OF TIME, IMPORTS)	60 mrem	163 mrem	0.2 mrad/yr.

*AVERAGE ANNUAL BONE DOSE (RAD) USING 50 YEAR TOTAL AND ALPHA QUALITY FACTOR OF 20.

TRU CONTRIBUTION IS A SMALL PART OF TOTAL DOSE DURING INITIAL 30 YEARS.

RADIATION-INDUCED CANCER IN THE ENEWETAK POPULATION

ENEWETAK PEOPLE WERE TOLD IF THERE WERE 10,000 DEATHS FROM CANCER NOT RELATED TO RADIATION, THERE MIGHT BE AN ADDITIONAL 10 PEOPLE DIE OF CANCER DURING THE NEXT 20 YEARS AS A RESULT OF THE RADIATION REMAINING ON THE ISLANDS, ASSUMING LIVING AND EATING PATTERNS IN CONFORMANCE WITH CASE 3 CLEANUP.

ASSUME THE FOLLOWING CONDITIONS:

- DURING THE NEXT 30 YEARS, AN AVERAGE OF 500 PEOPLE RESIDE ON ATOLL, WITH THE HELP OF IMPORTED FOOD. (15,000 PERSON-YEARS)
- CAUSES OF DEATH ARE THE SAME AS FOR THE U.S. POPULATION IN 1976 (FOR LACK OF BETTER DATA).

THEN, THERE MIGHT BE AN ADDITIONAL 0.026 DEATH FROM CANCER CAUSED BY THE RADIATION.

(NOTE: DOSE ESTIMATES INCLUDED INTAKE OF CESIUM AND STRONTIUM WHICH WERE EXCLUDED FROM CONSIDERATION IN THE CLEANUP CRITERIA.)

RISK OF RADIATION-INDUCED CANCER DEATH AT ENEWETAK

NUMBER RESIDENTS, AVERAGE/YEAR, 30 YEARS	500
ADDITIONAL RADIATION-INDUCED CANCER DEATHS, 30 YEARS	0.026
ADDITIONAL CANCER DEATHS PER YEAR, PER 500 RESIDENTS	0.0009
RATE PER 1,000,000	1.7
APPROXIMATE RISK TO FUTURE RESIDENTS	1.7×10^{-6}
APPROXIMATE RISK TO CLEANUP WORKERS	7.0×10^{-4}

THE GAME ISN'T OVER 'TIL THE LAST OUT

THE ENEWETAK CLEANUP PROJECT OFFICIALLY ENDED APRIL 15, 1980. ACTIVITIES SINCE THEN INCLUDE:

REPORT TO ENEWETAK PEOPLE, DOE	25 PGS	1979
ISLAND CERTIFICATION BY DOE,	92 PGS	1980
DOSE ASSESSMENT, LLNL	92 PGS	1980
PROJECT REPORT, DNA	700 PGS	1981
PROJECT REPORT, DOE	712 PGS	1982
SOIL SAMPLES IN ARCHIVE AT NTS UNTIL		?
MONITORING OF CACTUS DOME UNTIL		?
BEGIN RADIONUCLIDE MONITORING OF COCONUTS		1986
MONITOR COCONUTS UNTIL		?
SAVE DATA BASE TAPES UNTIL		?

OVERVIEW OF RADIATION DOSE STANDARDS AND RELEVANCE TO REMEDIAL ACTION CRITERIA (DOE/OMA)

Battelle

JANUARY 1984

J.P. CORLEY
RADIOLOGICAL SCIENCES DEPARTMENT

RADIATION PROTECTION STANDARDS ORGANIZATIONS

ADVISORY

- ICRP — INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION
- NCRP — NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS

- OTHERS — NUCLEAR ENERGY AGENCY
  INTERNATIONAL ATOMIC ENERGY AGENCY

REGULATORY

- EPA — ENVIRONMENTAL PROTECTION AGENCY (SUPERSEDED FRC-FEDERAL RADIATION COUNCIL)

- NRC — NUCLEAR REGULATORY COMMISSION
- OSHA — OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
- OTHERS — DEPARTMENT OF TRANSPORTATION
  BUREAU OF RADIOLOGICAL HEALTH
  AMERICAN NATIONAL STANDARDS INSTITUTE
  AMERICAN SOCIETY FOR TESTING AND MATERIALS

BASES FOR RADIATION LIMITS

- RISK
- DOSE LIMIT
- ALARA
- MULTIPLE OF "BACKGROUND"
- MEASUREMENT CAPABILITY

RELATIONSHIPS OF STANDARDS CRITERIA

STAGE	PERTINENT FACTORS	STANDARDS CRITERIA
EFFLUENT RELEASES		RELEASE GUIDES, OPERATING LIMITS
(A)	METEOROLOGY, BIOLOGY, HYDROLOGY, PHYSICAL AND CHEMICAL FORMS, CONCENTRATION FACTORS	
DISPERSION AND/OR RECONCENTRATION		CONCENTRATION GUIDES, CONTAMINATION LIMITS
(B)	EXPOSURE PERIODS, CONSUMPTION RATES	
INTAKE AND EXPOSURE		INTAKE RANGES -- FRC; ANNUAL LIMITS OF INTAKE -- ICRP
(C)	UPTAKE AND ABSORPTION FACTORS, DISTRIBUTIONS IN BODY, BIOLOGICAL HALF-LIVES, BODY DIMENSIONS, RADIATION TYPES AND ENERGIES	
DOSE		DOSE LIMITS --ICRP AND NCRP PUBLICATIONS DOE ORDER 5480.1A NRC (10 CFR 20 etc.) EPA (40 CFR 190 etc.)
(D)	DOSE/RESPONSE RELATIONSHIPS, INDIVIDUAL VARIATIONS	
HEALTH EFFECTS		RISK/PROBABILITY (ICRP NO. 26) (EPA - TRU IN SOIL)

REVIEW OF STANDARDS

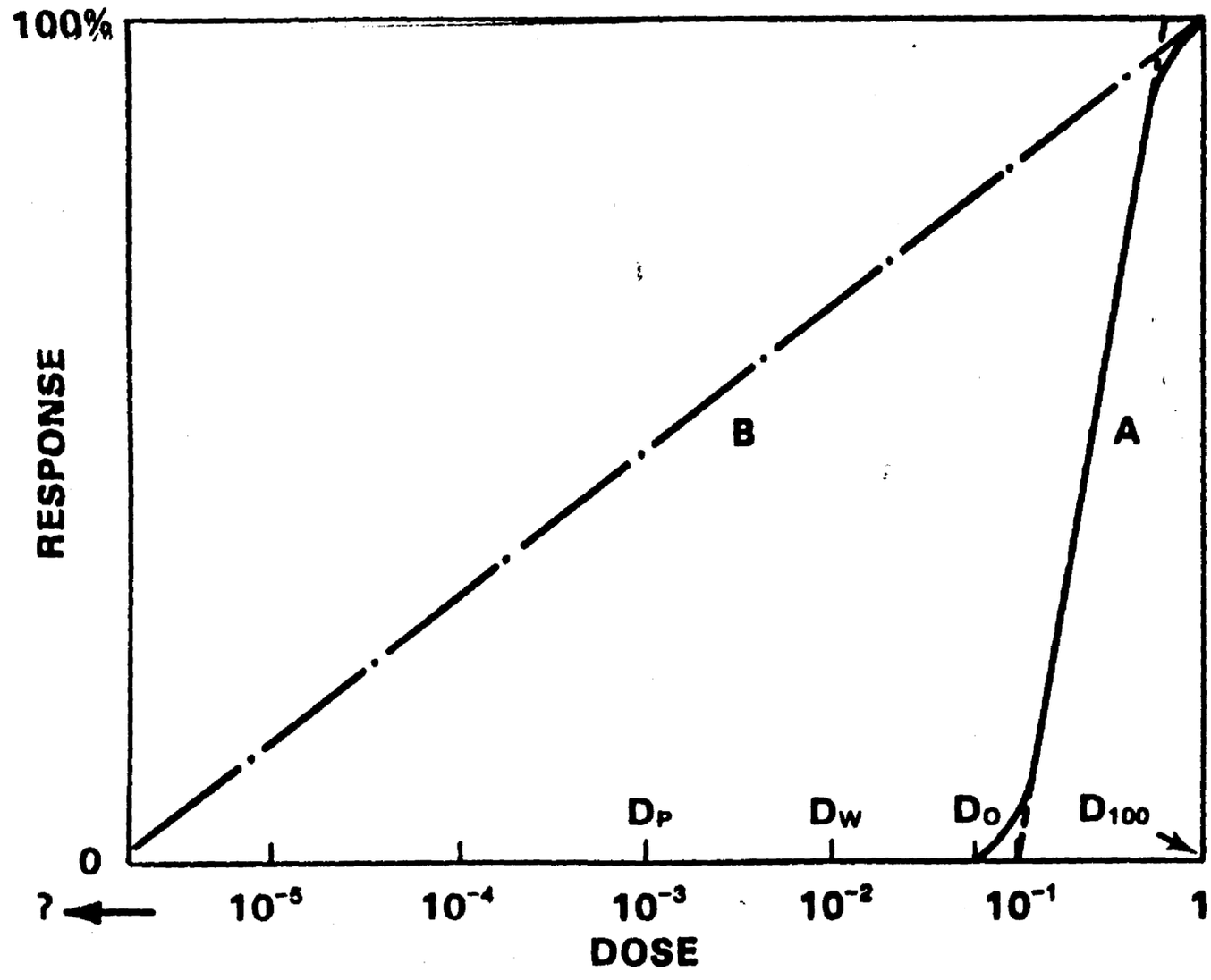
HISTORICAL

1. FRACTION OF DOSE FOR OBSERVABLE RESPONSE (e.g. ERYTHEMA, BLOOD COUNTS)
   - GENERALLY SHORT-TERM
   - NON-STOCHASTIC

2. GENETIC EFFECTS
   - AGE PRO-RATION; 5 (n-18)

3. ALARA (ALAP)
   - JUSTIFICATION

4. TOTAL RISK OF HEALTH EFFECTS
   - RISK ≡ PROBABILITY
   - STOCHASTIC RISKS CONTROLLING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RESPONSE
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DOSE

REVIEW OF TERMINOLOGY

DOSE (DOSE RATE)

UNIT	CONCEPT
rad	ABSORBED DOSE
rem	DOSE EQUIVALENT
rem	DOSE EQUIVALENT COMMITMENT (∞)
rem	COMMITTED DOSE EQUIVALENT (t)
rem	COMMITTED EFFECTIVE (WHOLE BODY) DOSE EQUIVALENT (WEIGHTING FACTORS FOR RISK)

REVIEW OF TERMINOLOGY

EXPOSURE (EXPOSURE RATE)

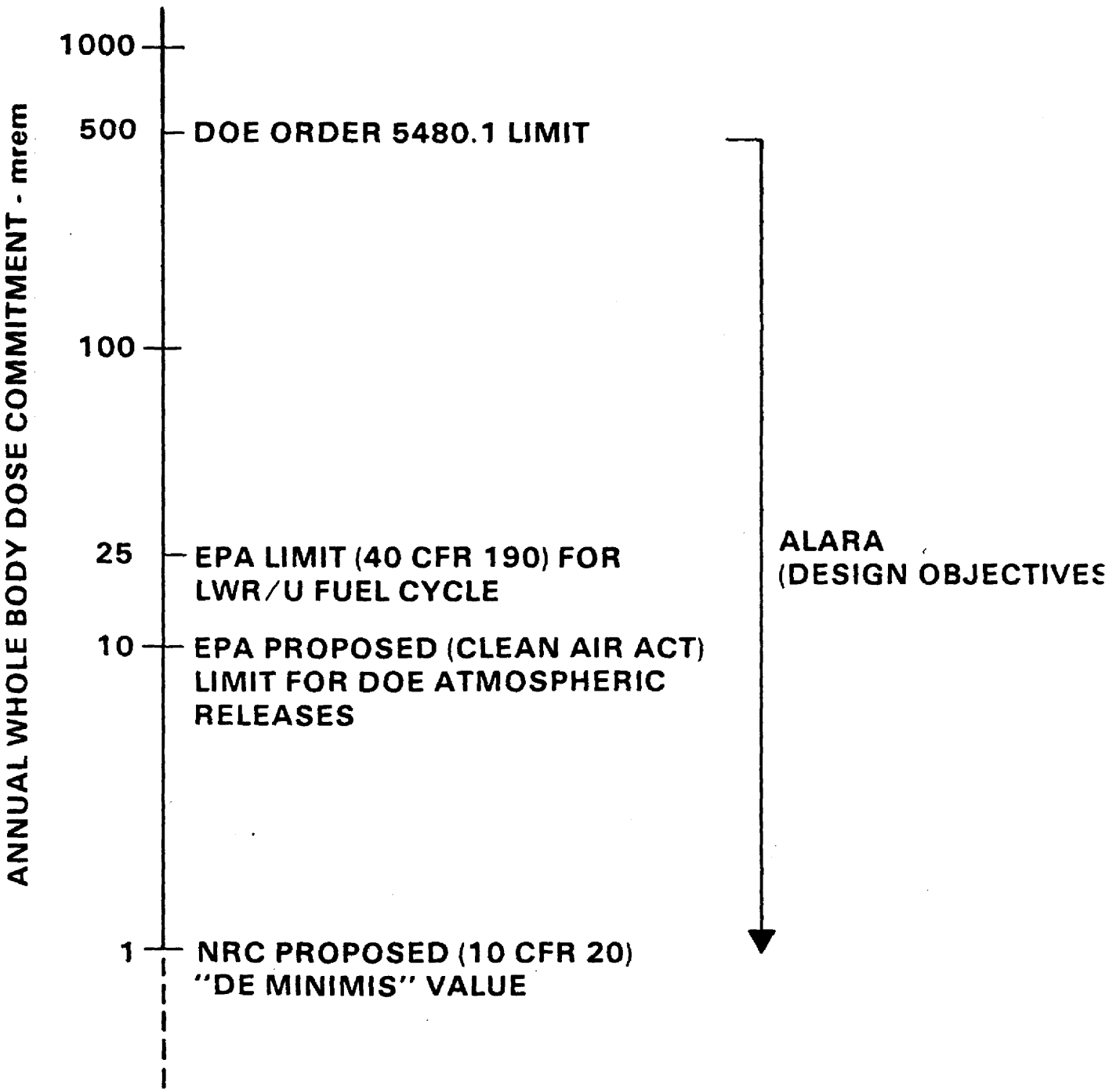
UNIT	CONCEPT
ROENTGEN	EXTERNAL GAMMA OR X RADIATION
CURIES PER CUBIC METER CURIES PER KILOGRAM	RADIONUCLIDE CONCENTRATION IN AIR, WATER, FOOD
CURIES PER SQUARE METER	CONTAMINATION OR EMANATION (RADON)
CURIES (PER UNIT TIME)	RADIONUCLIDE INTAKE QUANTITY

REVIEW OF TERMINOLOGY

REGULATION AND MANAGEMENT

- LIMITS
- ACTION (INTEREST) LEVELS/WORKING LIMITS
- SCREENING LEVELS
- ACCEPTABLE LEVELS
- ALARA
- LESS THAN REGULATORY CONCERN (de minimis)

DOSE COMMITMENT SCALE



MAJOR CHANGES IN ENVIRONMENTAL RADIATION PROTECTION CRITERIA

ICRP No. 26

- Committed vs. Annual dose equivalent
- Summation of Risk - Use of Weighting Factors
- Assumptions as to Distribution of Dose (Risk) in Exposed Population

EPA

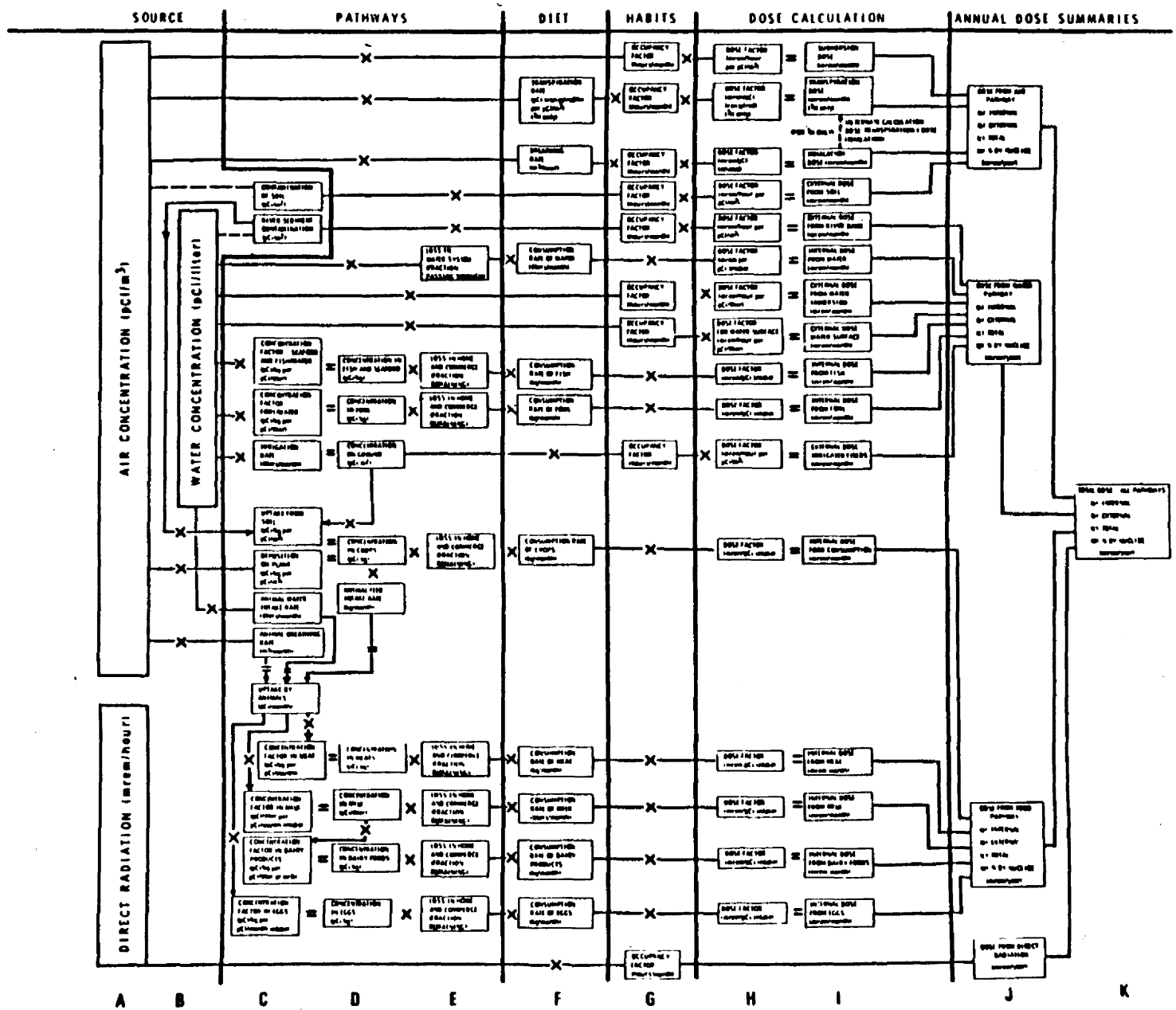
- Multiple Time Periods - Years of Committed Dose
  Years of Continuing Exposure
  Years of Environmental Buildup
- Quantification of ALARA

PROPOSED EPA REGULATIONS
WHOLE BODY (EFFECTIVE) RADIATION DOSE LIMITS

High level & TRU Waste Disposal (40CFR191)	25 mrem/yr
DOE Facilities - Clean Air Act (40CFR61)	10 mrem/yr
Phosphorus Plants - Clean Air Act	2 mrem/yr

EXISTING EPA REGULATIONS
WHOLE BODY (ANNUAL) RADIATION DOSE LIMITS

Safe Drinking Water Act (40CFR141)	4 mrem/yr
Nuclear Power Operations (40CFR190)	25 mrem/yr


SOURCE
PATHWAYS
DIET
HABITS
DOSE CALCULATION
ANNUAL DOSE SUMMARIES
AIR CONCENTRATION (pCi/m³)
WATER CONCENTRATION (pCi/liter)
DIRECT RADIATION (mrem/hour)
A
B
C
D
E
F
G
H
I
J
K

COMPARISON OF LIMITING AIR CONCENTRATIONS (μCi/ML)
MAXIMUM INDIVIDUAL IN UNCONTROLLED AREA

RADIONUCLIDE	DOE ORDER 5480.1A TABLE II (AIR) CG	ICRP No. 30[A]
^{3}H (AS HTO)	$2x10^{-7}$	$1x10^{-6}$
^{90}Sr	$3x10^{-11}$	$3x10^{-11}$
^{238}U	$5x10^{-12}$	$7x10^{-13}$
^{239}Pu	$6x10^{-14}$	$7x10^{-14}$

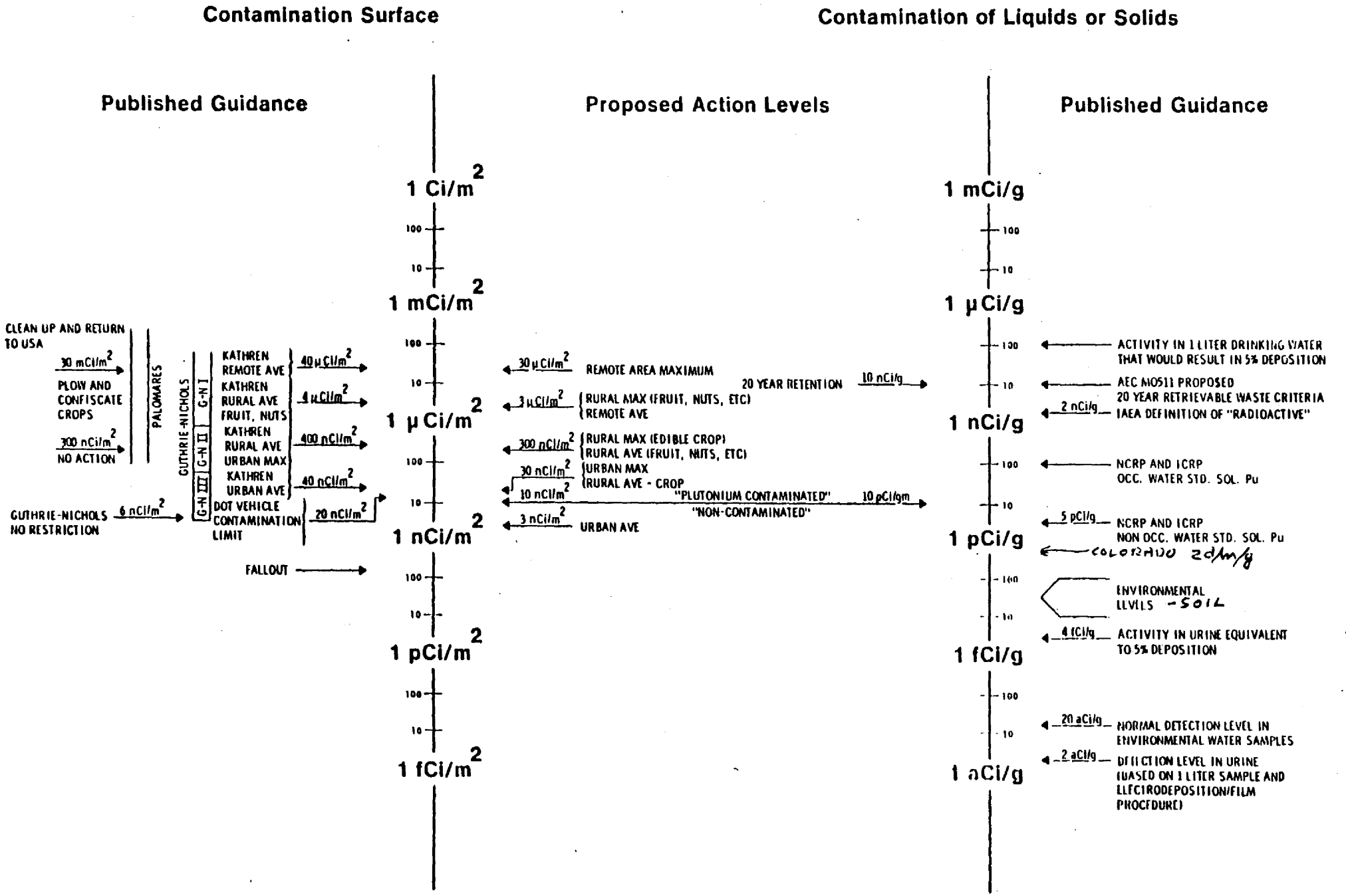
TABLE 1. Ratio of the Committed Dose Equivalent to the Annual Dose Equivalent for Inhalation

Radionuclide	Whole Body	Bone	Lung	GI-LLI	Thyroid
^{3}H	1.0	1.0	1.0	1.0	1.0
^{14}C	1.0	1.0	1.0	1.0	1.0
^{65}Zn	1.2	1.2	1.1	1.0	1.0
^{85}Kr	1.0	1.0	1.0	1.0	1.0
$^{90}Sr+D$	14	15	1.8	1.0	1.0
^{131}I	1.0	1.0	1.0	1.0	1.0
^{129}I	1.1	1.0	1.0	1.0	1.1
$^{137}Cs+D$	1.0	1.1	1.1	1.0	1.0
^{226}Ra	18	24	1.9	1.0	1.0
^{234}U	7.6	15	4.6	1.2	1.0
^{238}U	7.6	15	4.6	1.2	1.0
^{239}Pu	33	30	2.5	1.0	1.0

TABLE 2. Ratio of the Committed Dose Equivalent to the Annual Dose Equivalent for Ingestion

Radionuclide	Whole Body	Bone	Lung	GI-LLI	Thyroid
^{3}H	1.0	1.0	1.0	1.0	1.0
^{14}C	1.0	1.0	1.0	1.0	1.0
^{65}Zn	2.3	2.4	1.0	3.2	1.0
^{85}Kr	1.0	1.0	1.0	1.0	1.0
$^{90}Sr+D$	40	45	1.0	1.0	1.0
^{131}I	1.0	1.0	1.0	1.0	1.0
^{129}I	1.6	1.1	1.0	1.0	1.6
$^{137}Cs+D$	1.7	1.8	1.9	1.0	1.0
^{226}Ra	50	70	1.0	1.0	1.0
^{234}U	1.6	3.2	1.0	1.0	1.0
^{238}U	1.5	3.1	1.0	1.0	1.0
^{239}Pu	90	90	1.0	1.0	1.0

PLUTONIUM ACTION LEVELS



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JAN 25 10 37 AM '84

RBBU11FX RHEGLAF8737 0242228 MTMS-UUUU--RHEGNVF.

ZNR UUUUU

R 242228Z JAN 84

FM J W HEALY MS-P228 LOS ALAMOS NATIONAL LABORATORY

LOS ALAMOS NM 87545

TO RHEGGTF/TOMMY MCGRAW EP-342 USDOE WASHINGTON DC

RHEGRLF/JACK CORLEY BATTELLE NORTHWEST LABORATORY PO BOX 999

RICHLAND WA

RHEGRLF/KEN HEID BATTELLE NORTHWEST LABORATORY PO BOX 999

RICHLAND WA

RHEGORF/C R RICHMOND ORNL PO BOX X OAK RIDGE TN

RHEGRFF/ROBERT YODER ROCKWELL INTERNATIONAL ATOMICS INTERNATIONAL

DIVISION ROCKY FLATS PLANT PO BOX 464 GOLDEN CO

RHEGNVF/BRUCE CHURCH DOE PO BOX 14100 LAS VEGAS NV 0961

AE-XNAE

UNCLAS/NONWD/F A X

THIS TRANSMITTAL CONSIST OF 5 PAGES

BT

JAN 25 1984

DRAFT

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

January 24, 1984
JG-84-5

Mr. Tommy McGraw
EP-842
U. S. Dept. of Energy
Washington, DC 20545

Dear Mr. Cannon:

The Department of Energy has conducted the review of the proposed guidance for transuranium elements in the environment by a technical committee as promised in our letter of November 15, 1983. The following comments and recommendations arose from this review.

In our letter of July 8, 1981, we indicated that we had no objections to the basic dose equivalent limits proposed as guidance. There were also many additional comments on the draft guidance as then proposed including a reference to the nearly 300 pages of technical comments provided earlier. In our current review, we felt that there have been many developments since this letter was written which caused us to change our position on these numerical values in the guidance. These include the recent developments in risk based control of exposure by the ICRP and, more recently, the proposed risk system of the NCRP. The obsolescence of the detailed guidance now proposed by the EPA is an important factor. This guidance was developed in accord with a request from the State of Colorado to provide guidance for control of the Rocky Flats contamination. This situation now seems to be under control and other existing sites of contamination with transuranium elements appear to present little or no problems. Thus, the primary use of the guidance appears to be future weapons accidents or accidents in launching a nuclear power

(1)

DRAFT

source. It seems that the information used in developing the guidance was primarily for existing sites of contamination and little real attention has been paid to what now seems to be the primary usefulness of the guidance. This guidance has been in preparation for about ten years and there have been changes in policy in the EPA that should be considered before these numbers are accepted. A noteworthy example is the talk by Mr. Ruckelshaus before the National Academy of Sciences proclaiming the policy of the EPA to use the best science available in providing their regulations. We do not believe that the present limiting numbers represent a truly scientific approach to generally applicable standards. Perhaps the results of the recently appointed subcommittee of the EPA Scientific Advisory Board will be applicable to this guidance.

We do have a number of objections to this draft guidance. The DOE questions the wide range of limits in recently issued or proposed EPA regulations for the protection of the public from radiation. This draft guidance adds another set of values to the various ones accepted by the EPA. In fact, the use of mrads rather than mrems, as in the other standards, sets this one apart from the others leading to inconsistency in units as well as in risk values. Earlier we referred to a shift in the probable application of this guidance from present sites to future accidents. However, the background studies leading to this guidance have paid little attention to this aspect of its use. There are, for example, no analyses of the cost and practicality of the values given. In particular, the potential political problems caused by these low values if the accident occurs on foreign soil have not been addressed. The current guidance is now about seven years old. Much has

(2)

happened in that time, including added experience in the cleanup of areas contaminated with transuranium elements. Thus, we can only regard the present draft as obsolescent. Some of the later concepts and experience should be studied with respect to this guidance. In particular, the question of flexibility in application of the guidance should be considered. Since DOE will undoubtedly be a technical advisor to DOD or NASA in event of another accident, we are concerned that many options will be foreclosed by the present lack of flexibility. In this respect, there are words giving flexibility in the document, but not in the recommendations section. In fact, this section reflects the view that the guidance must be followed. Since we do not know what portion of this document will be signed by the President, if approved, this lack of flexibility in the recommendations could lead to serious problems in implementation. Finally, a number of statements in the present (and past) draft leads to belief that EPA was attempting to incorporate ALARA into their considerations but appropriate analyses for the present use in future accidents are not included.

As a result of this review, the DOE has several recommendations for the revision of this guidance and for development of future regulations and guidance.

(1) The EPA should issue generally applicable radiation standards in the form of a limiting risk.

(2) The scope of the generally applicable guidance should be broadened to cover all radionuclides in the environment. This would provide

guidance applicable to present decontamination and cleanup work and would not overemphasize the transuranium elements.

(3) The guidance should not be based on ALARA but rather on the EPA's version of a reasonable risk considering other risks. The use of ALARA should be in addition to meeting the standards and an applicable level of ALARA should be defined by the responsible agency that has knowledge of the details of the given situation.

(4) DOE has changed their former position on having EPA provide a screening level. We now believe that the EPA should provide the generally applicable guidance and that DOE, DOD, NASA, and other Agencies as needed, cooperate to produce any screening level required. As we now envision it, there are two levels that need to be defined: (a) a screening level below which action is not needed; and (b) an action level above which cleanup could be started without further studies. This would satisfy the need of the operator who needs a number to work with while other studies define the actions needed in the intermediate zone.

(5) The DOE recommends that EPA take a consistent approach to the setting of environmental standards and guidance so that these standards represent a coherent whole rather than a fragmented group of inconsistent standards.

DRAFT

(6) A general problem that has existed in the past, and is still present, is the lack of strong interagency working groups that allow involved people to talk to each other on policy, technical problems, and implementation. The DOE strongly recommends that EPA avail themselves of the help that can be obtained from other agencies in such working groups. The present system is not working because problems of mutual interest do not seem to arise at the infrequent meetings of the present interagency working group.

Copies Faxed to the following:

Jack Corley, Battelle NW
Ken Heid, Battelle NW
B. Church, NVOO
Chet Richmond, ORNL
Robert Yoder, Rocky Flats

(5)

Summary of
Radiological Guidelines for the
DOE FUSRAP Program
for
DOE Conference on EPA Transuranic Guides

Wayne R. Hansen
Los Alamos National Laboratory

The Department of Energy (DOE) programs for Surplus Facilities and Formerly Utilized Sites Remedial Action Program (FUSRAP) has prepared some draft criteria for residual radiation levels. This paper summarizes a joint effort by Los Alamos National Laboratory, Argonne National Laboratory, Oak Ridge Operations, and Bechtel National, Inc., to prepare a background document for such criteria.

The FUSRAP sites in the DOE program involve a wide range of radioactive contamination in soils, building wastes, sludges, and chemical residues. The majority of site contaminants involve higher than normal, naturally occurring radionuclides and three sites involve fission products and transuranics. Before remedial action decisions on these sites were possible, some basis for decision regarding completion of remedial action was necessary.

In 1981, the DOE Inspector General stated that decisions regarding the need for remedial actions should be based on site specific health effects assessments and a cost/benefit analysis. To meet the needs of the program, ORO-831 was prepared based on DOE Standards for Radiation Protection of the Public.

The methods of analysis and the source to dose conversion factors needed to derive soil concentration guidelines from radiation protection standards are presented; the health risk studies that provide a basis for the radiation protection standards are discussed; radiological guidelines for remedial action based on the previous discussions are presented; and considerations in applications of the guides are presented.

The translation of the ORO-831 guidance into DOE criteria for FUSRAP and Surplus Facility program guidance reflect some changes due to EPA guides. Changes in the Ra-226 guidance reflect the influence of the EPA standards for inactive uranium mill tailings. The limits for transuranics in soil have not been changed to reflect the EPA guidance.

Radiological Guidelines For the DOE FUSRAP Program

for
DOE Conference on Transuranic Guidance
January 17–18, 1984

Wayne R. Hansen
Environmental Surveillance Group
Los Alamos National Laboratory

Los Alamos

OTHERS

E. Lea Keller
William Bibb
James K. Alexander
DOE, Oak Ridge Operations

Carlyle J. Roberts
Thomas L. Gilbert
John M. Peterson
Robert W. Vocke
Argonne National Laboratory

Robert Rudolph
R. Daniel Glenn
Edward Walker
Bechtel National, Inc.

Los Alamos

Discussion to cover:

- Need for FUSRAP Guides
- Summary of Work on FUSRAP Guides
- Comparison with EPA Guides

Inspector General, DOE, 1981

Questioned expenditures on Remedial Actions Without

...site-specific health effects assessments...
...cost/benefit analyses...

Los Alamos

Purpose

Provide Guidance for Estimates of:

- o Health Effects
- o Dose Assessment
- o Methods for Field Use

Los Alamos

Approach

Attempt to provide brief guidance on:

- o Environmental Pathways Methods
- o Dose Estimation
- o Health Effects Estimation
- o Derived Clean-up Guides
- o Applications of Guides

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Starting Point

DOE Orders based on Acceptable Levels of Risk as Stated By ICRP and NCRP

500 mrem/yr Maximum Individual Whole Body
1500 mrem/yr Maximum Individual Organ Dose

Assumption that ALARA Applied in Field Implementation of Site Evaluation

ORO – 831

Table of Contents

Los Alamos

Health Effects Estimators

Based on BIER III

Exception - Radon + Daughters

Based on Value From International Workshop on Radon Risks

Published by Evans et al

Los Alamos

Derived Guides

1. What is Acceptable Risk?

   ICRP - 1 chance in 100,000 to
   1,000,000 per year
   EPA - 1 chance in 1000,000 per year

2. What is Dose Limit Corresponding
   to that Level of Risk?
   500 mrem/yr to Max. Individual
   170 mrem/yr to Segment of Population

3. What Levels of Contamination Corresponds
   to Dose Limit ?

Los Alamos

Soil Remedial Action Guidelines

Radionuclide	Surface Soil Guideline (pCi/g above background)	Reference
Am–241	20	Healy 1977
Pu–241	800	Healy 1977
Pu–239, –240	100	Healy 1977
Pu –238	100	Healy 1977
Natural uranium	75	Gilbert et al. 1983
U–238	75	Gilbert et al. 1983
Th–230	300	Gilbert et al. 1983
Ra–226	15	Gilbert et al. 1983
Cs–137	80	Healy et al. 1979
Sr–90	100	Healy et al. 1979
H–3 (pCi/ml Soil moisture)	5,200	Appendix B of ORO–831

Los Alamos

RADIUM-226 AND RADON-222 REMEDIAL ACTION GUIDES

(ABOVE BACKGROUND)

RADIONUCLIDE	GUIDE	ACTION	CONDITION
RADON-222	>0.03	REQUIRED ACTION	STRUCTURES
+DAUGHTERS	<0.02	NO ACTION	
RADON-222	>3PCI/1	REQUIRED ACTION	BOUNDARY OF CONTROLLED PROPERTY
	>30PCI/1	REQUIRED ACTION	OVER SURFACE OF CONTROLLED PROPERTY
RADIUM-226	>15PCI/G	REQUIRED ACTION	10 CM OR LESS SOIL THICKNESS
	>5PCI/1	REQUIRED ACTION	SURFACE WATER OR GROUND WATER
GAMMA DOSE	>0.02 MREM/HR	REQUIRED ACTION	EXTERNAL RADIATION

Radon + Daughters
Lung Cancer Mortality

Inhaled Daughters	Population Risk	Individual Risk
1 WLM	10 cancers in 100,000	1 chance in 10,000
BKG 1pCi/ℓ (0.25 WLM indoors) (0.005–0.01 WL)	2.5 cancers in 100,000	2.5 chances in 100,000
0.03 WL	7.5 cancers in 100,000	7.5 chances in 100,000

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Approximate Absolute Risks of Cancer Mortality (BEIR III)

Dose	Cancer Deaths	Percent of Normal Cancer Mortality
1 mrad/yr alpha to lung	0.1 in 100,000	0.03
3 mrad/yr alpha to bone	0.3 in 100,000	0.10
40 mrad/yr alpha to bone surface	0.1 in 100,000	0.03
Normal Annual Risk of Cancer Death	300 in 100,000	
500 mrem/yr whole body (low LET)	4 in 100,000	1.3
170 mrem/yr whole body low LET (0.02 mrem/hr)	1.5 in 100,000	0.5

Los Alamos

Approximate Absolute Risks of Cancer Mortality (BEIR III)

Dose	Cancer Deaths	Percent of Normal Cancer Mortality
1500 mrem/yr bone surface (high LET)	0.2 in 100,000	0.7
1500 mrem/yr lung (high LET)	7.5 in 100,000	2.5
Natural Background of 100 mrem/yr whole body (low LET)	0.9 in 100,000	0.3
Congressional Aide's Suggested Start of Disability Payments Due to Radiation Cause		10

Los Alamos

Application of Guides

Derived guides based on maximum individual

Modify based on considering:

- o present and future land use
- o occupancy factors
- o distribution of contamination
- o quantities of contaminated material
- o costs in dollars and health
- o socioeconomics

Department of Energy
Nevada Operations Office
P. O. Box 14100
Las Vegas, NV 89114-4100

JAN 13 1984

T. D. Pflaum, HQ, Chief of Envir., Safety & Health (DP-226.1) GTN

COMMENTS ON EPA-PROPOSED "DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT"

The Nevada Operations Office (NV) submitted comments on the subject dose limits via our letter, Church to Pflaum, dated October 19, 1983. For convenience a copy is enclosed.

Although much can be said on this subject I wish to take this opportunity to discuss the following points.

1. EPA Objective of Reducing Risk to 10^{-6} Ultra Conservative

EPA states that they believe it appropriate to limit the risk for a cancer fatality from a single radiation source to a person in the population to 10^{-6} per year. We contend that the proposed standards in reality impose a risk limit much more conservative and could be as low as 10^{-8}.

There is considerable uncertainty in developing risk estimates from observable health effect data, and there is considerable uncertainty in estimating environmental organ doses through pathway modeling because of the assumptions made and variability of individuals (i.e., lifestyles, ingestion, uptake and growth rates, etc.).

If the maximizing assumptions are always taken, the predicted risk to a population for leaving a contaminated area undisturbed could be several orders of magnitude less than the real risk encountered during cleanup operations.

One risk not considered by EPA is the risk benefit to personnel involved in the cleanup which approximates 10^{-4}. The criteria and consideration for cleanups should include the risk of death and injury resulting from the cleanup itself.

During the course of the Enewetak cleanup, two men died in work-related accidents; six others died from a variety of causes. It is well documented that construction activities have higher fatality rates than most industries.

Because of uneven distribution (re: Hot Particle Problem) there is Room for Mischief (e.g. Rocky Flats Experience)

The following table summarizes some selected fatality rates and risks.

Activity	Fatality Rate*	Risk
All industries (1976)	14	1.4×10^{-4}
Construction (1976)	57	5.7×10^{-4}
At work (1980) State of Nevada	4.9	4.9×10^{-5}
DOE & Contractors (1978-82 average)	5.6	5.6×10^{-5}
NTS (1965-1981 average)	27	2.7×10^{-4}
Enewetak cleanup	70	7.0×10^{-4}

*Per 100,000 worker-years.

Because of the great variability in the data, and the requirement to interpolate and extrapolate, it is essential that a careful uncertainty analysis be made by EPA. This analysis is necessary to ensure confidence that the risk of cleanup does not exceed the risk from leaving the contamination undisturbed; which may be as low as 10^{-8} or lower.

2. Imaginary Versus Real Deaths!

The models used to assess the health effects (i.e. radiation-induced cancer fatalities) on the Enewetak people during the planning phase estimated $\leq$ 3 health effects (cancer deaths) over 30 years with no cleanup and no restrictions on island or food usage.

An analysis of the total radiation dose to the returning people of Enewetak after the cleanup leads to the conclusion that there might be an additional 0.026 deaths in 30 years from cancer caused by radiation. This is compared to the two persons who died in course of the three-year cleanup.

The uncertainty which is inherent in cancer-risk estimates is graphically illustrated in Table V-4, page 147 in the 1980 BEIR report in which the expected number from continuous exposure of one rad per year to a population of 1,000,000 ranges from zero to 568.

The risk estimates of cancer deaths as required by the proposed EPA standard (maximizing risk estimates) give hypothetical, or imaginary deaths as compared to the real deaths which do occur in construction projects. The fact is that no increase in cancer rate has been, nor can be, identified at the dose levels comparable to background radiation levels.

NUCLEAR WEAPONS ACCIDENT AT PALOMARES, SPAIN, RESULTING IN RADIOACTIVE CONTAMINATION

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- PARACHUTES DID NOT DEPLOY ON 2 OF 4 WEAPONS (#2 and 3)
- WEAPONS 2 AND 3 EXPERIENCED HIGH EXPLOSIVE DETONATION UPON IMPACT
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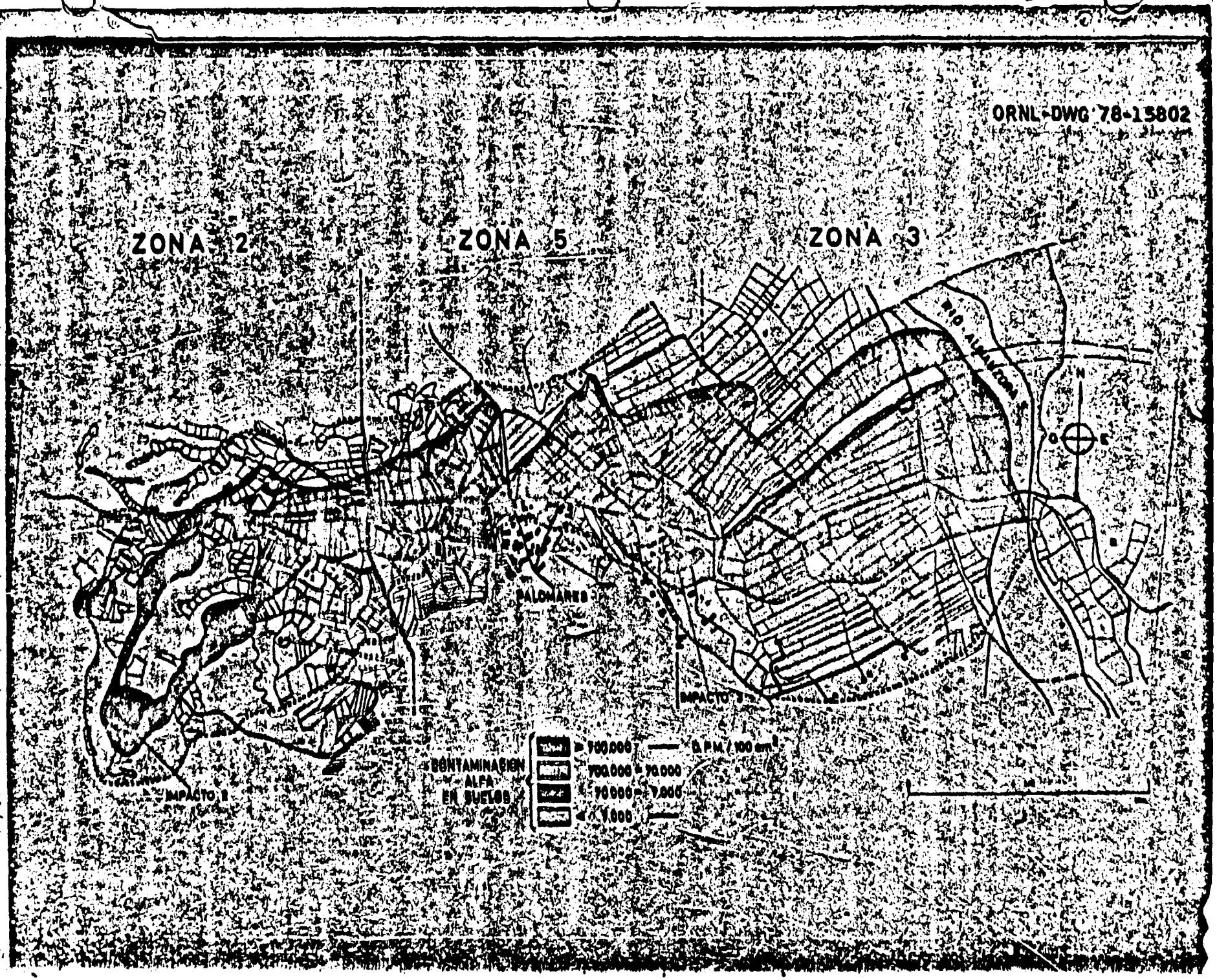
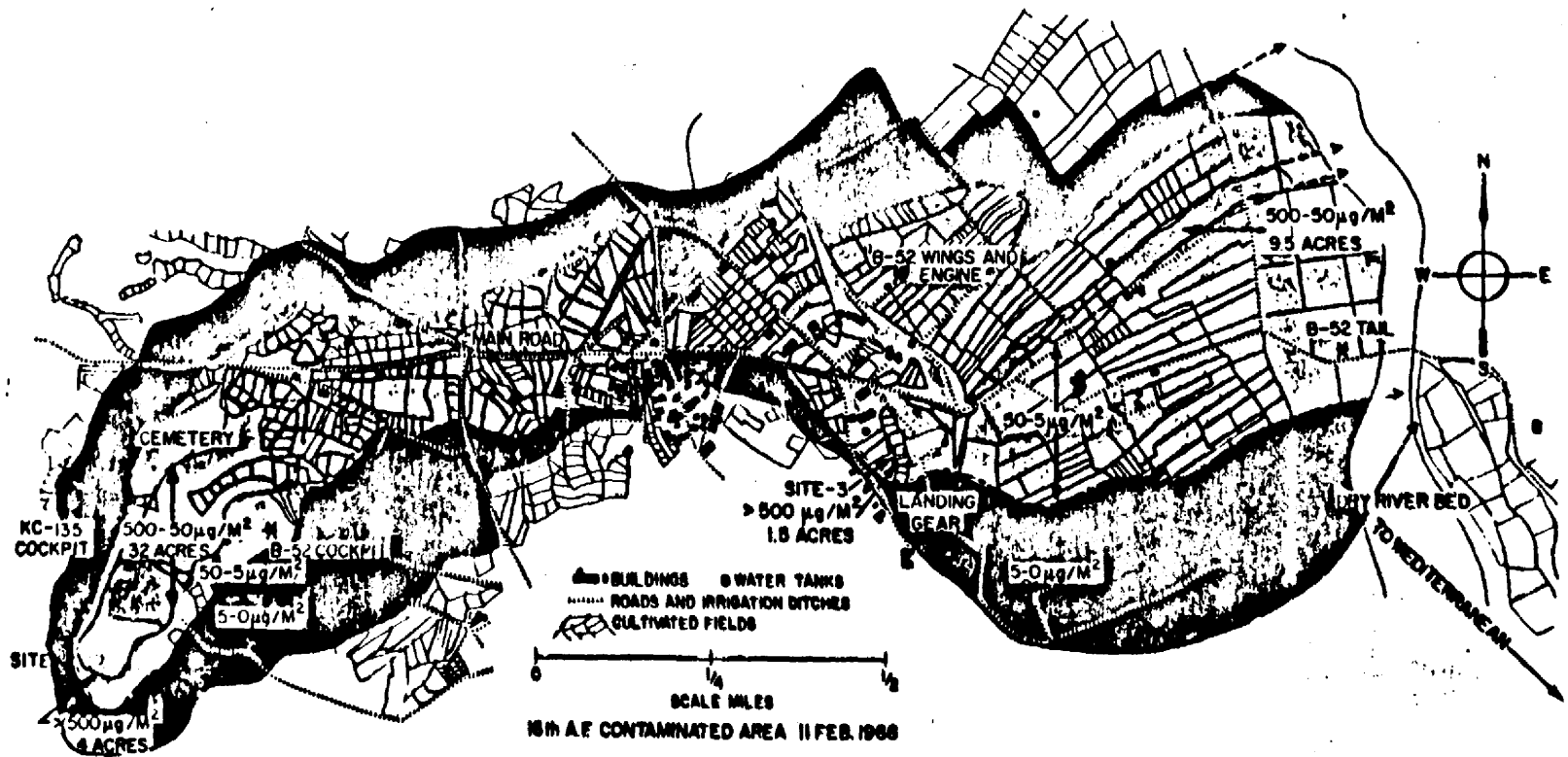

ORNL-DWG 78-15802
ZONA 2
ZONA 5
ZONA 3
RIO ALAMANCES
N
PALOMARES
IMPACTO 3
IMPACTO 2
CONTAMINACION ALFA EN SUELOS
> 100.000
100.000 a 70.000
70.000 a 7.000
< 7.000
D.P.M./100 cm²


MAIN ROAD
CEMETERY
KC-135 COCKPIT
500-50µg/M²
32 ACRES
B-52 COCKPIT
50-5µg/M²
5-0µg/M²
SITE
500µg/M²
4 ACRES
B-52 WINGS AND ENGINES
SITE-3
>500 µg/M²
1.8 ACRES
LANDING GEAR
500-50µg/M²
95 ACRES
B-52 TAIL
50-5µg/M²
5-0µg/M²
DRY RIVER BED
TO MEDITERRANEAN
N
W
E
S
BUILDINGS
WATER TANKS
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0
1/4
1/2
SCALE MILES
16th A.F. CONTAMINATED AREA 11 FEB. 1966

AIR SAMPLING PROCEDURE

- CELLULOSE FILTER 47mm DIAMETER WITH 1.2 μm PORE SIZE
- DAILY SAMPLES TAKEN YEAR AROUND
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AIR SAMPLING STATIONS IN PALOMARES

Station 2-1

- ESTABLISHED IN JUNE 1966
- LOCATED IN HILLS NEAR IMPACT POINT NUMBER 2
- SOIL IS ROCKY AND COVERED WITH WILD SHRUBS
- SOME PARTS WERE NOT POSSIBLE TO PLOUGH
- CONTAMINATION LEVELS WERE BETWEEN 3.2×10^{-1} and 3.2×10^{-2} $\mu C1/100cm^2$
- OUT OF COMMISSION SINCE SEPTEMBER 1969
- RECENTLY REESTABLISHED

AIR SAMPLING STATIONS IN PALOMARES

STATION 3-2

- ESTABLISHED IN JUNE 1966
- LOCATED NEAR THE CENTER OF HIGHEST REMAINING CONTAMINATION DOWN WIND FROM IMPACT POINT NUMBER 3
- ON PLAIN LYING ABOUT 4 METERS BELOW IMPACT POINT
- SURROUNDING AREA CONTAMINATED TO LEVELS BETWEEN 3.2×10^{-1} AND 3.2×10^{-3} $\mu Ci/100cm^2$
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VEGETATION, AND SOIL SAMPLING PLOTS

AT PALOMARES

- TWO EACH ESTABLISHED IN AREAS 2, 3 and 5 FOLLOWING REMEDIAL ACTION
- EACH 50 x 50 METERS
- NINE SAMPLING LOCATIONS PER PLOT
- FIVE SAMPLING DEPTHS (0-5; 5-15; 15-25; 25-35; 35-45 CM)
- ONE CONTROL PLOT ESTABLISHED ABOUT 8 KM FROM VILLAGE
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- VEGETATION SAMPLES OBTAINED ANNUALLY FROM EACH POINT FOR EACH PLOT IF CULTIVATED. AREA 2-1 ONLY CONTAINS WILD VEGETATION

Therefore, until the technology is developed to perform TRU cleanups where workers do not take substantially higher risks (which are real) to achieve a condition where the risks (which are hypothetical) are substantially lower than daily risks, guidance should be limited to reflect the greatest savings of life.

The Enewetak cleanup, which was designed to conform with the proposed EPA guidance is the epitome of the above discussion. According to risk analyses published in the planning documents, the islands could have been turned over to the people without a radiological TRU cleanup and saved lives. Ultraconservatism costs more than just time and dollars, it can cost real lives.

3. Cost Versus Benefit

Reasonable alternatives should be evaluated when decisions are made affecting the expenditure of resources. The radiological cleanup at Enewetak cost approximately $100 million and resulted in the potential of averting less than one cancer death from radiation in 30 years in the Enewetak population. How many premature deaths from disease and illness might have been averted in the Enewetak population by directing $100 million into improving health care knowledge, facilities, and capability? We may not have the information available to answer this question, but it is not unreasonable to consider this alternative. Similar logic should be applied in considering any radiological cleanup.

Bruce W. Church, Director
Health Physics Division

HPD:DLW

cc:
L. J. Deal, HQ (EP-342) GTN
T. F. McCraw, HQ (EP-32) GTN
A. B. Siebert, Jr., HQ (DP-3.1) GTN
P. J. Mudra, Dir., OD, NV
Roger Ray, DPO, NV
J. D. Stewart, OD, NV
E. D. Campbell, NSD, NV
D. R. Martin, SHD, NV

T. P. Pelaum, HQ, Chief of Envir., Safety & Health (DP-226.1) GTN
ATT": R. W. Nank, HQ (DP-226.1) GTN

COMMENTS ON EPA-PROPOSED "DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT"

The Nevada Operations Office (NV), Health Physics Division (HPD), has obtained comments from the scientific laboratories, appropriate contractors, and staff on the subject document. A brief summary of those comments is provided below.

Because the maximum measured Pu concentration outside of the Nellis Bombing and Gunnery Range (observed during sampling approximately 10 years ago) is less than a half of the screening level, we believe the recommendations of the report probably will not impact significantly on NTS activities. Even so, the recommendations are not considered reasonable. However, because there is great variability between locations of samples and aliquots of the same soil sample (i.e., the hot particle problem), it is conceivable that someone could find off-site locations which would exceed the screening level. In addition, we have substantial areas contaminated above these limits on the Nellis range, but off the NTS, as well as substantial areas above the limits on the NTS. It appears that the real basis for these recommendations is "as low as can be technically achieved without heavily consuming Agency budgets," and is not based on any cost-benefit analysis. Any number of approaches could be used to assign a value to a life and thereby calculate a dollar value for dose reduction which could be balanced against cleanup costs. Instead, the report lists an absolute risk of 10^{-2} to 10^{-4} deaths per year as reasonable and then turns around and selects 10^{-5} (not 5×10^{-5} or 3×10^{-5}) without considering cost or benefit.

The guidance levels of 1 nCi/yr to the pulmonary lung, 3 nCi/yr to bone, or 30 nCi/yr to the bone surface are not directly measurable quantities and therefore are of little practical use. Complex and questionable calculations would be required to transform measured contamination levels to doses. Any such calculations contain judgmental factors concerning dietary habits and personal preferences which could be challenged and the responsible agency could find itself in endless court battles regarding compliance. The only certain way to assure compliance would be prohibition for routine operations.

Costs of cleanup, if it should be required, are estimated in the EPA document at upwards of $10,000 per acre, which exceeds the intrinsic land value around the NTS by more than ten times. This kind of cost relative to the estimated potential health effects is much less than one one-millionth of a "health effect" seems grossly excessive.

T. Y. [illegible] -2-

[illegible] happy to work with [illegible] in developing [illegible] response to DOE on this matter.

[illegible]

Bruce M. Church, Director
Health Physics Division

BMC:FM:FM

cc:
T. F. McGraw, III (EP-23) CTY

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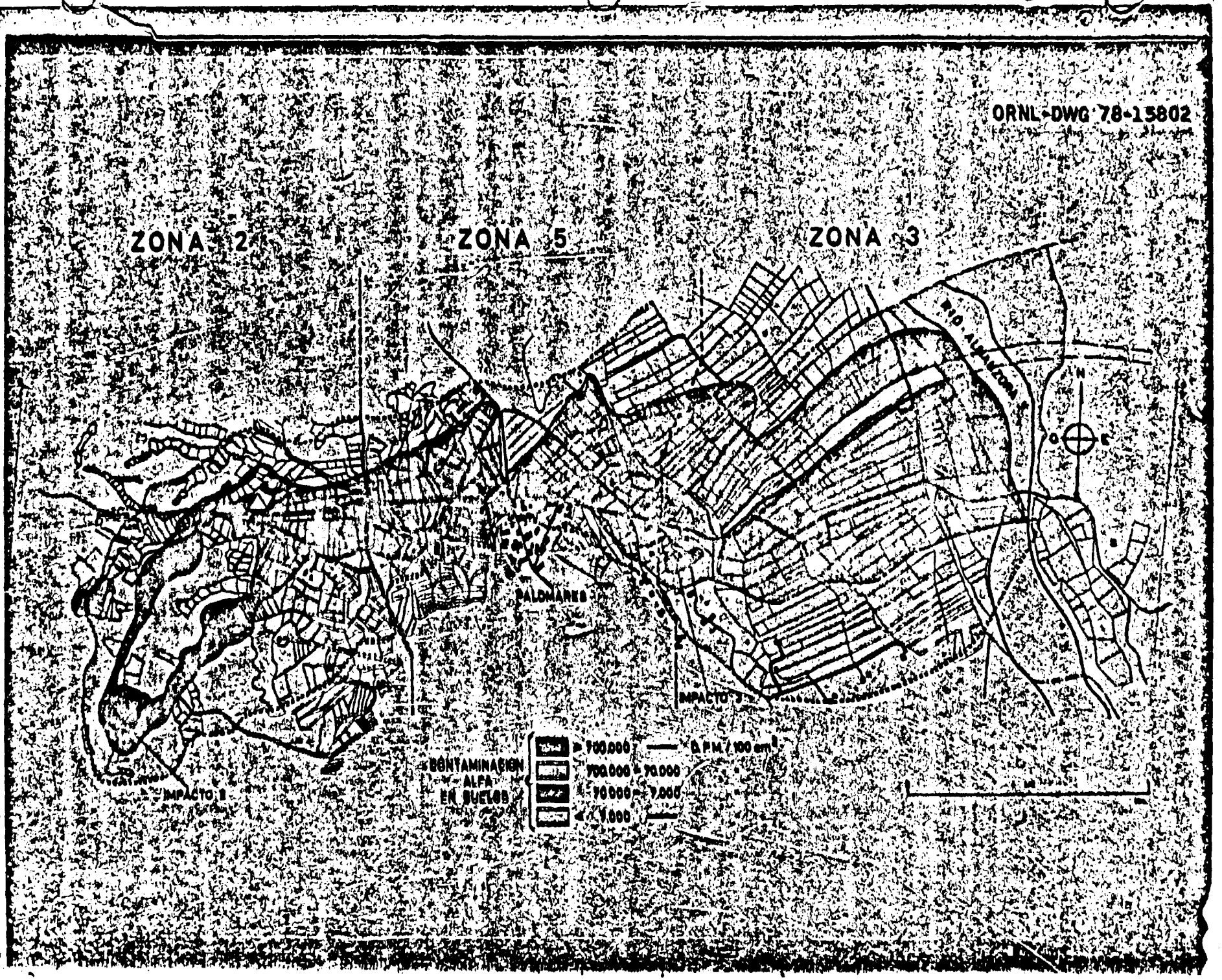
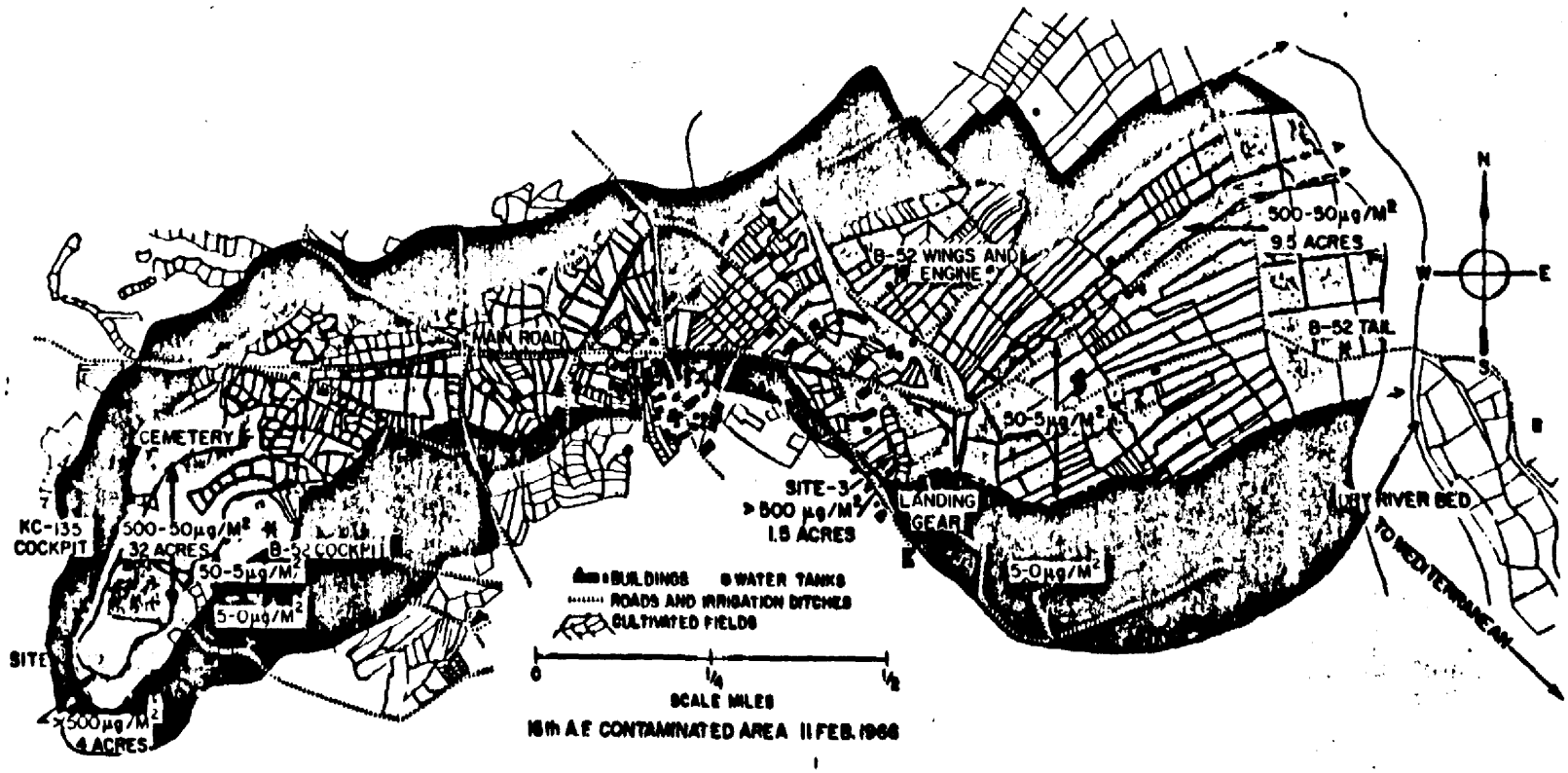

ORNL-DWG 78-13802
ZONA 2
ZONA 5
ZONA 3
RIO ALAMILLOS
N
O
E
PALOMARES
IMPACTO 2
IMPACTO 3
CONTAMINACION ALFA EN SUELOS
> 700.000
700.000 - 70.000
70.000 - 7.000
< 7.000
D.P.M./100 cm²


N
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500-50µg/M²
9.5 ACRES
B-52 WINGS AND ENGINE
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MAIN ROAD
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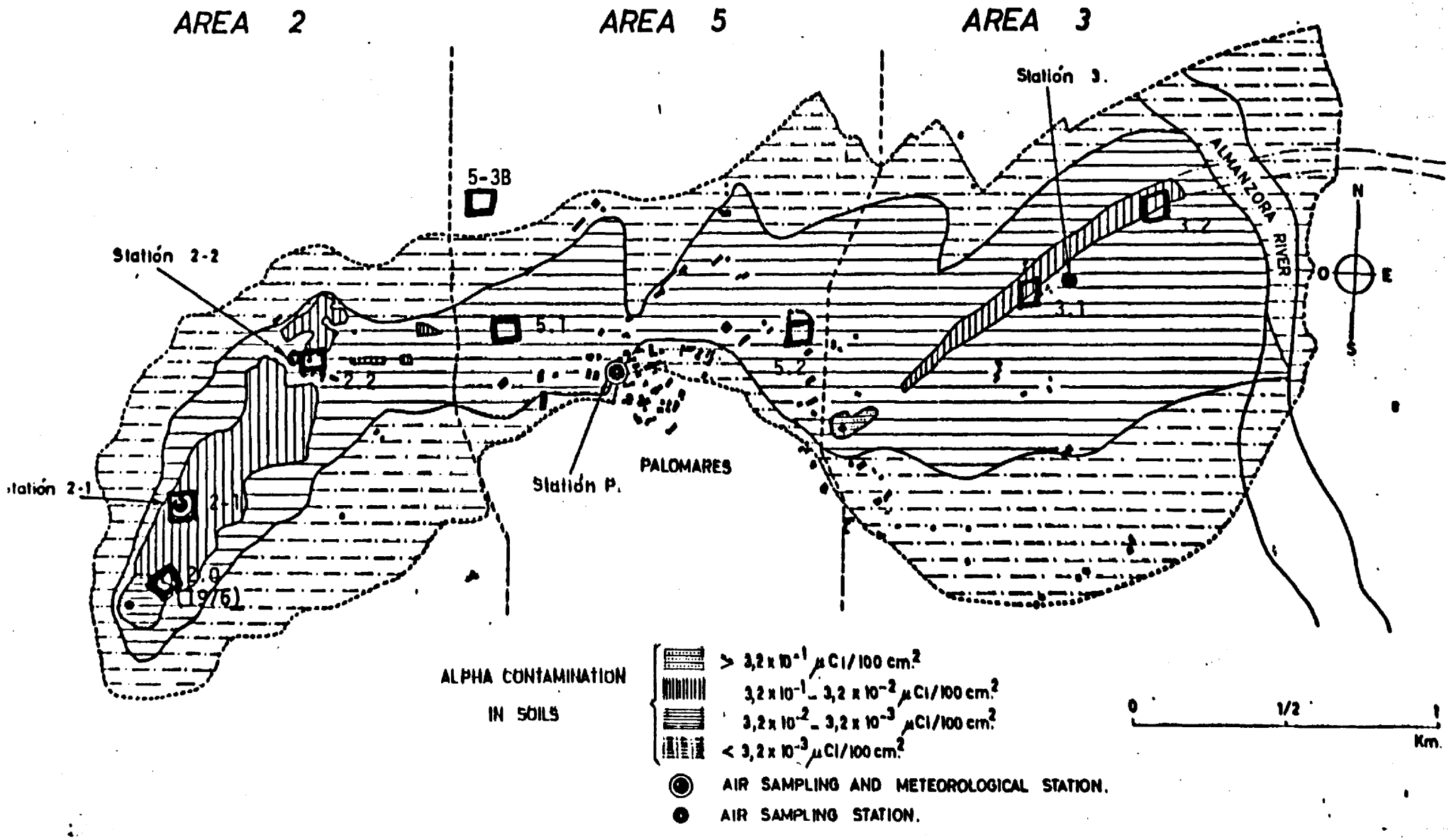
AREA 2
AREA 5
AREA 3
Station 3.
5-3B
Station 2-2
5.1
2.2
5.2
3.1
ALMANZORA RIVER
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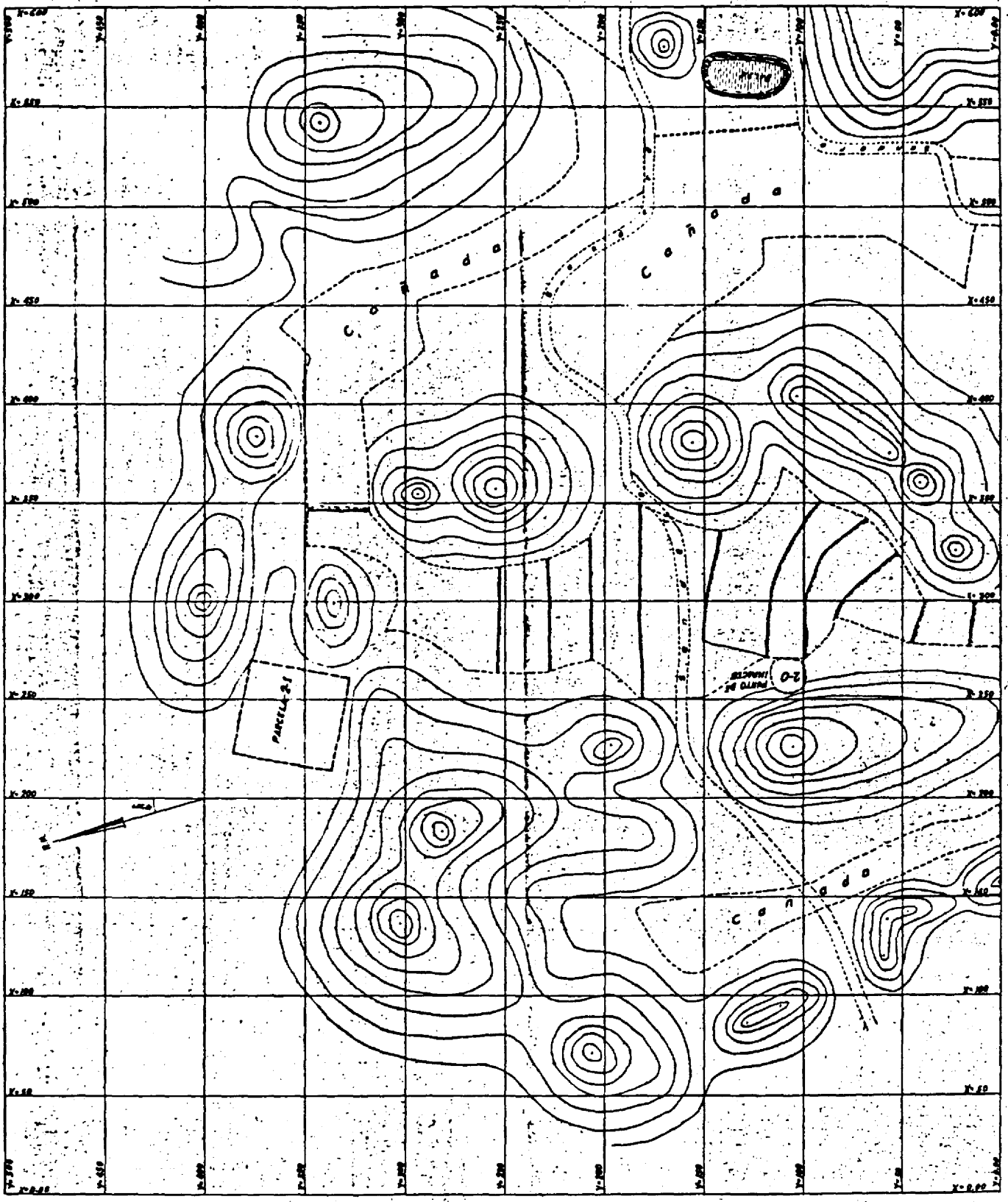
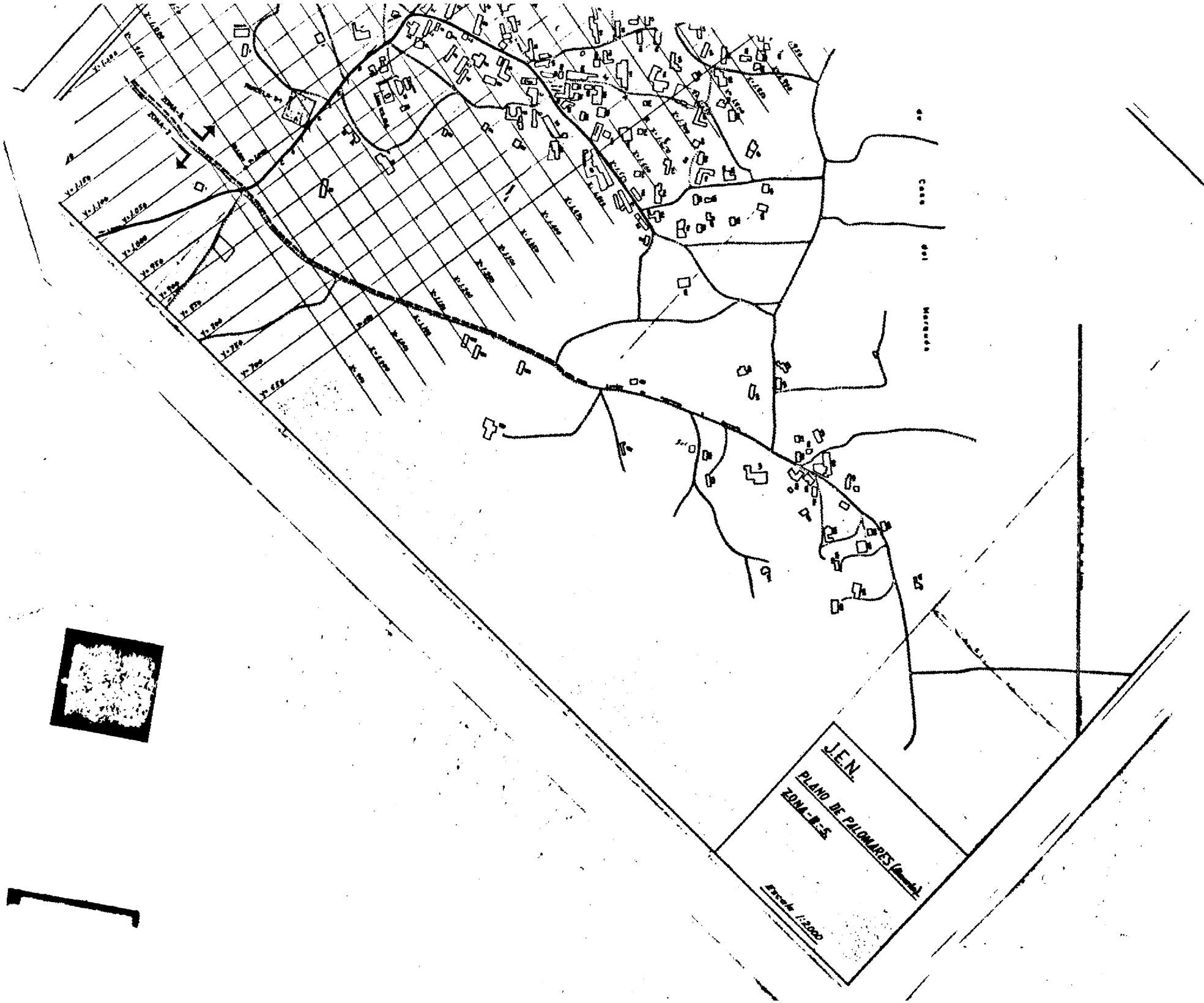
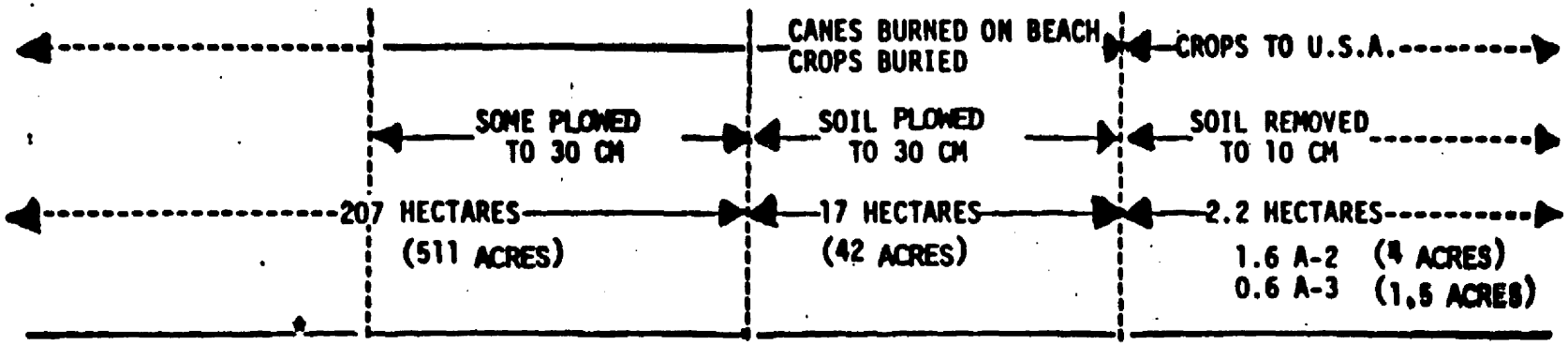
Station P.
PALOMARES
tation 2-1
2-1
2-3
(1976)
ALPHA CONTAMINATION
IN SOILS
> 3,2 x 10⁻¹ μCi/100 cm.²
3,2 x 10⁻¹ _ 3,2 x 10⁻² μCi/100 cm.²
3,2 x 10⁻² _ 3,2 x 10⁻³ μCi/100 cm.²
< 3,2 x 10⁻³ μCi/100 cm.²
AIR SAMPLING AND METEOROLOGICAL STATION.
AIR SAMPLING STATION.
0
1/2
1
Km.


PARCELA 2-1
2-0
Cañada


J.E.N.
PLANO DE PALOMARES
ZONA - II - 5
Escala 1:2000

REMEDIAL ACTIONS TAKEN AT PALOMARES FOLLOWING ACCIDENT IN JANUARY 1966



$\mu Ci/m^2$	.32**	3.2	32
$\mu g/m^2$	5.0	50.0	500
$dpm/100cm^2$	7000.0	70,000.0	700,000
Bq/m^2	1.18×10^4	1.18×10^5	1.18×10^6

* EPA Screening Level of 0.2 μCi Pu/m^2 ~ 4,400 dpm/100 cm^2 ~ 3.1 $\mu g/m^2$

** ~ 1.3×10^{10} 1 μm particles/m^2

MEAN ANNUAL Pu-239 AND Pu-240 CONCENTRATIONS IN

BREATHABLE AIR DURING THE

PERIOD 1966 - 1980

	CONCENTRATIONS AT STATION ($pCi \times m^{-3} \times 10^{-3}$)			
YEAR	2-1	2-2	P	3-1
1966	1.13	1.21	0.4	0.74
1967	0.41	11.94	0.11	0.35
1968	0.19	0.59	0.07	0.09
1969	4.35	3.84	0.07	0.38
1970		0.16	0.06	
1971		0.06	0.09	
1972		0.28	0.05	
1973		0.08	0.06	
1974		0.22	0.11	
1975		0.44	0.05	
1976		0.12	0.05	
1977		0.32	0.15	
1978		0.45	0.06	
1979		0.52	0.15	
1980		0.89	0.76	

POPULATION GROUPS CONSIDERED FOR CALCULATING THE DOSE EQUIVALENT

(YEARS OF INHALATION)

GROUP	BABY	CHILD	YOUTH	ADULT	TOTAL	AGE AT THE TIME OF THE ACCIDENT
1	0	10	5	0	15	1
2	0	0	6	9	15	11
3	0	0	0	15	15	18

DOSE RECEIVED (REM) BY INHALING Pu—239 THROUGH 12—31—1980 STATION IN PALOMARES

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	1.926—04	4.427—03	2.896—06	2.778—03	1.390—02	7.262—04
2	1.503—04	3.456—03	2.635—06	2.654—03	1.289—02	7.206—04
3	1.810—04	4.164—03	2.614—06	3.188—03	1.254—02	8.679—04

Particle size: 0.3 micron

DOSE RECEIVED (REM) BY INHALING Pu-239 THROUGH 12-31-2015(+)

STATION IN PALOMARES

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	6.870-04	1.591-02	2.900-06	1.040-02	2.350-02	3.085-03
2	9.620-04	2.232-02	2.639-06	1.501-02	2.508-02	4.592-03
3	1.089-03	2.528-02	2.618-06	1.690-02	2.564-02	5.197-03

(+)It is assumed that the Pu-239 concentration is nil after 12-31-1980

Particle size: 0.3 micron

DOSE RECEIVED (REM) BY INHALING Pu-239 THROUGH 12-31-1980

STATION 2-2

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	3.632-03	8.352-02	2.974-05	5.101-02	2.036-01	1.319-02
2	2.540-03	5.844-02	2.562-05	4.450-02	1.868-01	1.218-02
3	3.260-03	7.502-02	2.513-05	5.701-02	1.831-01	1.563-02

Particle size: 0.3 micron

DOSE RECEIVED (REM) BY INHALING Pu-239 THROUGH 12-31-1980

STATION 2-2

GROUP	BODY	BONE	INTESTINE	LIVER	LUNG	KIDNEY
1	3.632-03	8.352-02	2.974-05	5.101-02	2.036-01	1.319-02
2	2.540-03	5.844-02	2.562-05	4.450-02	1.868-01	1.218-02
3	3.260-03	7.502-02	2.513-05	5.701-02	1.831-01	1.563-02

Particle size: 0.3 micron

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR THE URBAN AREA THROUGH THE YEAR 2015 AS A RESULT OF INHALATION DURING THE PERIOD 1966-1980, AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	23.5	7.2	10.4	4.4	15.9	6.7
2	25.1	7.7	15.0	6.4	22.3	9.5
3	25.6	7.9	16.9	7.2	25.3	10.7

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	3.1	1.3	0.006	0.003	0.69	0.29
2	4.6	2.0	0.005	0.003	0.96	0.41
3	5.2	2.2	0.005	0.003	1.09	0.46

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR THE URBAN AREA DURING THE PERIOD 1966-1980 AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	13.9	4.2	2.8	1.2	4.4	1.9
2	12.9	3.9	2.7	1.1	3.5	1.5
3	12.5	3.8	3.2	1.4	4.2	1.8

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	Ø.73	Ø.31	Ø.006	Ø.003	Ø.19	Ø.08
2	Ø.72	Ø.31	Ø.005	Ø.003	Ø.15	Ø.06
3	Ø.87	Ø.37	Ø.005	Ø.003	Ø.18	Ø.08

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR STATION 2-2

DURING THE PERIOD 1966-1980 AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	203.6	63.0	51.0	21.6	83.5	35.4
2	186.8	57.6	44.5	18.9	58.4	24.8
3	183.1	56.0	57.0	24.1	75.0	31.8

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	13.2	5.7	0.060	0.030	3.6	1.5
2	12.2	5.2	0.052	0.026	2.5	1.1
3	15.6	6.7	0.051	0.025	3.3	1.4

EXTREME POTENTIAL DOSE EQUIVALENT VALUES (MREM) FOR STATION 2-2
UP TO THE YEAR 2015, FROM INHALATION DURING THE PERIOD 1966-1980,
AS A FUNCTION OF AEROSOL SIZE

	LUNGS		LIVER		BONE	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	240.0	73.2	99.6	42.2	161.4	68.4
2	244.0	75.0	132.5	56.1	200.8	85.1
3	255.1	78.5	177.0	74.9	270.2	114.4

	KIDNEYS		INTESTINES		REMAINDER	
GROUP	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM	MINIMUM
1	29.1	12.5	0.060	0.030	7.0	3.0
2	41.2	17.8	0.052	0.026	8.6	3.7
3	55.4	23.8	0.051	0.025	11.6	4.9

PLUTONIUM CONTAMINATION AT THULE

Summary of Notes for Talk

Given at DOE Meeting on Proposed

EPA Guidelines for Transuranium

Elements in the Environment

January 17, 1984

David S. Myers

Lawrence Livermore National Laboratory

PLUTONIUM CONTAMINATION AT THULE

On January 21, 1968, a B-52 carrying 4 nuclear weapons crashed and burned on the ice near Thule, Greenland. The 7 crew members bailed out before the crash and 6 survived. At the time of the crash, the plane was carrying about 225,000 pounds of JP-4 jet fuel. The resultant fire produced a blackened area on the ice of about 500 feet wide by 2100 feet long. The ice was cracked for about 100 yards in all directions from the point of the impact.

At the time of the crash, the temperature was -24°F and a 7 knot wind reduced this to an equivalent -53°F reading. It would be about 3 weeks yet until the sun made its first appearance after the long Artic night. During the next few weeks, several storms swept the area. The combination of darkness, storms, severe cold, and the remote location would make recovery operations extremely difficult.

Within a few days, members of the U.S. Air Force, scientific experts from LASL and Livermore, and Danish scientists were assembled at Thule to assess the accident situation. It quickly became clear that there was plutonium contamination around the crash site, but there was no evidenace of any nuclear yield. Also, it was determined that the ice at the crash site was 2 to 4 feet thick and sufficient to support vehicles and structures as long as adequate spacing was maintained.

One of the first priorities was to establish the extent of the contamination around the crash site and determine a zero line outside of which no contamination was detectible. The most valuable instrument for mapping the contamination level was the FIDLER detector developed at Livermore. This instrument is designed to detect the low energy x-rays (14 keV to 20 keV) from plutonium and the 60 keV photon from Am-241. Because of the snow cover, the 60 keV photons from ^{241}Am produced better sensitivity and were used for contamination contour mapping and hot-spot identification.

Thorough surveys of the contaminated area produced the isocontamination contour map shown in Figure 1. It was estimated that there were about 3150 g ($\pm$ 20%) of plutonium on the surface of the ice. About 99% of the contamination was confined to the blackened crust where the fuel had burned. The edge of the blackened crust was closely coincident with the 0.9 mg/m^2 isocontour line. This level is about 400 times greater than the proposed EPA "screening level" of 0.2 uCi/m^2 for transuranic contamination in soil.

Snow samples were taken by Danish scientists at numerous locations (primarily to the south and west) away from the immediate crash site. The maximum contamination level observed was 0.4 uCi/m^2. The geometric mean of all the samples was about 0.004 uCi/m^2.

One of the major constraints in the clean up operation was that whatever actions that were going to be taken on the ice had to be finished by the later part of April when the ice would become unsafe to work on. Whatever plutonium

contamination remained on or in the ice at that time would disappear into the bay.

It was decided to remove all of the snow inside of the blackened zone which included an area of about 60,000 m^2. With an average snow depth of 10 cm, this would produce a volume of 6000 m^3. Assuming that the volume ratio of packed snow to water would be about 2.5, this would produce about 6×10^5 gallons of water. After all of the aircraft debris had been removed from the ice, the snow in the blackened area was scraped into rows, picked up and transferred into sixty-seven 25,000 gallon tanks.

In the area of the aircraft impact, the ice had been broken, melted, and refrozen. To assess the level of contamination in the ice, 85 core samples were taken in the fractured area. There was plutonium contamination associated with black bands distributed in the ice which were produced by burned fuel. It was estimated that about 350 g of plutonium were contained in the roughly 2000 tons of ice. Studies showed that when samples of the ice were melted, essentially all of the plutonium contamination sank to the bottom. Another 48 core samples were taken outside the fractured area. They disclosed no contamination in or under the ice.

A decision was made to let the contaminated ice melt in place for three reasons. First, even if the plutonium were to stay suspended in water, it would rapidly be reduced to non-hazardous levels by dispersion. Second, it was likely that the plutonium would settle into the sediment layer on the

bottom of the bay and become effectively isolated from the inhabitants in the area. And third, the clean-up operations which had already taken place were not completed until the end of March, which left only a few weeks before the ice would become unsafe to work on.

Many environmental surveys have been conducted by Danish scientists in the years since the accident. These surveys have focused on determining the levels and distribution of plutonium contamination in the marine environment and investigating the possible impact that might be transmitted through the food chain to the Greenlanders (see Figure 2). The surveys have produced the following major conclusions:

1. The inventory of plutonium in the sediment on the bottom of the bay is about 30 Ci. The maximum concentration under the crash site is about 50 pCi/g (see Figure 3). The vertical displacement of the plutonium is about 7-8 mm/y which indicates that it will become increasingly unavailable to the biota in the sediments.

2. Plutonium has been found in increased quantities (up to 6 pCi/g) in the organisms (mussels, starfish, and shrimp) that live in the sediment, but the concentrations are decreasing with time.

3. Certain seaplants have been found to concentrate plutonium by a factor of about 13,000.

4. In 1979, seawater did not contain measurable amounts of plutonium from the accident, except in particles just above the seabed at the point of impact.

5. In the most recent environmental survey completed in 1979, plutonium from the accident was not detected in any of the higher animals (birds, fish, mammals) with any certainty. The contamination has been confined to the sediment and those organisms that live in or on the sediment.

The only direct link between the Greenlanders and the portion of the foodchain with detectable plutonium contamination is through the mussels (bivalves). In 1974, the average concentration of plutonium in the soft parts of the mussels found within a radius of 20 km of the crash site was about 20 pCi/kg. If we asume that a Greenlander eats 100 grams of mussels a day from this region for 70 years, the estimated annual dose rate to the bone at the end of 70 years would be .075 mrad (from EPA 520/-77-016, Table A3-6). Even with this extremely conservative scenario, the projected maximum annual dose rate is less than 3% of the proposed EPA limit.

I was unable to find any cost estimates for the clean up operation at Thule. It involved the resources and people of many organizations and would be difficult to reconstruct. However, since the clean up operations apparently were sufficient to meet the requirements for limiting exposures to individuals as currently proposed by the EPA, it is my opinion that the clean up costs wouldn't be appreciably different today than they were then, save the adjustment for inflation.

REFERENCES

1. "Project Crested Ice", USAF Nuclear Safety, Volume 65 (Part 2) Special Edition, Jan/Feb/Mar 1970.

2. Aarkrog, A, "Environmental Behavior of Plutonium Accidentally Released at Thule, Greenland", Health Physics, Volume 32, No. 4, April 1977.

3. Aarkrog, A, et al., "Radioecological Investigations of an Environmental Contamination with Transuranic Elements", 1980 Progress Report, Radiation Protection, Commission of European Communities.

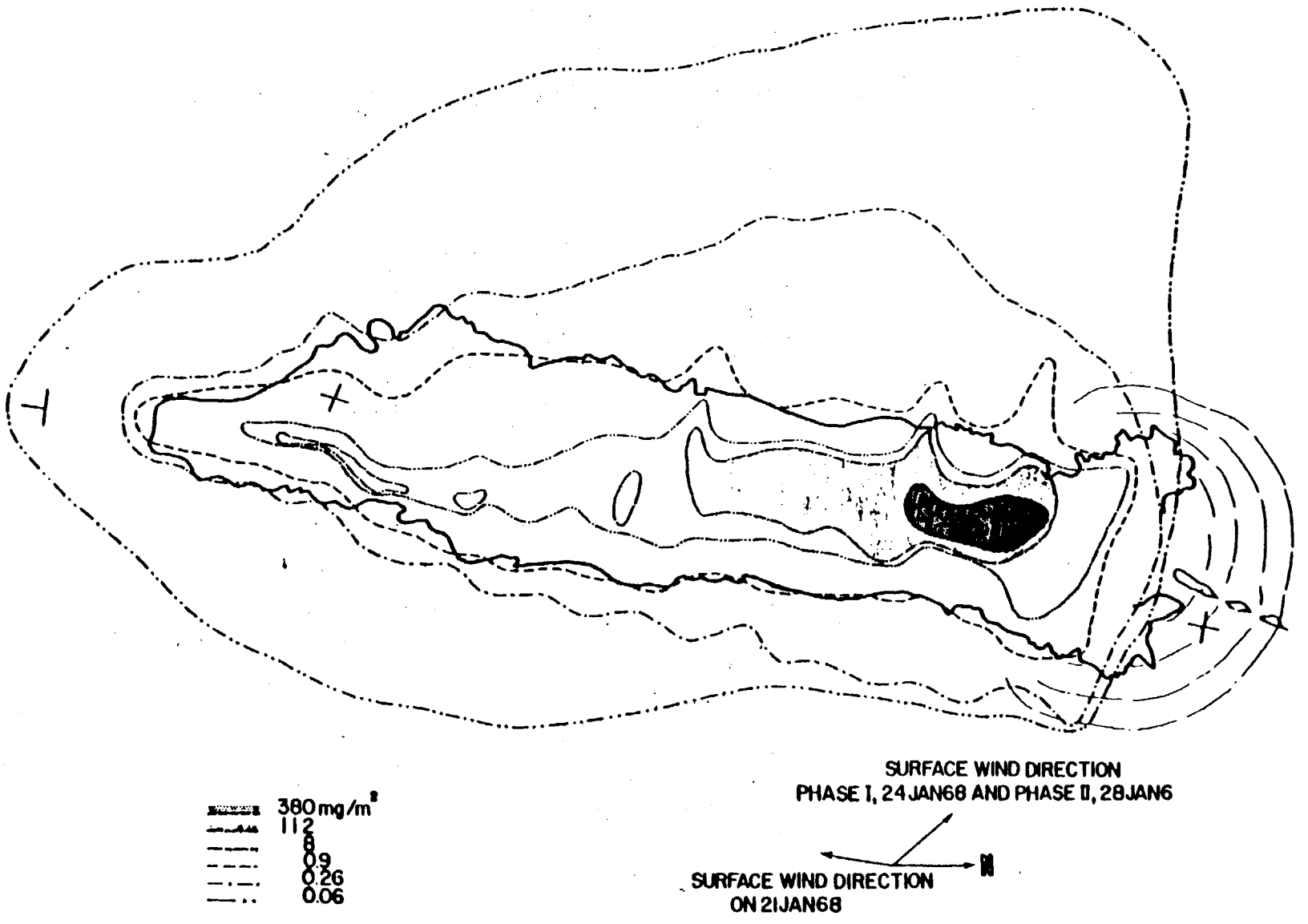


Figure 1 Plutonium contamination levels observed.

Taken from reference 1

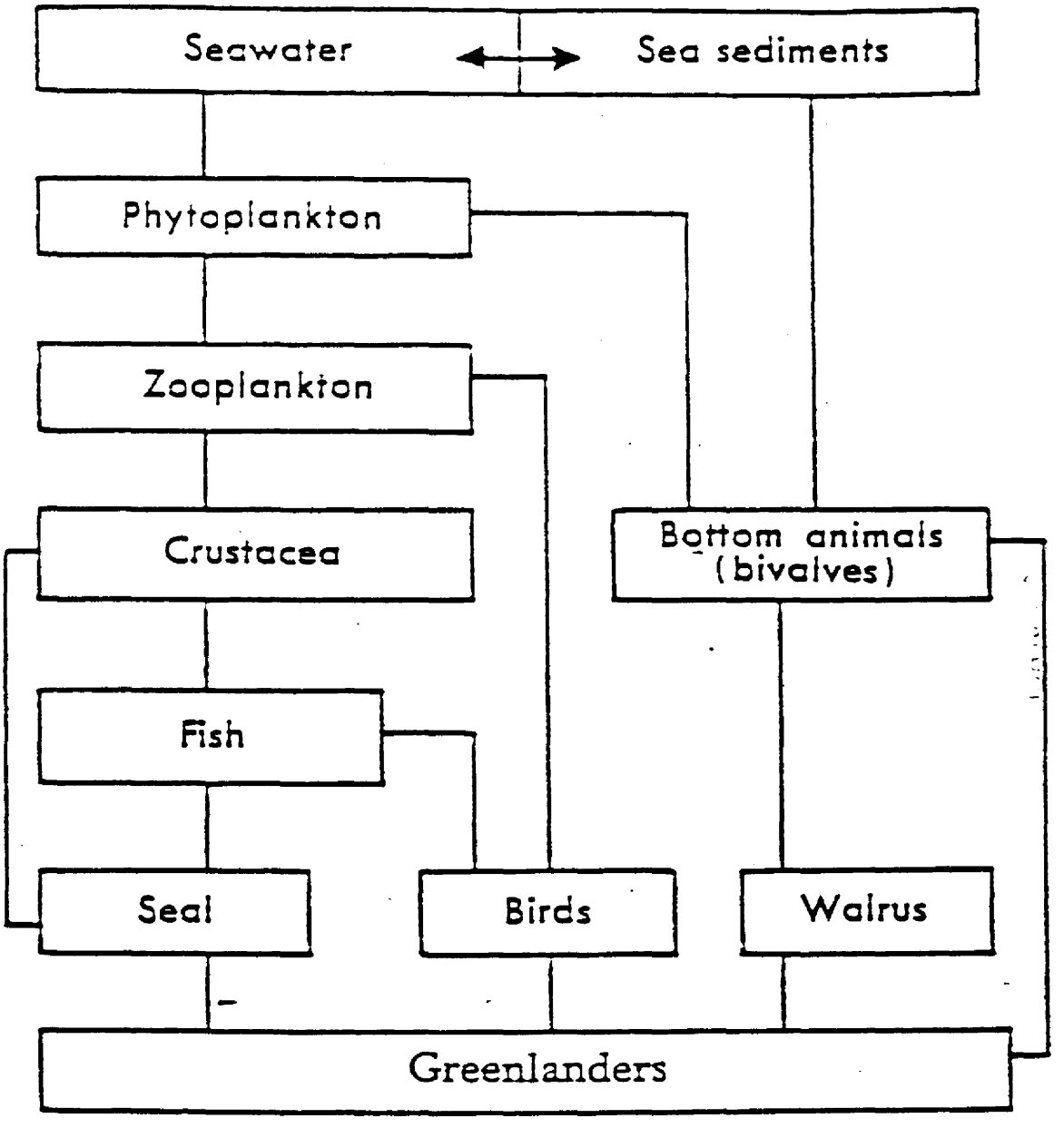


Figure 2 Food chains in an arctic, marine environment.

Taken from reference 1

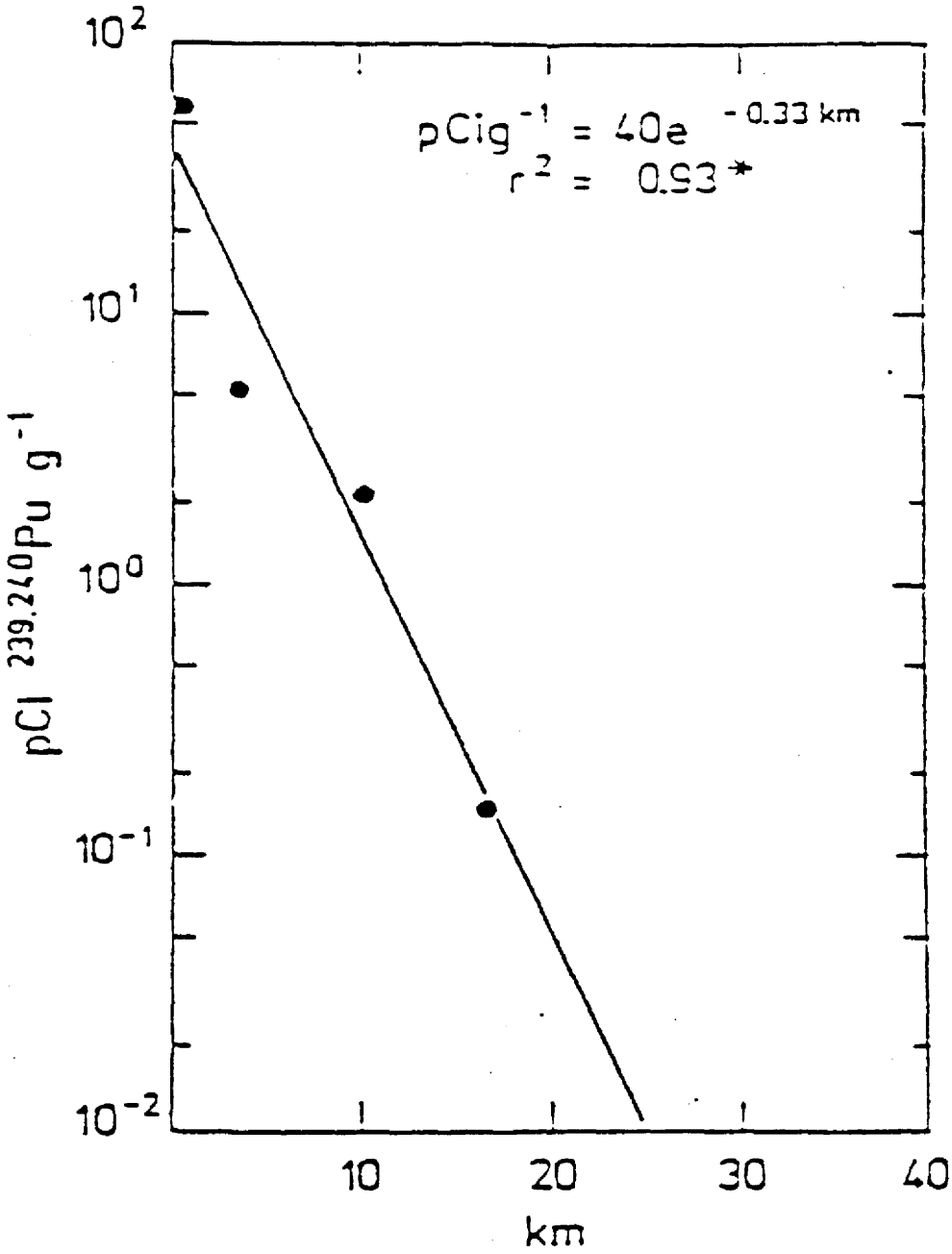


FIG. 3. The ^{239,240}Pu concentration in the sediment surface (0 cm depth) related to the distance (in km) from the point of impact.

Taken from reference 3

NEW EPA STANDARDS FOR Pu-238: POTENTIAL IMPACT AT MOUND

D.R.ROGERS
MOUND
MONSANTO RESEARCH CORP.

PRESENTED TO:

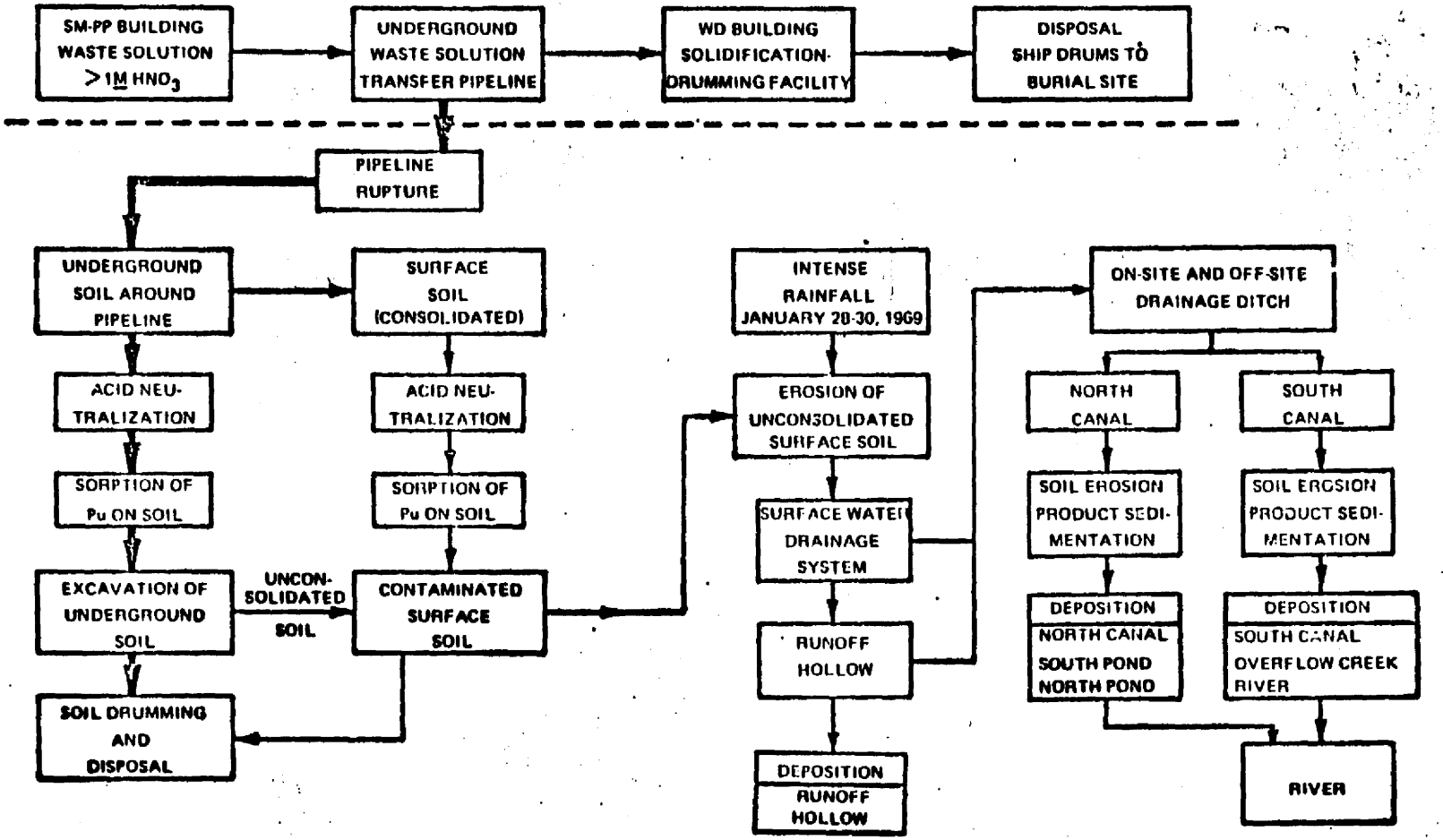
USDOE/OPERATIONAL SAFETY
USDOE/HQ
JAN. 17-18,1984

THERE IS ONE AREA NEAR MOUND WHICH POTENTIALLY EXCEEDS THE EPA SOIL "SCREENING LEVEL" BUT DOES NOT EXCEED THE AIR "SCREENING LEVEL".

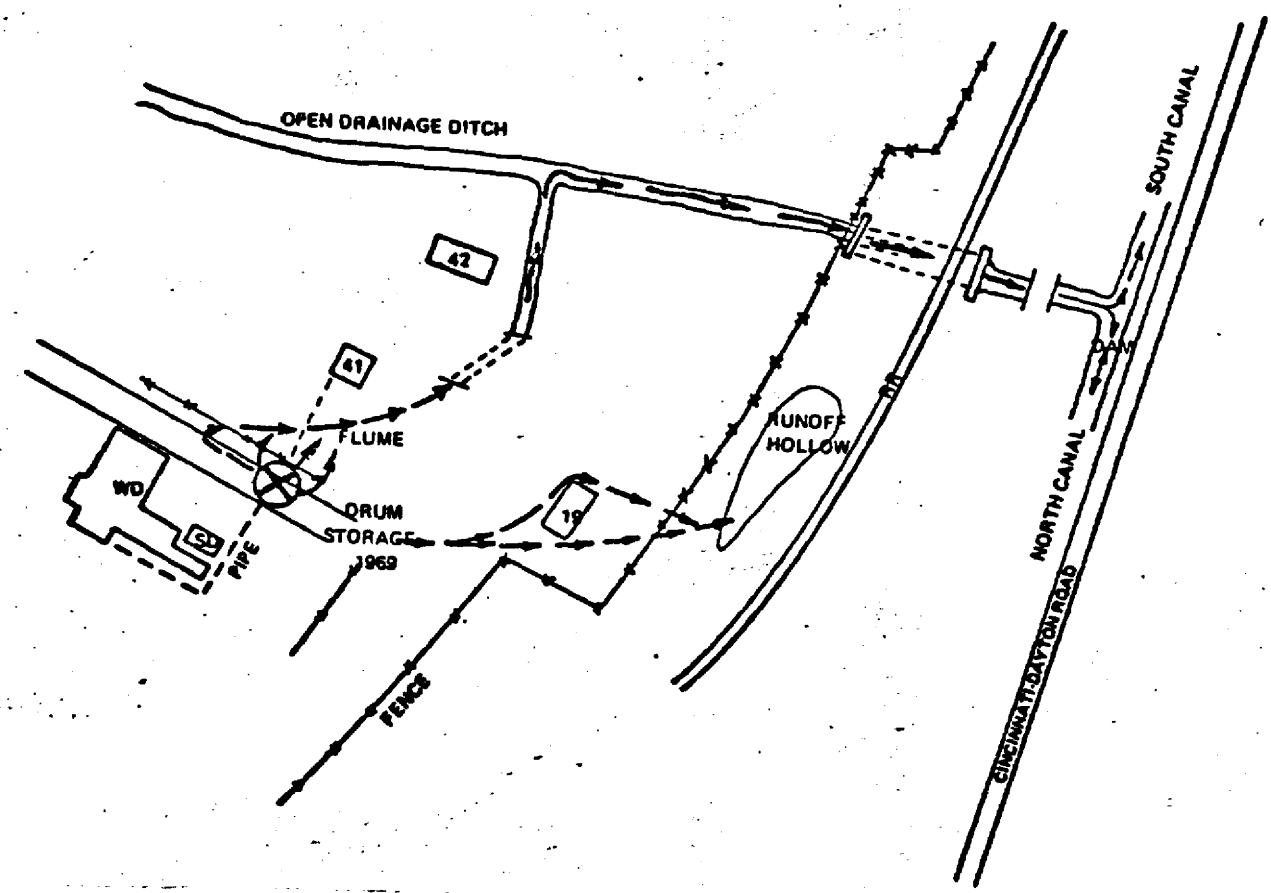
CONTAMINATED SEDIMENT CONFINED TO MIAMI-ERIE CANAL AND ASSOCIATED WATERWAYS.

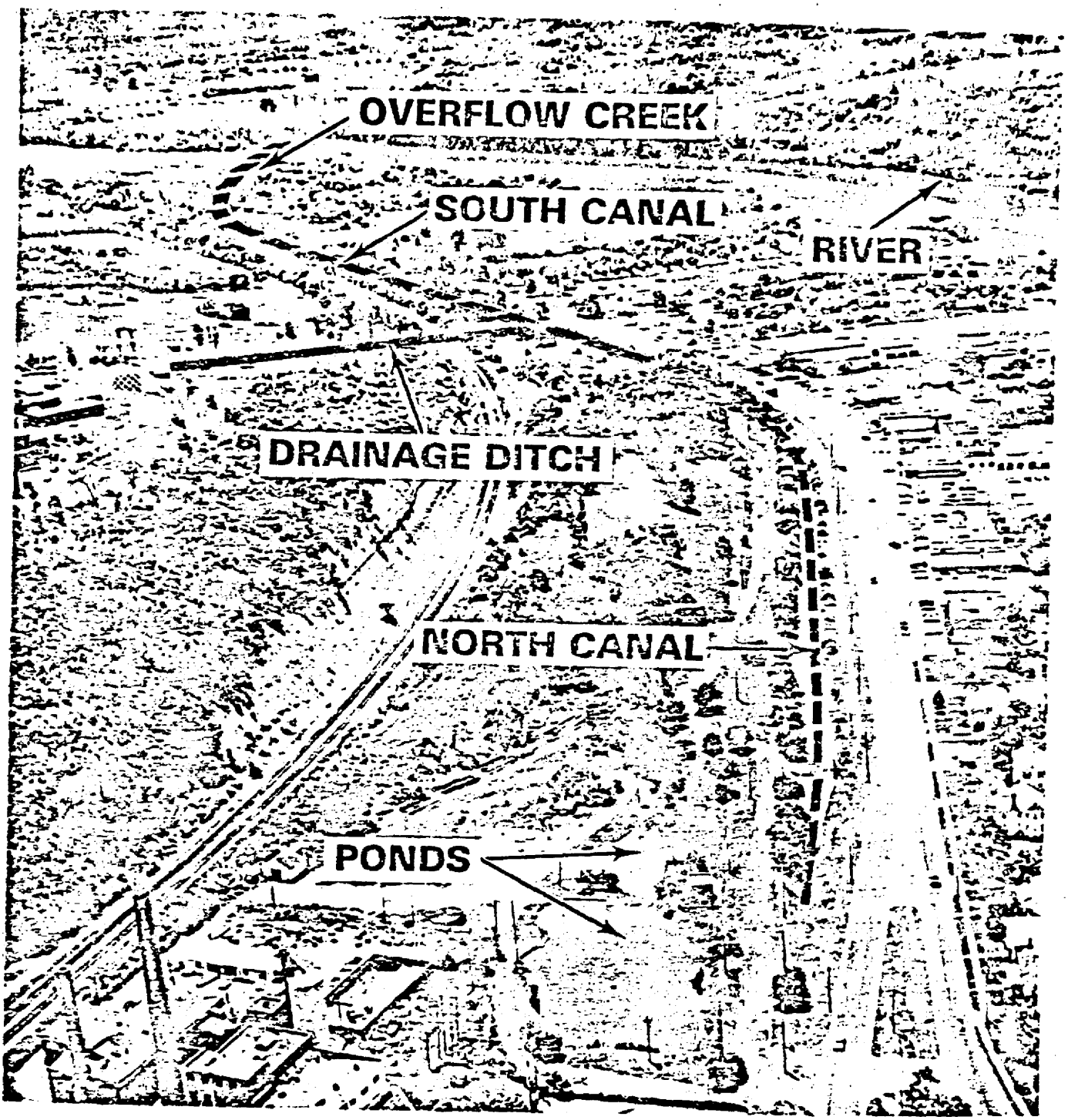
CONTAMINATED SEDIMENT RESULTED FROM THE RELEASE OF Pu-238 SOLUTION ON SITE SEVERAL YEARS AGO.

THE PLUTONIUM-238 SOLUTION WAS RELEASED WHEN AN UNDERGROUND PIPELINE RUPTURED DURING THE TRANSFER OF WASTE SOLUTION FROM THE Pu FACILITY TO THE WASTE FACILITY



THE CONTAMINATED SOIL WAS CARRIED OFF SITE BY THE OPEN DRAINAGE DITCH AND DEPOSITED MAINLY IN THE NORTH AND SOUTH CANALS.





THE CONTAMINATED SOIL WAS CARRIED OFF SITE BY THE OPEN DRAINAGE DITCH AND DEPOSITED MAINLY IN THE NORTH AND SOUTH CANALS.

HE MAXIMUM "VERY SURFACE" PU CONC.
N THE AREA WAS 0.45 nC/g

SEDIMENT IN WATERWAYS

OUTH POND	*	0.208	nC/g
ORTH CANAL	*	0.267	
RAINAGE DITCH	*	0.450	
OUTH CANAL	*	0.395	
VERFLOW CREEK	*	0.270	
UNOFF HOLLOW	*	0.029	
ORTH POND	*	0.022	

IMMEDIATE BANKS SUBJECT TO FLOODING

PONDS		0.002	
NORTH CANAL	*	0.054	
DRAINAGE DITCH	*	0.054	
SOUTH CANAL	*	0.061	
OVERFLOW CREEK		0.012	

ALL OTHER ADJOINING LAND

<0.001

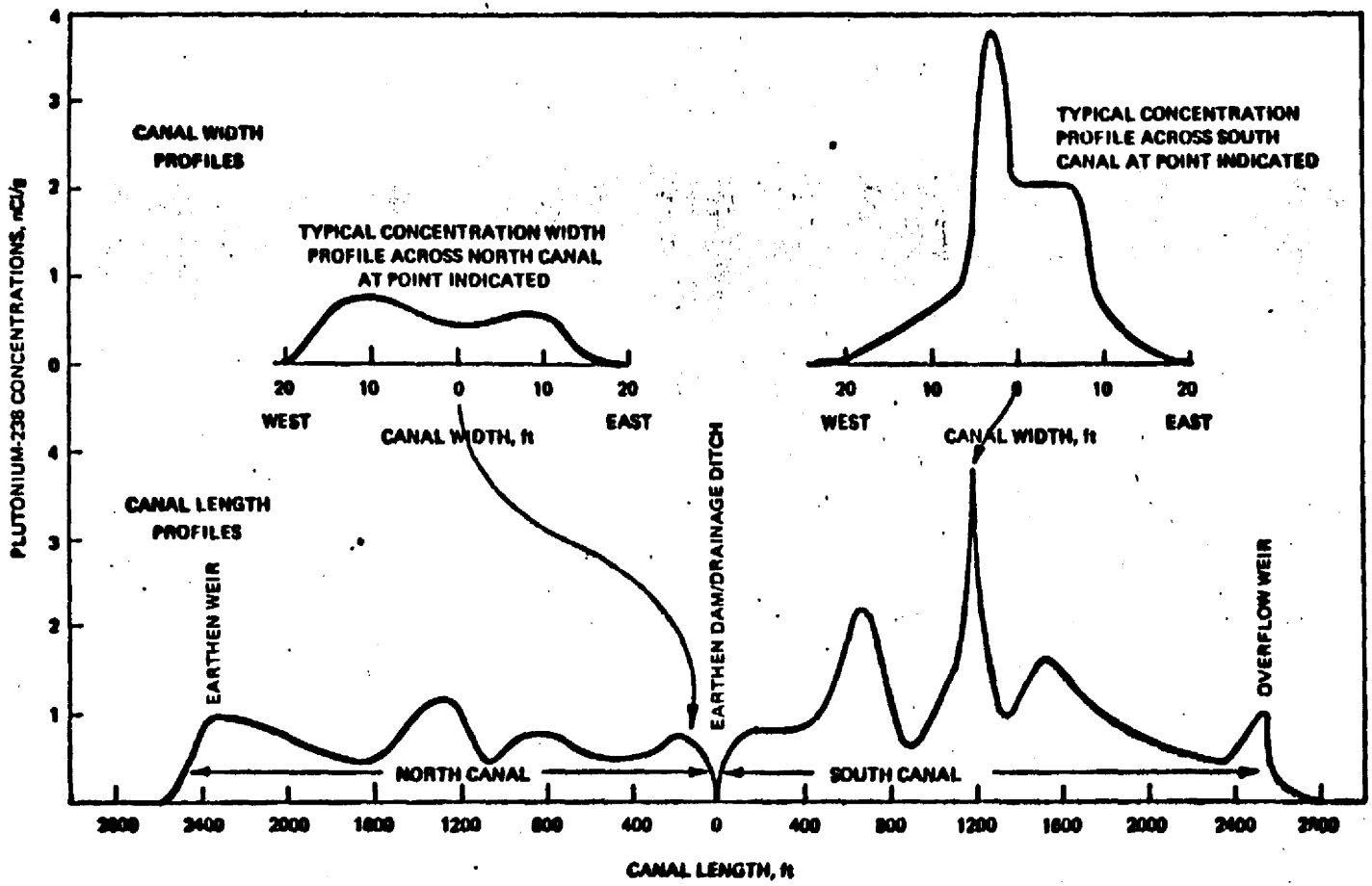
THE AIR SAMPLES COLLECTED IN THE CANAL AREA INDICATE COMPLIANCE WITH EPA "SCREENING LEVEL" FOR AIR CONC.

YEAR	YEARLY AVERAGE AIR CONC.(Pu238) 10(-15)CURIES/M(3) SOUTH CANAL	DITCH	DITCH/ CANAL	NORTH CANAL
1977	0.013	0.031	0.029	0.021
1978	0.011	0.032	0.030	0.022
1979	0.006	0.013	0.035	0.004
1980	0.006	0.007	0.014	0.003
1981	0.006	0.020	0.017	0.002
1982	0.005	0.024	0.017	0.003

.E MAXIMUM Pu CONC. IN THE FIRST FOOT
F CORE SAMPLES IN THE SEDIMENT OF THE
ITERWAYS WAS 3.8 nC/g.

INOFF HOLLOW	0.031	nC/g
ORTH POND	0.006	
OUTH POND	0.031	
ORTH CANAL	1.14	
.AINAGE DITCH	0.749	
OUTH CANAL	3.80	
VERFLOW CREEK	0.074	
IVER		
AST BANK AT OUTFALL	0.037	
EAST BANK DOWNSTREAM	0.002	
RIVER SEDIMENT AWAY FROM EAST BANK AT OUTFALL	<0.001	
ALL OTHER RIVER SAMPLES	<0.001	

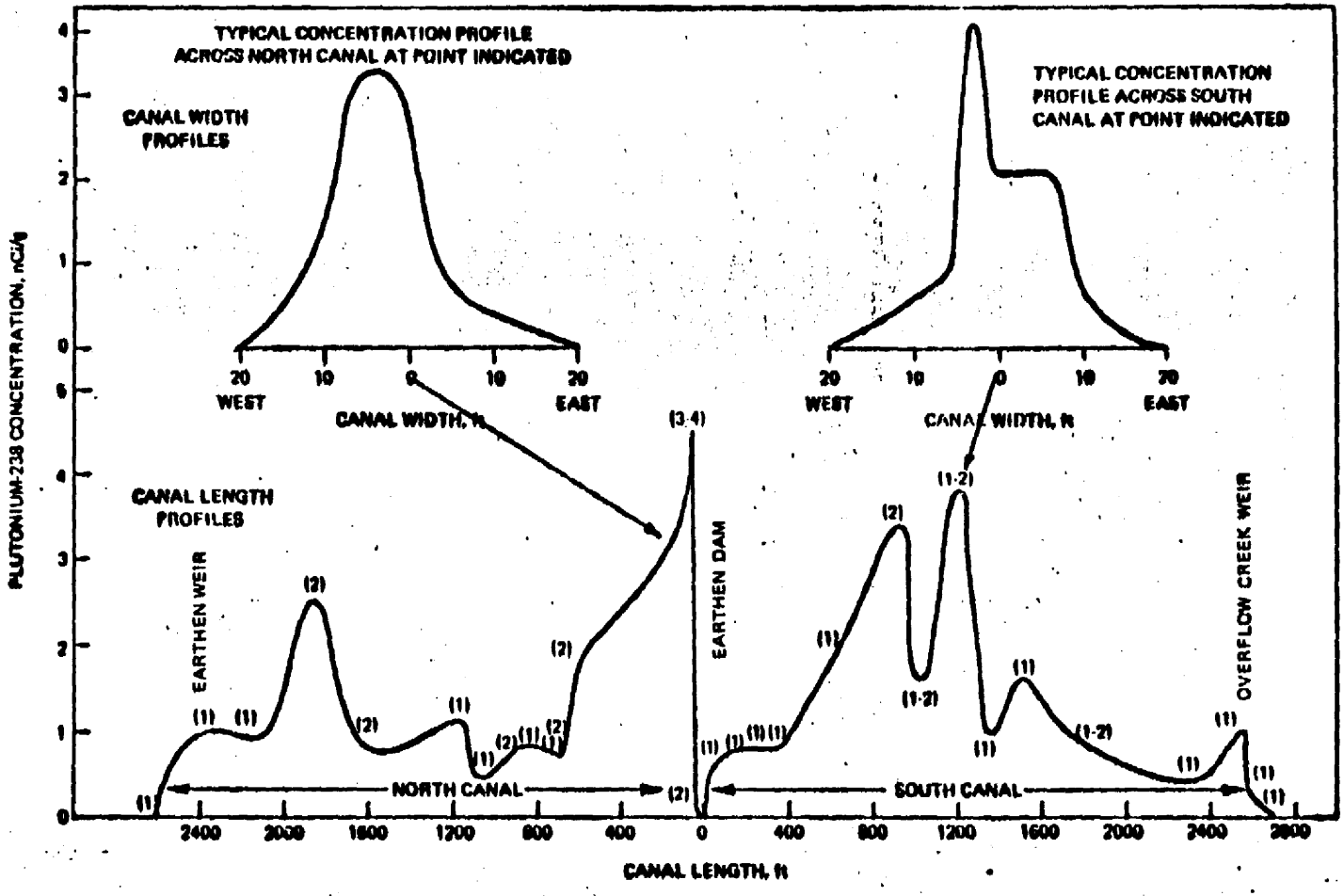
THE Pu CONC. IN THE SEDIMENT VARIED ALONG THE LENGTH AND WIDTH OF THE CANALS: CONC. FOUND IN THE FIRST FOOT.



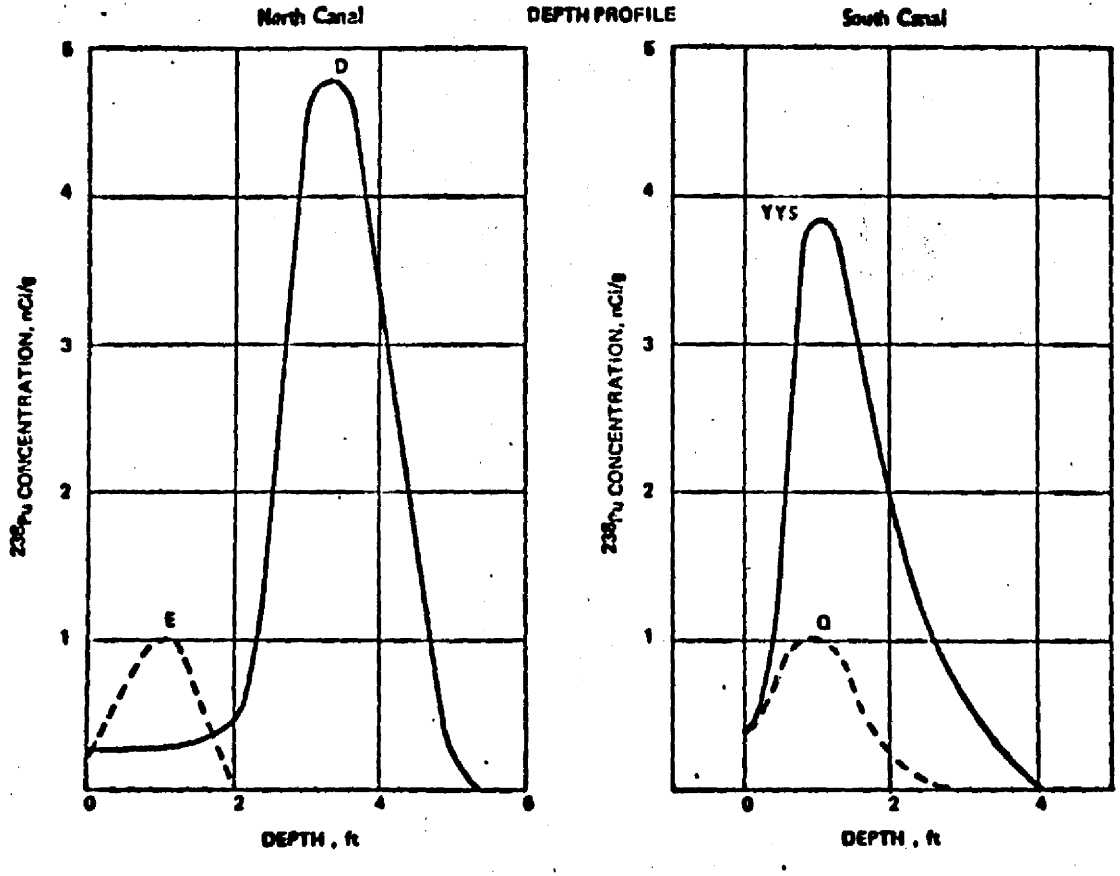
HE MAXIMUM Pu CONC. AT ANY DEPTH OF
HE CORE SAMPLES WAS 4.6 nC/g.

UNOFF HOLLOW	1	Ft	0.031	nC/g
ORTH POND	0		0.022	
OUTH POND	0		0.208	
ORTH CANAL	3		4.56	
RAINAGE DITCH	1		0.749	
OUTH CANAL	1		3.80	
JERFLOW CREEK	0		0.270	
IVER				
EAST BANK AT OUTFALL	2		0.042	
EAST BANK DOWNSTREAM	7		0.004	
RIVER AWAY FROM EAST BANK	4		<0.001	

THE Pu CONC. IN THE SEDIMENT VARIED ALONG THE LENGTH AND WIDTH OF THE CANALS: CONC. FOUND AT ANY DEPTH.

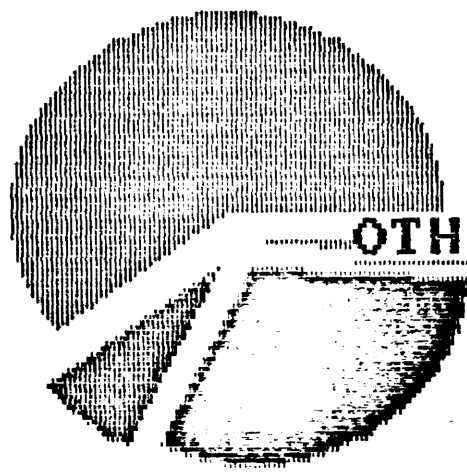


THE Pu CONC. ALSO VARIES WITH DEPTH.



INVENTORY: 5.2 CURIES OF Pu-238.

SOUTH CANAL 3.17

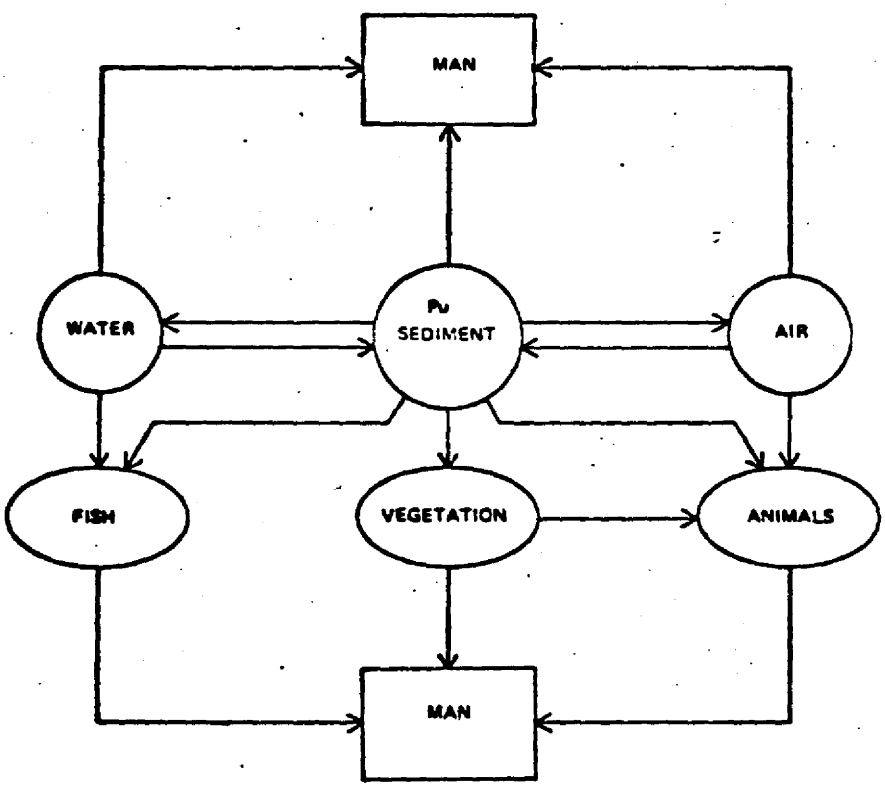


OTHER 0.04

CREEK 0.34

NORTH CANAL 1.65

AN EXTENSIVE "PATHWAY ANALYSIS" WAS PERFORMED TO ESTABLISH "DECISION GUIDES" FOR Pu-238 CONCENTRATION IN SOIL AND SEDIMENT.



SEVERAL OTHER SITE-SPECIFIC PARAMETERS WERE DETERMINED DURING THE STUDY.

* POSITIVE I.D. OF SPILL EVENT
* NATURE OF SOLN SPILLED
* NEUTRALIZATION OF ACID BY SOIL
* SORPTION OF Pu ON SOIL
* MECHANISM OF TRANSPORT AND DEPOSIT
* Pu CONC. VS PARTICLE SIZE SOIL/SED.
* ANALYSIS FOR HOT PARTICLES
* RESUSPENSION FACTOR FOR SOIL/SED.
* PARTICLE SIZE DISTRIBUTION-SOIL/SED.
* SOLUBILITY OF Pu FROM SOIL/SED.
* MINERALOGY OF SOIL & SEDIMENT
* NEUTRALIZATION CAPACITY OF SOIL/SED.
* ION EXCHANGE CAPACITY OF SOIL/SED.
* LOCAL TOPOLOGY, CLIMATE, & WEATHER
~~* WEATHER AND CLIMATE~~

THE MOST CRITICAL PATHWAY WAS DIRECT INGESTION OF SOIL/SEDIMENT BY CHILDREN WITH PICA.

PATHWAY	"DECISION GUIDE" SOIL CONC.
INGESTION	
SEDIMENT	52-520 nC/g
WATER	520
VEGETABLES	>1000
LARGE ANIMALS	>1000
SMALL ANIMALS	129
FISH	>1000
ABSORPTION	
SKIN	>1000
WOUNDS	>1000
INHALATION	
DUST LOADING	100-250
WIND RESUSPENSION	183-1300
RESUSPENSION FACTOR	188
CLOTHING CONTAMINATION	100
HOME CONTAMINATION	150

NONE OF THE Pu-238 SOIL/SEDIMENT CONCENTRATIONS FOUND IN THE CANAL AREA APPROACHED THESE "DECISION GUIDES."

	MAX CONC. nC/g
VERY SURFACE (AVAILABLE)	
SEDIMENT SUFACE IN WATERWAYS	0.450
IMMEDIATE WATERWAY BANKS	0.060
CONTIGUOUS LAND AREAS	0.001
FIRST FOOT (POTENTIALLY AVAILABLE IN THE FUTURE)	
SEDIMENT IN WATERWAYS	3.80
BANKS	0.010
CONTIGUOUS LAND AREAS	<0.001
ANY DEPTH (WORST CASE AVAILABLE IN THE FUTURE)	
SEDIMENT IN WATERWAYS	4.60
BANKS	0.060
CONTIGUOUS LAND AREA	0.001

THE MAXIMUM Pu CONC. IN WATER WAS 0.014 nC/L IN THE SOUTH CANAL.

RUNOFF HOLLOW	<0.001	nC/L
NORTH POND	<0.001	
SOUTH POND	<0.001	
NORTH CANAL	0.005	
DRAINAGE DITCH	0.006	
SOUTH CANAL	0.014	
OVERFLOW CREEK	0.003	
RIVER AT OUTFALL	0.001	

THE CONCENTRATION OF Pu IN BIOTA NEAR THE WATERWAYS WERE MEASURED

GRASS TAKEN ALONG BANKS NOT SUBJECT TO FLOODING	0.000018 nC/
GRASS TAKEN ALONG BANKS SUBJECT TO FLOODING	0.000874 to 0.00305
GREEN ALGAE FROM CANALS AND PONDS	0.00239
FISH (EDIBLE PORTIONS)	
BOTTOM FEEDERS	0.000005
OTHER	0.0000008

THE MOUND STUDY AND PATHWAY ANALYSIS WAS REVIEWED BY A GROUP OF OUTSIDE EXPERTS.

Dr. W. J. BAIR (Chairman)
Battelle, Pacific Northwest Lab.

Dr. RICHARD BLANCHARD
USEPA

Col. L. T. ODLAND
Wright Patterson AFB, USAF

Dr. E. L. SAENGER
College of Medicine, Univ. of Cinn.

Dr. L. WILDING
Agronomy Dept. Ohio State University

Dr. M. E. WRENN
Environmental Medicine, New York Univ.

THE FINDINGS OF THESE STUDIES CONCLUDED THAT THE Pu-238 IN THESE WATERWAYS:

(MOUND)-".. DOES NOT AND WILL NOT IN THE FUTURE PRESENT A HAZARD ..."

(REVIEW COMMITTEE)-"..IS NOT, UNDER CURRENT CONDITIONS, A HEALTH HAZARD .."

(USEPA)- "..CLEANUP NOT NECESSARY, BUT CONTINUED SURVEILLANCE IS REQUIRED."

MOUND IS IN COMPLIANCE WITH THE PROPOSED EPA STANDARD BECAUSE ALL AIR SAMPLING STATIONS INDICATE AIR CONCENTRATIONS BELOW THE SCREENING LEVEL.

- A SOIL SAMPLING PROGRAM WILL HAVE TO PERFORMED TO COMPLY WITH EPA "1 cm DEPTH".
- ADDITIONAL SITE-SPECIFIC PARAMETERS WILL HAVE TO BE STUDIED.
- AN ADDITIONAL PATHWAY ANALYSIS WILL HAVE TO BE PERFORMED
- ALL OF THIS INFORMATION WILL HAVE TO BE DISCUSSED WITH THE PUBLIC.

SHOULD WE BE REQUIRED AT SOME FUTURE TIME TO DIG UP AND DISPOSE OF THE Pu-238 IN THE WATERWAYS, THE IMPACT WOULD BE SEVERE.

- TRAUMA TO OUR NEIGHBORS.
- SEVERE MEDIA REACTION.
- POSSIBLE INCREASED RISK.
- POSSIBLE LITIGATION.
- BIG BUCKS.
- DIFFICULTY IN EXPLAINING REASONS FOR REMOVAL.

G-157
9AM

Briefing on Cleanup of TRU Contaminated Soil
January 17, 1984
Planning Phase
Enewetak Atoll Cleanup
T. McCraw

This summary reviews actions during the period 1972-77 by AEC-ERDA-DOE to conduct radiological surveys, to develop radiological cleanup criteria, and to assist in obtaining approval and funding for cleanup and rehabilitation of Enewetak, an Atoll used for U.S. nuclear tests from 1948 to 1958. These criteria are compared with current EPA draft criteria. Mr. Bruce Church will cover Enewetak cleanup field operations. This presentation highlights those aspects of criteria development and planning that are different from and/or incompatible with EPA's draft criteria.

Figure 1 is a chronological outline of the events leading to cleanup field operations at Enewetak. Following the announcement of the U.S. commitment to return this Atoll to the Trust Territory, and without waiting for a final agreement on AEC, DOD, and DOI responsibilities, an AEC task group began development of recommendations on cleanup concurrently with the radiological survey phase of the project. The first draft dose estimates from the 1972-73 radiological survey of Enewetak began to be available during the period of task group deliberations.

As the task group members formed their opinions, a number of ideas were considered and rejected that might have misdirected cleanup planning. Among these were proposals that radiological criteria were not needed and that the amount of cleanup performed would automatically be determined by the amount of funding provided by Congress, or that cleanup criteria should be derived through a consideration of risk estimates, or that dose criteria should be equivalent to the highest doses being received by any population such as those living in high natural radiation areas in Brazil. There was also the idea that the benefits to the Enewetak people of return to their homeland transcended any risk from radiation. The task group chose instead to derive its recommendations on cleanup criteria through a conservative application of current national and international standards for individuals in the population, and considering a wide range of land use and soil cleanup options.

The task group sought to recommend soil criteria that were practical in their application and expressed as a flexible guideline, not a limit. Its recommendations were considered to be site-specific for Enewetak. There was a consensus within the group that if its recommendations were to be technically defensible and useful, site-specific soil cleanup criteria must be developed that were related to current radiation standards, and expressed in units that could be compared with measurements made in the field. The task group recommended use of 50 percent of the annual doses for individuals and 80 percent of the 30 year dose for populations issued by the FRC, for cleanup and resettlement planning for fission product doses. Soil cleanup

was recommended for TRU contamination only. The soil levels recommended were associated with 10 percent to 100 percent of the ICRP lung values for individuals. Enjebi Island was to be cleaned up for TRU but not resettled at this time due to high fission product doses. Runit, the island for disposal of contaminated soil and debris, was to remain quarantined.

From the outset, the task group's recommendations were the subject of controversy. On occasion, a strong technical defense of their validity was needed. Agreement on the final draft criteria was a fragile product. Some NV staff did not support the recommendations. DNA staff preferred to establish their own cleanup criteria. EPA staff agreed that they would not disagree, but were looking toward developing their own TRU cleanup criteria. The Enewetak people and their legal council sought cleanup that would achieve zero risk for their return. The task group's recommendations were the subject of an AEC staff paper that was approved by the Commission.

The remaining figures identify agency responsibilities, the task group members, the basis for their judgments and recommendations, options considered, their conclusions, the position taken on risk, the features of the EIS related to Task Group recommendations, and some of the obvious differences between the Enewetak criteria and current EPA draft dose limits.

The role of those who performed the early work to develop Enewetak cleanup criteria largely ended with the issuance of the task group's report. Cleanup planning, field operations, and participants were documented in DOE and DNA reports. However, no overall post-mortem evaluation of this project has been conducted and little effort made to learn from all aspects of this unique experience. So far as I know, this meeting is the first time that the Enewetak project has been reviewed since DOE's report on field operations was issued. In that context I would like to acknowledge the important contributions made toward the success of this effort by the task group members and particularly Walter Nervik of LLNL. Jack Healy of LANL and Lyn Anspaugh of LLNL provided the critical relationship between TRU soil concentrations, air concentrations, and dose to lung. Harold Beck and Jim McLaughlin of HASL, Paul Gudiksen of LLNL, and Oliver Lynch of NVO provided input for external doses. Vic Nelson of the University of Washington and Vic Noshkin of LLNL provided marine data. Bill Robinson of LLNL provided the many dose estimates needed for a matrix of land use and cleanup alternatives.

The reason for citing these contributions is to emphasize that development of site-specific criteria and options for cleanup of a contaminated environment requires a large amount of detailed environmental information that has been evaluated for use in cleanup planning. Mandatory cleanup dose limits derived from extremely low risk values such as those in the EPA draft, had they been in existence in 1973, may well have made Enewetak cleanup appear to be an impossible task with a price tag that was out of the

question, and with so much soil requiring disposal that the only option would have been ocean disposal, an action EPA advised was not acceptable. The removal of soil from much larger land areas,an action that would have been required by the EPA limits, would have accomplished only a small increment of additional dose and risk reduction. How the EPA screening level would have been interpreted in planning Enewetak cleanup is a matter for guesswork. It may have been a liability because of the potential for misuse and misinterpretation.

I do recall several matters that may be relevant. The task group had little faith in use of air sampling data to determine that significant levels of TRU contamination were not present in the soil. Also, they considered but did not recommend plowing to dilute TRU concentrations below the levels to be considered for soil removal. In retrospect, use of EPA dose limits to plan soil cleanup at Enewetak appears incompatible with the need to prepare a complete spectrum of cleanup alternatives that would give OMB and Congress some choice as to the magnitude of the Enewetak cleanup effort.

The task group recommended a conservative application of existing standards for use at Enewetak. In recommending use of dose limits based upon an extremely conservative risk value, EPA ignores these standards. Viewed from the prospective of the Enewetak experience, EPA's development of yet another set of numerical dose values significantly lower than Federal standards and described as limits, restricts rather than promotes flexibility in cleanup decision-making.

For Enewetak there where significant areas of land contaminated with TRU elements and fission products, high visibility and public interest and concern, the involvement of land owners and their legal advisors, and concern for the cost of cleanup. Under such circumstances, AEC acting on its own judgment may have found it impossible to justify conduct of soil cleanup not meeting Federal dose limits even with advice from EPA that these limits are not to be interpreted as absolute values to be met in every instance. If available in 1973, dose limits that need not always be applied as absolute values, would have been a new and confusing concept in radiation prediction and I suggest this is true today as well.

Though permitted by the EPA criteria, development of cleanup recommendations that present a justification for exceeding a dose limit that is some fraction of the FRC standards for use at Enewetak, would have created a problem for those planning cleanup. Almost any advice that was not supported by existing standards would have resulted in disagreement on technical and legal issues. This could have made cleanup a more controversal political issue than it was.

A justification for exceeding EPA's dose limits would have focussed attention away from the fact that basic radiation standards could be (and were) met at Enewetak through a combination of cleanup actions and land restrictions.

In terms of the total cleanup effort, 1 year was required to develop Enewetak cleanup criteria, the time from the announcement until funding was more than 4 years, and the time from the announcement until the end of cleanup was 8 years. Since the fission product doses on some cleaned-up islands are likely to be higher than the EPA draft dose limits for TRU elements in soil for a number of years, one could now argue that Enewetak cleanup was not adequate. This is one of the problems avoided by use of a conservative application of basic standards for both fission products and TRU contamination.

Enewetak planning experience would seem to support the idea that as much advice and as many recommendations on soil cleanup as can be agreed upon should be issued as Federal criteria. However, such guidance must not close off the possibility for consideration of a range of cleanup options wherein dose to the public is only one of several considerations.

One final point, compared to the task group's recommendations, EPA's draft criteria commit that agency to very little in terms of agreements on acceptable methods for dealing with the practical problems incurred in planning and conduct of soil cleanup, many of which are ameniable to generic guidelines. The possibilities for such guidelines can be derived from the published records of Enewetak cleanup.

AGENCY RESPONSIBILITIES
ENEWETAK CLEANUP AND REHABILITATION

DOD — Precleanup Engineering Survey

Monitoring to Insure Safety of Cleanup Personnel

Radiological and Nonradiological Cleanup

Reimburse AEC Support of Cleanup in Field

AEC — Precleanup Radiological Survey

Development of Radiological Criteria and Recommendations

Monitoring Support for Cleanup Field Operations

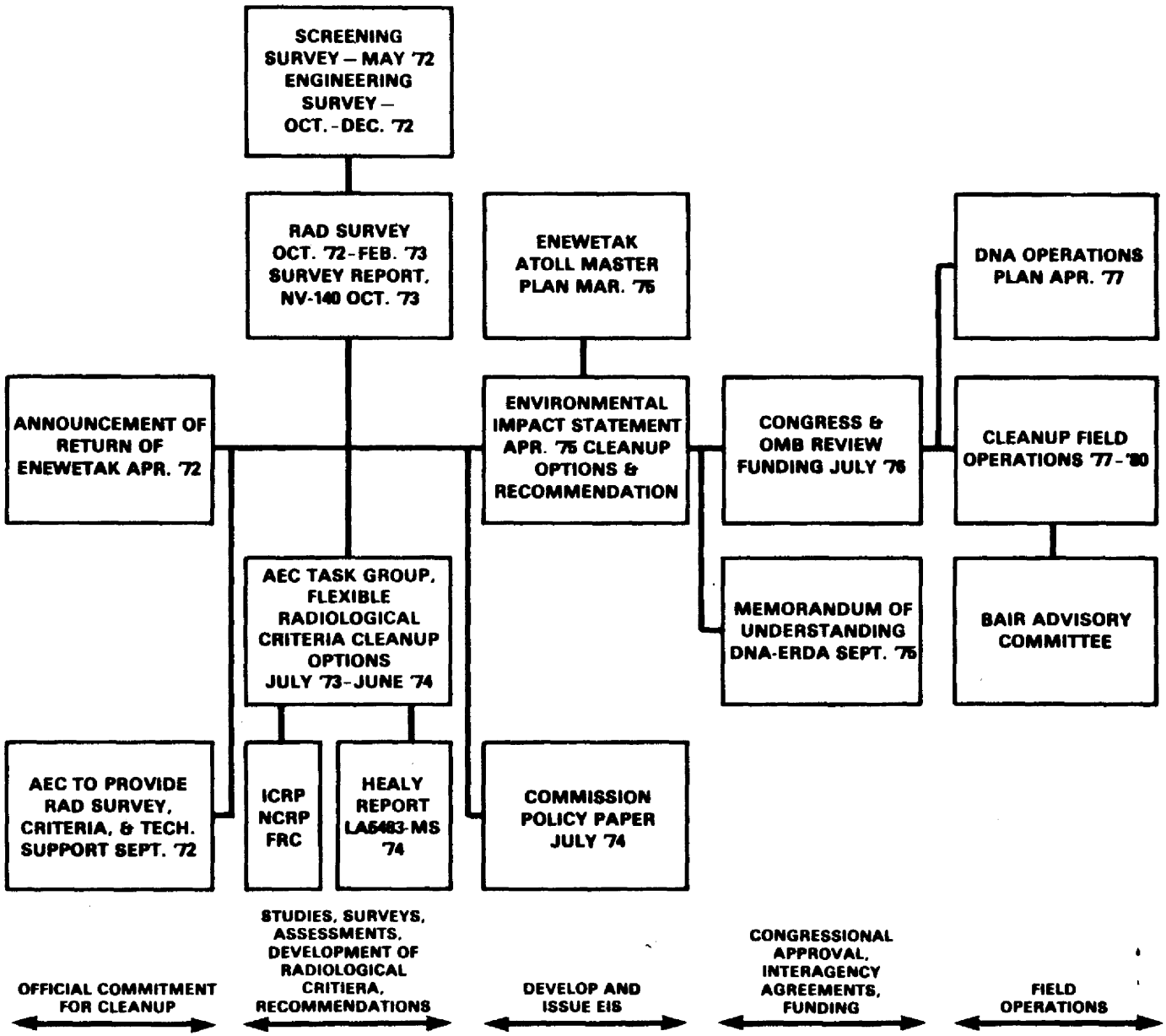
Certification of Completion

Followup Radiological Monitoring After Cleanup

DOI — Rehabilitation

Resettlement

ENEWETAK ATOLL CLEANUP — SEQUENCE OF EVENTS



AEC TASK GROUP ON RECOMMENDATIONS FOR CLEANUP AND REHABILITATION OF ENEWETAK ATOLL

Members:

T. McCraw	AEC/OS
W. Schroebel	AEC/DBER
W. Nervik	LLL
D. Wilson	LLL

Advisors:

H. Soule	AEC/WMT
N. Barr	AEC/DBER
R. Maxwell	AEC/DBER
J. Deal	AEC/OS
R. Ray	AEC/NVO
E. Held	AEC/REG

Liaison:

C. Palmiter	EPA
R. Leachman	DNA

ALTERNATIVES CONSIDERED

The Task Group Evaluated:

- **A Five by Six Matrix of Cleanup Degrees and Food Production Locations vs Living Patterns**
- **Five Cleanup Options Ranging from no Radiological Cleanup and no Return, to Extensive Soil Removal and Some Soil Replacement on Certain Northern Islands**
- **Six Options for Disposal of TRU Contaminated Soil and Scrap**

TASK GROUP POSITION ON RISK

"Most of the exposure to whole body, at Enewetak, and in fact to all organs will come from internal emitters. The shape of the dose-effect curve for exposure from internal emitters is most uncertain because of lack of experience and lack of confidence in extrapolation of high dose and dose rate effects into the very low dose and low dose rate situation. A lack of confidence in the statistic and risk estimate drawn therefrom has therefore led the Task Group to have serious reservations about their validity. The Task Group holds the opinion that such estimates cannot be used in any definitive way to draw conclusions on whether current radiation standards are too high or too low or as a basis for decision-making relative to resettlement of Enewetak Atoll."*

***Report by AEC Task Group on recommendations for cleanup and rehabilitation of Enewetak Atoll, June 18, 1974**

TASK GROUP CONCLUSIONS

- Cleanup and Rehabilitation of Enewetak Atoll is Feasible
- Doses from Fission Products will Predominate
- The Degree of Cleanup of the Atoll Should be Dictated by the Requirement to Keep Exposure within Acceptable Standards
- National and International Standards Apply
- A Fraction of FRC's, RPG's for Individuals Should be Utilized to Evaluate Cleanup and Land Use Options Involving Fission Product Doses
- A Fraction of ICRP Standards for Lung for Individuals Should be Utilized to Develop Flexible Soil Cleanup Criteria Expressed as a Concentration of TRU Elements in Soil, i.e., pCi/gm*

TASK GROUP CONCLUSIONS (CONT'D)

- A Group of Experts Should Support Cleanup Operations with Advice on Application of Task Group Criteria to Specific Situations

- Land Use Restrictions, as Opposed to Soil Removal, are the Recommended Method for Controlling Exposure from Fission Products

- Removal and Disposal of Soil, or a Permanent Quarantive, are the Only Effective Measure Against Soil TRU Concentrations Exceeding Task Group Criteria

*The Task Group believed that site-specific criteria could be developed on a case-by-case basis using conservative assumptions and a safety factor, but that biological and environmental information is not adequate to establish general cleanup guidance.

TASK GROUP JUDGEMENTS AND RECOMMENDATIONS

"The Task Group approach for development of judgements and recommendations for the radiological cleanup and rehabilitation of Enewetak was to consider a number of alternatives for exposure reduction that may be feasible. Basically the procedure involved four steps."

- **Assessment of doses for current conditions**
- **Assessment of dose reductions by modifying the diet**
- **Assessment of dose reductions by removing contaminated soil**
- **Comparison of dose assessment matrices with Task Group guidelines**

TASK GROUP CRITERIA AND THEIR CONTEXT

TRU IN SOIL

>400 pCi/g, Corrective Action Required
1,500 m Rem/yr, Lung (150 m Rad/yr)

<40 pCi/g, Corrective Action Not Required
150 m Rem/yr, Lung (15 m Rad/yr)

40 to 400 pCi/g, Corrective Action Determined on Case-by-Case Basis

FISSION PRODUCTS*

250 m Rem/yr, Whole Body and Bone Marrow

750 m Rem/yr, Thyroid

750 m Rem/yr, Bone

4,000 m Rem/30 yrs, Gonads

*50% of Federal Radiation Council (FRC) Radiation Protections Enider (RPG's) for Annual Doses for Individuals and 80% of the 30-year Criterion for a Population

ENEWETAK CLEANUP EIS

- Presents AEC Task Group Recommendations as Conservative Guidelines that are Necessary Because of Uncertainties in Exposure Predictions
- For TRU Contaminated Soil Removal Stresses Need for a Team of Experts to Advise on Cleanup Actions
- Presents Five Cases (Options) for Land Use and Degree of Cleanup and a Matrix Showing a Range of Alternatives Detailing Dose Reduction, Health Effects, Cost, and General Acceptability
- Recommends Case 3 as Offering the Best Combination of Features

EPA DOSE LIMITS AND THEIR CONTEXT

1 Millirad Per Year to Lung*

3 Millirad Per Year to Bone*

".....while the recommendations are expressed in terms of numerical limits.....these are not to be interpreted as absolute values which must be met in every instance. Rather, Federal Radiation Guidance relies on the judgement of the implementing agency, and only specifies that the general objectives are to be met and deviations must be justified."

"Suggestions that higher dose rate limits should be used were rejected because the Agency had shown that the proposed limits were reasonable and achievable."

***Risk is less than 10^{-6} per year to critical segment of population.**

GUIDANCE RECOMMENDATIONS (REVISED)

In order to assure the protection of persons in the general population by limiting the radiation doses that an individual in a critical segment of the population may receive from concentrations of transuranium elements present above average background levels in the general environment, the following recommendations shall apply for the guidance of Federal agencies:

1. Dose rates to persons in the general population for continuing exposure to transuranium elements should not exceed the recommendations provided in Federal Radiation Guidance No. 1, and reasonable efforts should be made to keep all exposures as low as reasonably achievable.

2. Contamination levels in the general environment should be limited to assure that the annual alpha radiation dose rate to members of the critical segment of the exposed population as the result of exposure to transuranium elements not exceed either:

   a. 1 millirad per year to the pulmonary lung, or
   b. 3 millirad per year to the bone or 40 millirad per year to the bone surfaces.

3. For newly contaminated areas, the Federal agency responsible for implementation of these recommendations should take immediate action to minimize both the residual levels of transuranium elements in the general environment and the radiation exposure of the general public. Determination and implementation of further appropriate measures, to ensure that projected dose rates to persons in the general population are as low as reasonably achievable and in full compliance with the above recommendations, should begin as promptly as possible and should be completed within a reasonable period of time.

4. The recommendations are to be used only as radiation protection guidance for presently existing cases of environmental contamination by transuranium elements and for possible future cases of environmental contamination from unplanned releases of transuranium elements. Federal agencies are not to use them as limits for planned releases of transuranium elements into the general environment.

5. Remedial actions for contaminated sites should be planned to provide maximum protection of the public health at reasonable cost, and should be implemented with the objective of minimizing adverse impacts on the environment.

6. The relationship between the projected dose rates to persons in a "critical segment of the population" and the ambient concentration of transuranium elements in air, soil and food is to be determined on a site-specific basis, taking into account all possible environmental pathways. For purposes only of eliminating certain lands from further more detailed evaluation, a soil "screening level" of 0.2 uCi/m^2 of alpha-emitting transuranium elements, for samples collected at the surface to a depth of 1 cm and for particle sizes less than 2 mm, may be used under most circumstances. Areas which do not exceed the "screening level" generally may be considered in compliance with the recommendations; those that exceed it would require further evaluation to determine the actual dose rates to exposed persons. The "screening level" is not to be used by Federal agencies as a soil concentration limit for purposes of implementing these recommendations.

DOSE COMPARISONS

EPA Dose Limit is:

$\frac{1}{15}$ **Enewetak Level where No Action Required**

$\frac{1}{150}$ **Enewetak Level where Action Required**

COMPARISON OF MAJOR FEATURES

AEC Task Group	EPA Draft
Site-specific Soil Criteria Recommendations Developed with Knowledge of Rad Survey Data Base	General Criteria to be Applied to Current Situations or Future Accidents on Site-specific Basis
Conservative Application of Existing Radiation Standards	Selection of 10^{-6} Risk, Derivation of Associated Doses Expressed as Limits not to Interpret as Absolute Values, Limits Shown by EPA to be Reasonable and Achievable.
Cleanup and Land Use Options Evaluated Against Dose and Soil TRU Concentration Criteria	Dose Limits to be Applied on Site-specific Basis, Explicit Guidance not Given in Order to Allow Flexibility, No Examples Cited
Anticipates Need for Full Spectrum of Cleanup Options in EIS and that Final Decisions on Cleanup to be Made at Higher Level Such as OMB and Congress	Recommendations Anticipate Decision Point for Flexible Implementation of Dose Limit Lies within Implementing Agency, Application Relies on Judgement of this Agency
No Equivalent	Soreening Levels

DATA FOR ENJEBI ISLAND*

Maximum Annual Dose

m Rem/y

Bone Marrow	293/718**
Whole Body	245/540**

Transuranium Soil Contamination

pCi/g Top 15 cm

0.08 to 170

* AEC Task Group Report, June 19, 1974. Note: The Task Group recommended Enjebi not be resettled until test food crops showed acceptable low levels.

** Imports available/Imports unavailable average dose primary from Cs-137, Sn-90, and external radiation. TRU dose smaller by comparison.

ENEWETAK CLEANUP PROJECT

- UNITED STATES BORROWED ENEWETAK ATOLL IN 1947 FOR NUCLEAR TESTING.
- NATIVE POPULATION DISPLACED TO SMALLER ATOLL.
- TESTING PROGRAM:
  - — DESTROYED VEGETATION VITAL TO SUSTENANCE OF NATIVE INHABITANTS.
  - — GENERATED THOUSANDS OF TONS OF DEBRIS WHICH WAS LEFT IN PLACE.
  - — INTRODUCED RADIOACTIVE CONTAMINATION TO NORTHERN HALF OF ATOLL.
- UNITED STATES PROMISED IN 1972 RETURN OF THE ATOLL TO DISPLACED OWNERS.
- CLEANUP AND REHABILITATION WAS ACCOMPLISHED DURING 1977-80.
- ENTIRE PROJECT INVOLVED:
  - — REMOVAL OF DEBRIS FROM ISLANDS.
  - — CONSOLIDATION OF SOIL CONTAMINATED ABOVE CLEANUP CRITERIA.
  - — RESTORATION OF VEGETATION FOR AGRICULTURAL PURPOSES.
  - — CONSTRUCTION OF 116 NEW DWELLINGS AND TWO COMMUNITY CENTERS.
- DNA WAS RESPONSIBLE FOR CLEANUP WITH DOE IN ADVISORY AND SUPPORT ROLES. CLEANUP WORK DONE BY MILITARY PERSONNEL.

TABLE 5-6: ESTIMATED 30-YEAR INTEGRATED DOSES TO INDIVIDUALS[a] (REM)

HABITATION PLANS / CLEANUP ACTIONS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED[b]	C LIVE ON SOUTHERN ISLANDS; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS[c]	D LIVE ON SOUTHERN ISLANDS; VISIT ON SOUTHERN ISLANDS; USE FOOD GROWN ON ONLY SOUTHERN ISLANDS.
I. NO CLEANUP.	CASE 1 WB = 6 B = 60 L = 0.1	WB = 3 (6 ON ENJEBI) B = 10 (20 ON ENJEBI) L = 0.06 (0.1 ON ENJEBI)	WB = 1 B = 5 L = 0.04	CASE 2 WB = BACKGROUND[d] B = BACKGROUND L = BACKGROUND
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	WB = 6 B = 60 L = BACKGROUND	CASE 4 WB = 3 (6 ON ENJEBI) B = 10 (20 ON ENJEBI) L = BACKGROUND	CASE 3 WB = 1 B = 5 L = BACKGROUND	SAME AS CASE 2
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	CASE 5 WB = BACKGROUND B = BACKGROUND L = BACKGROUND	HABITATION RESTRICTION NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5

LEGEND

WB = WHOLE BODY DOSE
B = BONE DOSE
L = LUNG DOSE

[a] DOSES CALCULATED TO ONE SIGNIFICANT FIGURE BASED ON DATA FROM NVO-140 AND AEC TASK GROUP REPORT.

[b] DOSES CALCULATED FROM AN ASSUMED POPULATION DISTRIBUTION OF 44 PERCENT OF THE ATOLL POPULATION ON ENJEBI AND THE BALANCE OF THE POPULATION ON THE SOUTHERN ISLANDS.

[c] DOSES CALCULATED FROM ISLAND AREA WEIGHTED DISTRIBUTION OF COCONUTS: 40 PERCENT FROM MIJIKADREK TO BILLAE AND BIKEN, AND 60 PERCENT FROM THE SOUTHERN ISLANDS.

[d] BACKGROUND MEANS THAT THE DOSE IS ESTIMATED TO BE NO GREATER THAN WOULD BE ABSORBED FROM NATURALLY OCCURRING SOURCES, EITHER EXTERNALLY OR INTERNALLY. ESTIMATES FOR BACKGROUND 30-YEAR DOSES ARE: WB = 1 rem, B = 4 rem, AND L = 0.0009 rem.

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975 VOL I.

TABLE 5-7: ESTIMATED MAXIMUM ANNUAL DOSES TO INDIVIDUALS[a] (REM)

HABITATION PLANS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED.	C LIVE ON SOUTHERN ISLANDS: VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS	D LIVE ON SOUTHERN ISLANDS: VISIT ON SOUTHERN ISLANDS: USE FOOD GROWN ON ONLY SOUTHERN ISLANDS.
I. NO CLEANUP.	CASE 1 WB = 0.3 B = 2 L = 0.004	WB = 0.1 (0.3 ON ENJEBI) B = 0.5 (1 ON ENJEBI) L = 0.002 (0.004 ON ENJEBI)	WB = 0.05 B = 0.2 L = 0.001	CASE 2 WB = BACKGROUND[b] B BACKGROUND L BACKGROUND
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	WB = 0.3 B = 2 L = BACKGROUND	CASE 4 WB = 0.1 (0.3 ON ENJEBI) B = 0.5 (1 ON ENJEBI) L = BACKGROUND	CASE 3 WB = 0.05 B = 0.2 L = BACKGROUND	SAME AS CASE 2
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	CASE 5 WB = BACKGROUND B = BACKGROUND L = BACKGROUND	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5	HABITATION RESTRICTIONS NOT REQUIRED. SEE CASE 5

LEGEND

WB = WHOLE BODY DOSE
B = BONE DOSE
L = LUNG DOSE

[a] DOSES CALCULATED TO ONE SIGNIFICANT FIGURE BASED ON DATA FROM NVO-140 AND AEC TASK GROUP REPORT. AEC GUIDELINES FOR MAXIMUM ANNUAL DOSE ARE: WB = 0.25, B = 0.75. SEE TABLE 5-6 FOR ASSUMPTIONS USED IN DOSE CALCULATIONS FOR COLUMNS B AND C.

[b] BACKGROUND MEANS THAT THE DOSE IS ESTIMATED TO BE NO GREATER THAN WOULD BE ABSORBED FROM NATURALLY OCCURRING SOURCES, EITHER EXTERNALLY OR INTERNALLY. ESTIMATES FOR ANNUAL BACKGROUND DOSE ARE: WB = 0.04 rem, B = 0.1 rem, and L = 3×10^{-3} rem.

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975, VOL. I.

TABLE 5-8: RATIOS OF ESTIMATED MAXIMUM ANNUAL DOSES TO RECOMMENDED ANNUAL DOSE GUIDELINES FOR INDIVIDUALS[a]

HABITATION PLANS / CLEANUP ACTIONS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED [b]	C LIVE ON SOUTHERN ISLANDS; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS	D LIVE ON SOUTHERN ISLANDS; VISIT ON SOUTHERN ISLANDS; USE FOOD GROWN ON ONLY SOUTHERN ISLANDS
I. NO CLEANUP.	CASE 1 RWB = 1.2 RB = 2.7	RWB = 0.4 (1.2 ON ENJEBI) RB = 0.7 (1.3 ON ENJEBI)	RWB = 0.2 RB = 0.3	CASE 2 b
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	RWB = 1.2 RB = 2.7	CASE 4 RWB = 0.4 (1.2 ON ENJEBI) RB = 0.7 (1.3 ON ENJEBI)	CASE 3 RWB = 0.2 RB = 0.3	b
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	CASE 5 b	b	b	b

LEGEND

RWB = RATIO OF MAXIMUM ANNUAL DOSE TO RECOMMENDED LIMIT FOR WHOLE BODY DOSE (0.25 rem/yr).
RB = RATIO OF MAXIMUM ANNUAL DOSE TO RECOMMENDED LIMIT FOR BONE DOSE (0.75 rem/yr).

[a] APPLICABLE TO AVERAGE INDIVIDUAL ON ENTIRE ATOLL, EXCEPT WHERE NOTED. PEOPLE SHOULD NOT RETURN IF THE RATIO IS GREATER THAN UNITY.

[b] THE RATIOS ARE EFFECTIVELY LESS THAN OR EQUAL TO THE RATIO OF BACKGROUND DOSE TO RECOMMENDED GUIDELINE WHERE RWB$\leq$0.16 AND RB$\leq$0.13.

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975, VOL. I.

TABLE 5-12: ESTIMATED NUMBER OF HEALTH EFFECTS[a] FROM 30-YEAR DOSES TO POPULATION OF 1,000

HABITATION PLANS / CLEANUP ACTIONS	A NO RESTRICTION ON ISLAND FOOD USAGE.	B LIVE ON SOUTHERN ISLANDS AND ENJEBI; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS OR ENJEBI PLUS COCONUT FROM 12 N.E. ISLANDS AND PANDANUS AND BREADFRUIT FROM ENJEBI FARM PLOTS OR IMPORTED.	C LIVE ON SOUTHERN ISLANDS; VISIT NORTHERN ISLANDS; FOOD FROM SOUTHERN ISLANDS PLUS COCONUT FROM 12 N.E. ISLANDS	D LIVE ON SOUTHERN ISLANDS; VISIT ON SOUTHERN ISLANDS; USE FOOD GROWN ON ONLY SOUTHERN ISLANDS.
I. NO CLEANUP.	H(WB)≤ 0.3 TO 1 H(B)≤ 2 H(L)≤ 0.003 H(TOTAL)≤ 3	H(WB)≤ 0.2 TO 0.5 H(B)≤ 0.3 H(L)≤ 0.002 H(TOTAL)≤ 0.8	H(WB)≤ 0.05 TO 0.2 H(B)≤ 0.1 H(L)≤ 0.001 H(TOTAL)≤ 0.3	CASE 2 BACKGROUND[b]
II. REMOVAL OF ALL SCRAP AND Pu CONCENTRATION GREATER THAN 40pCi/g FROM RESIDENCE AND AGRICULTURE ISLANDS.	H(WB)≤ 0.3 TO 1 H(B)≤ 2 H(L)≤ BACKGROUND[b] H(TOTAL)≤ 3	CASE 4 H(WB)≤ 0.2 TO 0.5 H(B)≤ 0.3 H(L)≤ BACKGROUND[b] H(TOTAL)≤ 0.8	CASE 3 H(WB)< 0.05 TO 0.2 H(B)< 0.1 H(L)< BACKGROUND H(TOTAL)< 0.3	SAME AS CASE 2
III. TOTAL CLEANUP OF RESIDENCE AND AGRICULTURE ISLANDS.	BACKGROUND[b]	SAME AS CASE 5	SAME AS CASE 5	SAME AS CASE 5

LEGEND

H(WB) = MAXIMUM EXPECTED WHOLE BODY HEALTH EFFECTS
H(B) = MAXIMUM EXPECTED BONE HEALTH EFFECTS
H(L) = MAXIMUM EXPECTED LUNG HEALTH EFFECTS
H(TOTAL) = MAXIMUM EXPECTED TOTAL HEALTH EFFECTS

[a] HEALTH EFFECTS MEAN SOMATIC CANCER INDUCTIONS THAT RESULT IN FATALITY, CALCULATED TO ONE SIGNIFICANT FIGURE. THE NUMBER OF FATAL AND NONFATAL CASES IS ESTIMATED TO BE TWICE THE NUMBER OF FATAL CASES. SEE TABLE 5-1 FOR DOSE RESPONSE RATES USED TO ESTIMATE HEALTH EFFECTS. THESE EFFECTS WOULD BE IN ADDITION TO THOSE FROM BACKGROUND RADIATION.

[b] HEALTH EFFECTS FOR 30-YEAR BACKGROUND DOSES OF WB = 1 rem, B = 4 rem, and L = 0.0009 rem ARE: H(WB)≤ 0.05 TO 0.2
H(B)≤ 0.1
H(L)≤ 0.00002
H(TOTAL)≤ 0.3

FROM ENVIRONMENTAL IMPACT STATEMENT CLEANUP, REHABILITATION, RESETTLEMENT OF ENEWETAK ATOLL, MARSHALL ISLANDS. DNA, APRIL 1975, VOL. I.

DEVELOPMENT OF CLEANUP CRITERIA

1974 TASK GROUP REPORT

DOSE BASED ON FEDERAL RADIATION COUNCIL LIMITS
— TO INDIVIDUALS, 50 PERCENT OF FRC ANNUAL RATE LIMIT
— TO POPULATION, 80 PERCENT OF FRC 30-YEAR GENETIC LIMIT

RESULTING GUIDANCE APPLICABLE TO PLUTONIUM CONCENTRATION IN SOIL:
— OVER 400 pCi/g, REMOVE SOIL
— UNDER 40 pCi/g, LEAVE IN PLACE
— BETWEEN 40 AND 400, CASE-BY-CASE DECISION

1977 SERIES OF FALL MEETINGS BETWEEN DOE AND DNA

— CRITERIA TO INCLUDE ALL TRANSURANICS, NOT JUST PLUTONIUM
— CLEANUP CRITERIA LINKED TO INTENDED ISLAND USE
— AGRICULTURAL ISLAND TO MEET CRITERIA OF 100 pCi/g
— CRITERIA INTENDED TO COMPLY WITH EPA PROPOSED GUIDELINES

DEVELOPMENT OF CLEANUP CRITERIA (CON'T)

1978 SERIES OF SPRING MEETINGS BETWEEN DOE AND DNA

PRELIMINARY DOSE ESTIMATES BY LLL INDICATED CLEANUP SHOULD BE ACCOMPLISHED TO THE FOLLOWING LEVELS TO MEET PROPOSED EPA CRITERIA:

- RESIDENCE ISLAND 10 pCi/g
- AGRICULTURAL ISLAND 20 pCi/g
- FOOD GATHERING ISLAND 40 pCi/g

1978 BAIR COMMITTEE RECOMMENDATIONS:

1st PRIORITY - CLEANUP TRANSURANICS ON RESIDENTIAL ISLANDS TO AVERAGE LESS THAN 40 pCi/g FOR EACH QUARTER-HECTARE AREA

2nd PRIORITY - CLEAN TRANSURANICS ON AGRICULTURAL ISLANDS TO AVERAGE LESS THAN 80 pCi/g FOR EACH HALF-HECTARE AREA

3rd PRIORITY - CLEAN TRANSURANICS ON FOOD GATHERING ISLANDS TO AVERAGE LESS THAN 160 pCi/g FOR EACH HALF-HECTARE AREA

1978 MAY DECISION CONFERENCE AT DNA/HQ

DIRECTOR, DNA, AGREED TO ACCEPT THE CRITERIA RECOMMENDED BY THE BAIR COMMITTEE.

IN ALL OF THE ABOVE, DIFFERENT CRITERIA FOR ISLANDS OF DIFFERENT INTENDED USE WAS ABOVE ON ESTIMATES OF THE TIME SPENT ON EACH ISLAND.

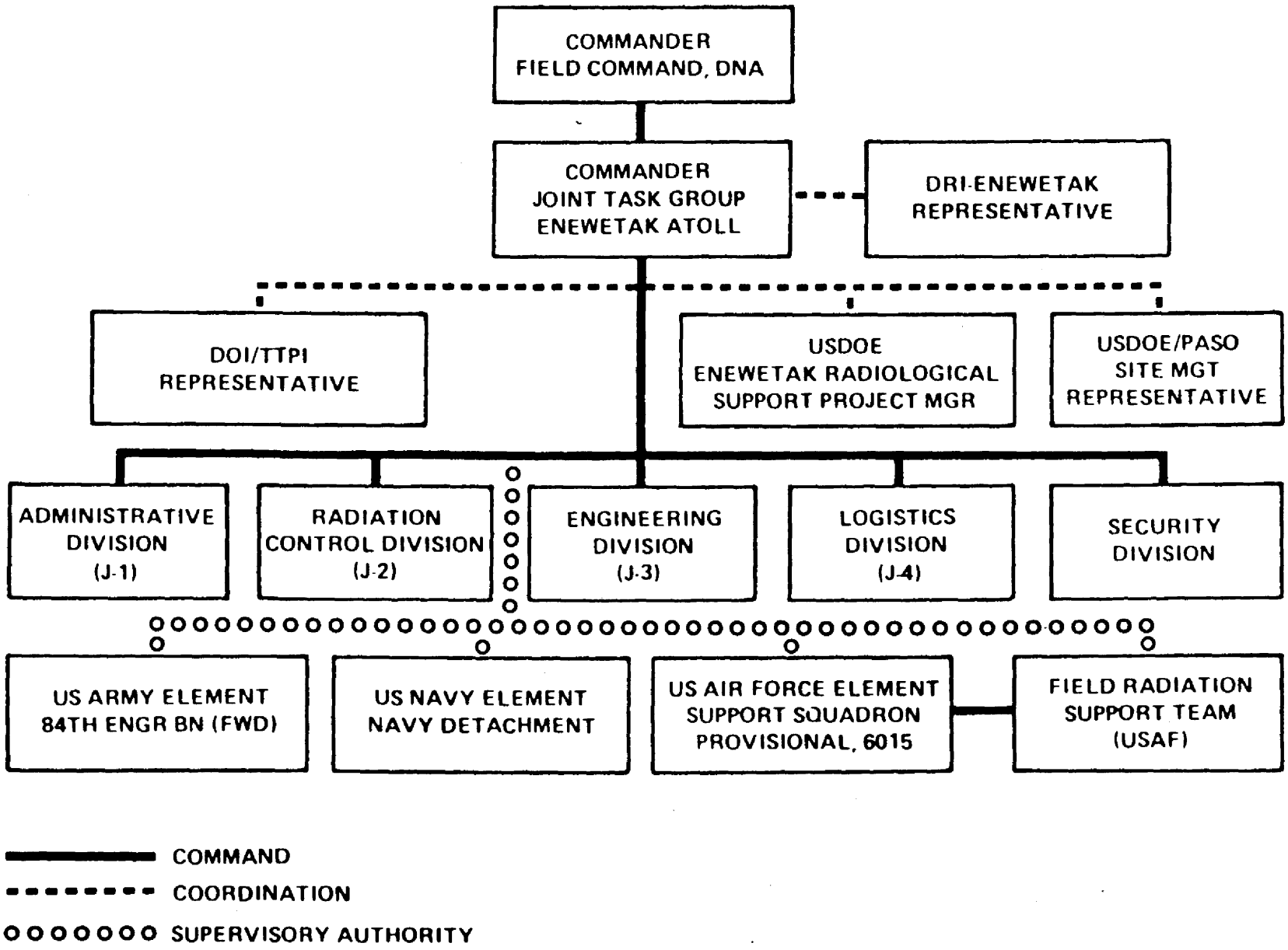


FIGURE 3-12. JOINT TASK GROUP ORGANIZATION.

TYPICAL ATOLL POPULATION DURING ENEWETAK CLEANUP

U.S. ARMY	270
NAVY	220
AIR FORCE	75
DOE & CONTRACTORS	130
DOE/TTPI	100
DNA/JTG	25
VISITORS/MARSHALLESE	75
TOTAL	900

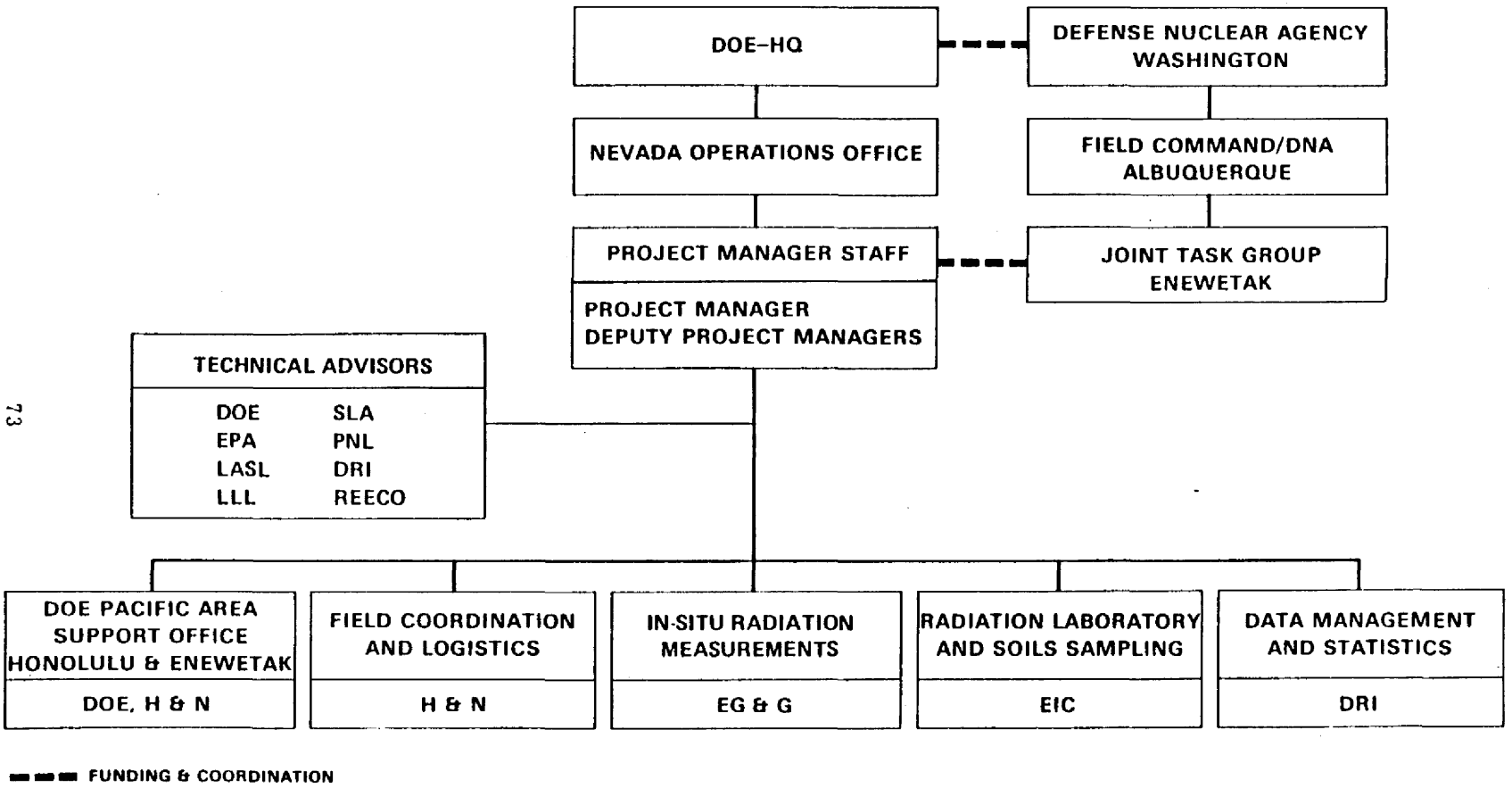


FIGURE 2-5
ENEWETAK RADIOLOGICAL SUPPORT PROJECT (ERSP)

DOE/ERSP ON-ISLAND STAFF (NORMAL OPERATIONS)

MANAGEMENT	
PROJECT MANAGER OR DEPUTY	1
TECHNICAL ADVISOR	1
STAFF ASSISTANT	1
IN-SITU MEASUREMENT SYSTEMS	
SCIENTIST	1
TECHNICIAN	2
DRIVER/MECHANIC (AIR FORCE)	2
RADIATION/SOILS LABORATORY	
MANAGER	1
CHEMIST	1
ELECTRONIC TECHNICIAN	1
FIELD SUPERVISOR	1
SOIL SAMPLER (NAVY)	7
STATISTICS/DATA MANAGEMENT	
STATISTICIAN	1
DATA TECH (NAVY)	1
TOTAL	21

VARIATIONS IN FIELD EXPERIENCE AT ENEWETAK

PRE- AND POST-CLEANUP DATA ARE NOT ABSOLUTELY COMPARABLE FOR VARIOUS REASONS, BUT REPRESENT THE BEST ESTIMATES AVAILABLE DURING CLEANUP.

IRENE CLEANUP WAS DIRECTED TOWARD REMOVAL OF SUBSURFACE POCKETS OF TRU ABOVE CRITERIA, RATHER THAN REMOVAL TO MEET SURFACE CRITERIA. THERE ARE NO COMPARABLE PRE- POST TRU DATA.

JANET CLEANUP WAS CONDUCTED IN 1/4 ha BLOCKS IN "WORST FIRST" ORDER WHERE EVER THE BLOCKS OCCURED.

PEARL CLEANUP WAS DONE AS (ESSENTIALLY) ONE LARGE BLOCK WITH 2 SMALL AREAS REQUIRING A SECOND "LIFT".

SALLY CLEANUP CONSISTED OF 3 SMALL AREAS WHERE AS MANY AS 5 ITERATIONS OR "LIFTS" WERE REQUIRED; ESSENTIALLY A COMBINATION OF SURFACE AND SUBSURFACE EXCISION.

YVONNE CLEANUP WAS QUITE COMPLEX AND NO COMPARABLE DATA EXIST FOR VALID PRE- AND POST-CLEANUP COMPARISON.

CLEANUP OF TRANSURANICS AT ENEWETAK ATOLL

Northern Islands*	Code	Approx. Island Area, ha	Radiological Cleanup Project: Soil Excision Area, ha	Excised Soil**, m^3	Final Surface TRU pCi/g	Final Surface Area Exceeding Screening Level 20 pCi/g, ha	40pCi/g, ha
ALICE	FG	9			76	9	8.8
BELLE	FG	12			95	12	11.2
CLARA	A	3			40	3	0.6
DAISY	A	8.5			43	8.5	2.8
EDNA	R	4			33	4	--
EDNA'S DAU	FG	0.5			103	0.5	0.5
IRENE	A	18	0.6	3775	32	11	3.3
JANET	R	118	15.5	40525	20	36	4
KATE	R	6.5			20	3.5	0.4
LUCY	A	8			35	5.5	3
PERCY	R	0.8			6	--	--
MARY	R	5			19	1.5	0.1
MARY'S DAU	FG	0.5			54	0.5	0.3
NANCY	A	4.5			34	4	0.6
OLIVE	A	16.5			20	4	1
PEARL	A	22	9.7	11415	36	14	6.5
PEARL'S DAU	FG	0.5			123	0.5	0.5
RUBY	R	1.5			8	--	--
SALLY	R	40	1.8	8100***	8	4	0.4
SALLY'S CHILD	R	0.8			21	0.5	--
TILDA	R	21			7	--	--
URSULA	R	16			2	--	--
VERA	R	15.5			7	--	--
WILMA	R	6.5			3	--	--
SO. YVONNE	Q	15.5			8	3.5	0.2
NO. YVONNE	Q	21.5	5.0	8210	41	19.5	5.5
TOTALS		375.6	32.8	72025		145	49.7

Code: FG = Food Gathering; A = Agricultural; R = Residence; Q = Quarantined

*Northern Islands were more contaminated than Southern Islands, which had an average of less than 1 pCi TRU per gram of soil.

**Includes subsurface pockets excised to depths exceeding 1 meter.

***Does not include 7500 m^3 excised from subsurface repository to depth of 7 meters.

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

TRU = 238,239,240 Pu + 241 Am

ISLAND	% OF ISLAND CLEANED	TRU pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3			
JANET	13	26	20	-24
PEARL	44	72	36	-50
SALLY	4.5	11	8	-27

* TOP 15 cm.

RESULTS BY ISLAND FOR FISSION PRODUCTS

Island	^{137}Cs IN 0-15 cm SOIL SAMPLES 1979 Fission Product Data Base Program			^{90}Sr IN 0-15 cm SOIL SAMPLES 1979 Fission Product Data Base Program		
	No. of Locations Sampled	Range of Activity, all depths, (pCi/g)	0-15cm Mean (pCi/g)	No. of Locations Sampled	Range of Activity, all depths, (pCi/g)	0-15cm Mean (pCi/g)
Alice	26	<0.4 - 114	39.9	7	1.3 - 347	85.9
Belle	40	<0.4 - 204	61.0	11	3.5 - 339	107.4
Clara	8	0.3 - 105	22.4	4	1.4 - 243	42.8
Daisy	26	<0.4 - 34	6.8	8	1.9 - 144	34.8
Edna	5	<0.4 - 7	2.9	3	4.3 - 48	21.7
Irene	53	<0.4 - 54	6.1	15	0.6 - 136	31.0
Janet	364	<0.4 - 142	16.4	99	<0.1 - 244	31.9
Kate	18	<0.4 - 35	7.8	6	1.0 - 31	13.3
Lucy	22	<0.4 - 40	11.7	8	1.0 - 94	21.9
Percy	2	<0.4 - 2	0.6	2	2.0 - 7	5.4
Mary	12	<0.4 - 18	6.0	4	1.1 - 46	14.2
Mary's Dau.	3	<0.4 - 72	12.3	1	5.2 - 107	41.9
Nancy	11	<0.4 - 60	10.8	6	<0.15 - 82	20.1
Olive	50	<0.4 - 60	7.5	12	<0.12 - 83	16.2
Pearl	72	<0.4 - 43	7.2	17	0.4 - 38	11.4
Pearl's Dau.	2	<0.4 - 7	5.6	1	1.3 - 28	18.0
Ruby	3	1.1 - 11	2.0	1	5.5 - 9	5.8
Sally	137	<0.4 - 43	3.5	39	<0.10 - 25	4.4
Sally's Ch.	4	<0.4 - 13	6.9	4	1.0 - 60	16.7
Tilda	48	<0.4 - 20	3.2	15	<0.12 - 25	5.6
Ursula	15	<0.4 - 4	1.2	15	<0.08 - 70	3.0
Vera	48	<0.4 - 20	3.0	13	0.2 - 29	4.8
Wilma	17	<0.4 - 5	1.3	5	0.2 - 19	2.9
Yvonne+	14	<0.4 - 11	1.5	5	<0.13 - 5	1.1

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

CS—137

ISLAND	% OF ISLAND CLEANED	CS-137 pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3	10	6	-40
JANET	13	31	16	-48
PEARL	44	15	7	-53
SALLY	4.5	7	3.5	-50

*TOP 15 cm.

REDUCTION OF RADIOISOTOPES BY REMOVAL OF SURFACE* SOIL

SR—90

ISLAND	% OF ISLAND CLEANED	SR-90 pCi/g		PERCENTAGE CHANGE IN CONC.
		PRE-	POST	
IRENE	3	47	31	-33
JANET	13	69	32	-54
PEARL	44	28	11	-61
SALLY	4.5	12	4	-67

* TOP 15 cm.

ENEWETAK CLEANUP PROJECT COSTS (000)

DNA-MILCON	$18,177.4
DNA-BASE CAMP EXPANSION	1,362.8
DNA-OPERATION & MAINTENANCE	19,692.0
SERVICES-AIR FORCE	3,877.1
-ARMY	33,797.5
-NAVY	7,863.8
DOE-RADIOLOGICAL SUPPORT*	3,371.0
DOI-REHABILITATION	14,100.0
	$102,241.6

*AN ADDITIONAL $1.5 MILION DOE COST WAS REIMBURSED FROM DNA-MILCON FUNDS.

SOME COST RATIO APPROXIMATIONS

TOTAL COST OF CLEANUP AND REHABILITATION: $102,240,000.

COST PER:	UNITS	COST
HECTARE*	33	$3,100,000
ACRE*	81	1,262,000
CUBIC METER SOIL	79,500	1,285
CURIE	14.7	6,955,000
FATALITY	2	51,120,000
LIFE SAVED	0.025	4,089,664,000

*INCLUDES ONLY THAT AREA FROM WHICH SOIL WAS REMOVED.

CLEANUP YARDSTICKS

SOIL MOVED TO CACTUS CRATER, yd^3	104,097
TRU IN MOVED SOIL, CURIES	14.7
DEBRIS — UNCONTAMINATED - TO LAGOON, yd^3	122,810
— UNCONTAMINATED - TO SALVAGE, yd^3	54,500
— CONCRETE RUBBLE - SHORE PROTECTION, yd^3	76,340
— CONTAMINATED - TO CACTUS CRATER, yd^3	5,883
SOIL SAMPLES ARCHIVED	11,455
AIR SAMPLED, m^3	866,227
AIR FILTERS ANALYZED	5,204
GAMMA SPECTROMETRY - IN LAB	11,553
- IN-SITU	6,000 +
COCONUT TREES PLANTED	30,333
DOCUMENTATION GENERATED, LINEAR FT	200 +

FATALITIES DURING ENEWETAK RADIOLOGICAL CLEANUP

MILITARY

19 AUG 77*	USN WELDER, EXPLOSION WHILE WELDING ON LANDING CRAFT.
17 NOV 77	USA PVT, CARDIAC ARREST WHILE PLAYING BASKETBALL.
14 AUG 78*	USA NCO, CARDIAC ARREST WHILE PINNED BETWEEN D8 DOZER AND DUMP TRUCK.
29 DEC 78	USAF CPT, LOST WHILE SAILBOATING FOR RECREATION.
29 DEC 78	USA PFC, LOST WHILE SAILBOATING FOR RECREATION.
06 JAN 80	USA SPEC 4, ASPIRATION OF THE LUNGS ON HIS OWN VOMITUS, THEN SUFFOCATION.

* SATISFIES NATIONAL SAFETY COUNCIL CRITERIA FOR INCLUSION IN DATA TABLES FOR REPORTING ACCIDENT STATISTICS

DOE & CONTRACTORS

JUL 79	EIC FIELD SUPERVISOR, DEPARTED ATOLL FOLLOWING INCIDENCE OF CHEST PAINS, AND CHECKED INTO HOSPITAL IN HONOLULU, DIED SEVERAL DAYS LATER OF HEART PROBLEMS.
79	H&N BARBER, DIED IN HIS SLEEP OF NATURAL CAUSES. (?)

TOP CAUSES OF DEATH IN U.S. POPULATION, 1976

CAUSE	DEATH RATE*	EXPECTED DEATHS IN 30 YR IN POPULATION OF 500
ALL CAUSES	888	133
HEART DISEASE	336	50
CANCER	171	26
STROKE	91	14
ACCIDENTS	48	7

*DEATHS PER 100,000 POPULATION (FROM ACCIDENT FACTS, 1977)

WORK ACCIDENTS

INDUSTRY GROUP	WORKERS (000) [a]	DEATHS [a]	DEATH RATES [b] 1976	1981
ALL INDUSTRIES	87,800	12,500	14	12
TRADE	20,300	1,300	16	5
MANUF. & SERVICE	39,800	3,500	19	7
GOVERNMENT	14,900	1,700	11	10
TRANSP. & UTILITIES	4,800	1,500	31	31
AGRICULTURE	3,500	1,900	54	54
CONSTRUCTION	3,700	2,100	57	40
MINING	800	500	63	55
ENEWETAK CLEANUP	1	0.7	70	

[a] IN 1976

[b] PER 100,000 WORKERS IN EACH GROUP.

[c] TOTAL OF 8033 INDIVIDUALS INVOLVED IN 3 YEAR PROJECT WITH NO MORE THAN 1000 INVOLVED AT ONE TIME.

BASIC DATA FROM ACCIDENT FACTS, 1977 AND 1982.

AT-WORK ACCIDENTAL DEATHS, 1980

	AT WORK	
	DEATHS	RATE[a]
TOTAL U.S.	13,000	5.7
HIGHEST STATE - WYOMING	63	13.3
- NEVADA	39	4.9
LOWEST STATE - NEW YORK	174	1.0
DOE & CONTRACTORS		5.6[b]
NTS AVERAGE 1965-81	1.35	27.0[c]

a. DEATHS PER 100,000 WORKER YEARS. (FROM ACCIDENT FACTS, 1981)

b. 1978-82 AVERAGE (FROM INJURY AND PROPERTY DAMAGE SUMMARY, JAN-JUN 1983, USDOE)

c. BASED ON NTS AVERAGE MONTHLY WORK FORCE.

SUMMARY OF AT-WORK FATALITY RATES

ACTIVITY	FATALITY RATE*	RISK
ALL INDUSTRIES (1976)	14	1.4×10^{-4}
CONSTRUCTION (1976)	57	5.7×10^{-4}
ALL AT WORK, STATE OF NEV. (1980)	4.9	4.9×10^{-5}
DOE & CONTRACTORS (1978-82 AVG.)	5.6	5.6×10^{-5}
NTS (1965-81 AVG.)	27	2.7×10^{-4}
ENEWETAK CLEANUP	70	7.0×10^{-4}

*DEATHS PER 100,000 WORKER YEARS

INFORMATION THAT HAS BEEN OBTAINED

IF PEOPLE WILL LIVE ON ENEWETAK, JAPTAN, AND MEDREN;
IF THEY WILL EAT FOOD FROM THEIR ATOLL ALONG WITH FOOD FROM OUTSIDE;
IF THEY DO GATHER COCONUTS FROM BILLAE TO MIJIKADREK;

THE LARGEST AMOUNT OF RADIATION ONE PERSON MIGHT RECEIVE DURING 1 YEAR.		28 millirem
AVERAGE AMOUNT OF RADIATION A PERSON MIGHT RECEIVE DURING 30 YEARS.	(WHOLE BODY)	200 millirem
	(BONE MARROW)	250 millirem
THE INCREASE OF CANCERS THAT MIGHT OCCUR WITHIN THE NEXT 30 YEARS.		0.10%
THE POSSIBLE INCREASE OF CHILDREN BORN WITH HEALTH DEFECTS WITHIN THE NEXT 30 YEARS.		0.04%

THIS MEANS THAT IF THERE WOULD BE 10,000 PEOPLE DIE WITHIN THE NEXT 30 YEARS FROM ANY CANCER OTHER THAN THAT CAUSED BY RADIAITON LEFT FROM ATOMIC BOMBS, THERE MIGHT BE AN ADDITIONAL 10 WHO DIE FROM CANCER THAT IS CAUSED BY RADIATION LEFT FROM ATOMIC BOMBS

THIS MEANS THAT IF THERE WERE 10,000 CHILDREN BORN WITH HEALTH DEFECTS OCCURING FROM ANY CAUSE OTHER THAN RADIATION LEFT FROM ATOMIC BOMBS, WITHIN THE NEXT 30 YEARS, THERE MIGHT BE AN ADDITIONAL 4 CHILDREN BORN WITH DEFECTS CAUSED BY RADIATION LEFT FROM ATOMIC BOMBS.

ESTIMATES OF TRU DOSE TO RETURNING ENEWETAK PEOPLE

	30 YEARS	50 YEARS	AVERAGE*
[illegible]			
ESTIMATES OF POST-CLEANUP WORST CASE	7,800 mrem	13,000 mrem	13.0 mrad/yr.
[illegible]			
[illegible] (100% OF TIME, IMPORTS UNAVAILABLE)	394 mrem	1,000 mrem	1.0 mrad/yr.
[illegible] (80% OF TIME, IMPORTS)	60 mrem	163 mrem	0.2 mrad/yr.

*AVERAGE ANNUAL BONE DOSE (RAD) USING 50 YEAR TOTAL AND ALPHA QUALITY FACTOR OF 20.

TRU CONTRIBUTION IS A SMALL PART OF TOTAL DOSE DURING INITIAL 30 YEARS.

RADIATION-INDUCED CANCER IN THE ENEWETAK POPULATION

ENEWETAK PEOPLE WERE TOLD IF THERE WERE 10,000 DEATHS FROM CANCER NOT RELATED TO RADIATION, THERE MIGHT BE AN ADDITIONAL 10 PEOPLE DIE OF CANCER DURING THE NEXT 20 YEARS AS A RESULT OF THE RADIATION REMAINING ON THE ISLANDS, ASSUMING LIVING AND EATING PATTERNS IN CONFORMANCE WITH CASE 3 CLEANUP.

ASSUME THE FOLLOWING CONDITIONS:

- DURING THE NEXT 30 YEARS, AN AVERAGE OF 500 PEOPLE RESIDE ON ATOLL, WITH THE HELP OF IMPORTED FOOD. (15,000 PERSON-YEARS)
- CAUSES OF DEATH ARE THE SAME AS FOR THE U.S. POPULATION IN 1976 (FOR LACK OF BETTER DATA).

THEN, THERE MIGHT BE AN ADDITIONAL 0.026 DEATH FROM CANCER CAUSED BY THE RADIATION.

(NOTE: DOSE ESTIMATES INCLUDED INTAKE OF CESIUM AND STRONTIUM WHICH WERE EXCLUDED FROM CONSIDERATION IN THE CLEANUP CRITERIA.)

RISK OF RADIATION-INDUCED CANCER DEATH AT ENEWETAK

NUMBER RESIDENTS, AVERAGE/YEAR, 30 YEARS	500
ADDITIONAL RADIATION-INDUCED CANCER DEATHS, 30 YEARS	0.026
ADDITIONAL CANCER DEATHS PER YEAR, PER 500 RESIDENTS	0.0009
RATE PER 1,000,000	1.7
APPROXIMATE RISK TO FUTURE RESIDENTS	1.7×10^{-6}
APPROXIMATE RISK TO CLEANUP WORKERS	7.0×10^{-4}

THE GAME ISN'T OVER 'TIL THE LAST OUT

THE ENEWETAK CLEANUP PROJECT OFFICIALLY ENDED APRIL 15, 1980. ACTIVITIES SINCE THEN INCLUDE:

REPORT TO ENEWETAK PEOPLE, DOE	25 PGS	1979
ISLAND CERTIFICATION BY DOE,	92 PGS	1980
DOSE ASSESSMENT, LLNL	92 PGS	1980
PROJECT REPORT, DNA	700 PGS	1981
PROJECT REPORT, DOE	712 PGS	1982
SOIL SAMPLES IN ARCHIVE AT NTS UNTIL		?
MONITORING OF CACTUS DOME UNTIL		?
BEGIN RADIONUCLIDE MONITORING OF COCONUTS		1986
MONITOR COCONUTS UNTIL		?
SAVE DATA BASE TAPES UNTIL		?

EPA BACKGROUND PAPER OUTLINING RISK ASSESSMENT RATIONALE, REGULATORY PLAN FOR CONTROLLING BENZENE UNDER CLEAN AIR ACT (Dated December 15, 1983)

National Emission Standards for Hazardous Air Pollutants (NESHAPS) for BENZENE

PURPOSE

The U.S. Environmental Protection Agency (EPA) intends to establish emission standards for certain industrial sources of benzene. This paper will discuss (1) the statutory basis for this action, (2) background information on benzene, (3) EPA's standard-setting process, and (4) a summary of the final standard, the proposed standard and those the agency proposes to withdraw.

INTRODUCTION

Section 112 of the Clean Air Act of 1970 requires EPA to identify and list pollutants which cause or contribute air pollution which "may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness," and to issue National Emission Standards for Hazardous Air Pollutants (NESHAPS) for classes of sources of these pollutants. EPA listed benzene as a hazardous air pollutant on June 8, 1977. On April 18, 1980, EPA proposed a benzene emission standard for maleic anhydride plants. On December 18, 1980, EPA proposed a benzene emission standard for ethylbenzene and styrene plants. On December 19, 1980, EPA proposed a benzene emission standard for benzene storage vessels; and on January 5, 1981, EPA proposed a benzene emission standard for fugitive emissions from petroleum refineries and chemical manufacturing plans. A lawsuit brought by environmental and industry groups to compel EPA to act on benzene standards is now pending in the Federal District Court in Washington.

EPA intends to promulgate final regulations soon on the proposed standard for benzene fugitive sources and to propose a standard for a new source category, coke by-product recovery plants. The agency intends to propose to withdraw the standards for maleic anhydride plants, ethylbenzene and styrene plants, and benzene storage vessels, based on its assessment that the risks to public health are small and that the proposed standard would minimally reduce those risks. Consequently, EPA has concluded that the three source categories do not warrant regulatory concern at the federal level.

BACKGROUND ON BENZENE

Benzene is a major industrial chemical, ranking among the top fifteen with the U.S. production volume of almost 6 million megagrams (or 6.6 million tons) in 1979. In addition to industrially produced benzene, roughly an equal amount is found in gasoline. The vast majority of benzene is derived from petroleum, with a smaller percentage produced as a by-product of coke ovens. Most benzene is used to produce other industrial chemicals, which in turn are used to manufacture a wide range of products including nylon, plastics, insecticides, and polyurethane foams. Stationary source categories of benzene include "fugitive" emissions (non-stack emissions, such as leaks) from petroleum refineries and chemical manufacturing plants, the gasoline marketing system, process vents at several types of chemical manufacturing plants, coke oven by-product plants, and benzene storage and handling facilities.

Numerous occupational studies conducted over the past 50 years provide evidence of the health hazards resulting from prolonged inhalation of benzene. Benzene has been recognized since 1900 as a toxic substance capable of causing acute and chronic effects. Benzene attacks the hematopoietic (blood-forming) system, especially the bone marrow, and its toxicity is manifested primarily by alterations in the level of the formed elements in the circulating blood (red cells, white cells and platelets). The degree of severity of these effects ranges from mild and transient episodes to severe and fatal disorders. The mechanism by which benzene produces its toxic effects, although under investigation, is still unknown. The adverse effects on the blood forming tissues have been documented in studies of workers in a variety of industries and occupations including the manufacturing and processing of rubber, shoes, rotogravure, paints, chemicals, and natural rubber cast film. These studies include single case reports, cross-sectional studies and retrospective studies of morbidity and mortality among a defined cohort of workers industrially exposed to benzene.

Occupational exposure levels are much higher than ambient concentrations of benzene. In addition, EPA believes that non-cancer effects of benzene exposure are unlikely to occur at ambient concentations. Discussions of these issues are included in documents supporting EPA's regulation of benzene prepared by or for EPA entitled the "Assessment of Health Effects of Benzene Germane to Low Level Exposure," the "Assessment of Human Exposures to Atmospheric Benzene," and the "Carcinogen Assessment Group's Report on Population Risk to Ambient Benzene Exposures."

Benzene exposure is causally related to a number of blood disorders, including acute myelogenous leukemia (a cancer of the blood-forming system in adults.) Benzene does not appear to cause another form of leukemia, acute lymphocytic leukemia which occurs almost totally in children. Acute myelogenous leukemia, which is caused by benzene, almost never occurs in children.

Although the health studies of benzene involve industrial exposure to benzene at higher levels than those found in the ambient air, in the absence of sound scientific evidence to the contrary, prudent public health policy requires that carcinogens be considered for regulatory purposes to pose some finite risk of cancer at any exposure level above zero. Because of its widespread use, benzene emissions in the ambient air from some sources result in significant human exposure. Therefore, in June 1977, the Administrator of

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EPA concluded that benzene satisfied the definition of a "hazardous air pollutant" under Section 112 of the Clean Air Act.

THE STANDARD-SETTING PROCESS

Carcinogens and Section 112

Once a substance has been listed as a hazardous air pollutant, Section 112 of the Clean Air Act requires EPA to publish standards which provide an "ample margin of safety" to protect the public health. However, neither the language nor the legislative history of Section 112 reveals any specific Congressional intent as to how to apply the phrase, "ample margin of safety" to protect the public health from pollutants like benzene.

In some cases, scientific evidence indicates that a given chemical is hazardous at high levels of exposure but has no effect below a certain level. For most carcinogenic chemicals such as benzene, however, scientists are unable to identify such a threshold below which no effects take place; moreover, to the extent scientists understand the process of carcinogenesis, there is some reason to believe thresholds may not exist. For such substances, EPA and other Federal agencies have taken the position that any level of exposure may pose some risks of adverse effects with the risks increasing as the exposure increases.

Since any given environmental carcinogen is responsible for at most a small fraction of a community's overall cancer incidence, with current statistical techniques it is virtually impossible to directly link actual human cancers with actual ambient air exposure to chemicals such as benzene. Consequently, EPA relies on mathematical modeling techniques to estimate these human health risks. These techniques — "quantitative risk assessment" — are used to assess the risk of adverse health effects from exposure to benzene in the ambient environment by mathematically extrapolating those effects found at the higher occupational exposure levels down to lower concentration levels that more nearly reflect the exposure of people from the ambient air around industrial sources of benzene.

"Quantitative risk assessment" (described below) couples the mathematical dose-response models with estimates of population exposures to describe the magnitude of the risk posed by sources of carcinogens such as benzene. It is an attempt to synthesize and apply available scientific knowledge about carcinogens to predict the effects of environmental exposures. At best, quantitative risk assessment gives us an estimate of how severe the health problem could be. What to do about the risks-what controls, if any, to require — constitutes "risk management." Risk assessment, then, provides information that is important, but it alone is insufficient to make risk management decisions. That is, in addition to information on health risks, any risk management policy also requires information on control technologies, their effectiveness and costs.[1]

Risk Assessment

EPA's approach to risk assessment for suspected carcinogens may be divided into several steps. The first is a qualitative evaluation of the evidence to determine whether a substance should be considered a human carcinogen for regulatory purposes. As described earlier, this was done in the case of benzene before the chemical was listed as a hazardous air pollutant in 1977. The next stage is quantitative: how large is the risk of cancer at various levels of exposure? The result of this examination is a dose-response function which gives the lifetime risk per unit of exposure (or "potency.") The next stage is to estimate how many people are exposed to the substance, and at what levels. These exposure estimates then are combined with the dose-response function to obtain estimates of the risk caused by emissions of the pollutant, in this case benzene, into the environment.

All stages of the process are subject to uncertainties because of gaps in scientific knowledge and data limitations. One step that has great uncertainty is estimating the dose-response function. The fundamental problem is in extrapolating from data on the relatively high doses in the epidemiological or animal toxicological studies to the far lower exposure levels found in the environment. In the case of benzene, the data showing increased risk are based on workers exposed to many parts per million, but most environmental exposures for the general public are no higher than several parts per billion. In other words, it is necessary to extrapolate to doses a thousand or more times lower than those at which increased cancer rates have been observed.

Scientists have proposed many different mathematical models for low-dose extrapolation. EPA generally relies on the linear, no-threshold model, which assumes that risk is proportional to dose. This model is chosen because it has some biological justification. With this model, decreasing the dose by a factor of 1000 also reduces the risk by a factor of 1000. Most of the other models predict much smaller risks at low doses. The linear model generally yields a higher estimate of potency than other models and most scientists accept it as giving a plausible upper-limit estimate for a chemical's potency at low levels of exposure. In other words, the potency of a substance is unlikely to be higher than estimated using the linear model, and could be substantially lower. Use of the linear model reflects EPA's decision to err on the side of caution in the face of uncertainties. The final result is a "unit-risk factor," which gives the estimated upper-limit lifetime risk per unit of exposure.

Exposure levels for each specific source categories are derived using emissions estimates, dispersion modeling, and population data. For any given level of emissions, dispersion models predict concentrations at different distances from the emission source. By combining those estimated concentrations with census data on population densities, the number of people exposed at different levels can be estimated. Several factors suggest that actual exposure levels will be lower than those estimated. In estimating exposure, the most exposed individuals are hypothetically subjected to the maximum annual average concentration of the emissions for 24 hours every day for 70 years (roughly a lifetime). This does not take into account indoor vs. outdoor air, for instance, or the fact that most people in their daily routines move in and out of the specific areas where the emissions concentrations are the highest.

The final risk estimates are the product of the exposure levels and the estimated unit-risk factor. Two summary measures are of particular interest: "maximum individual risk" and "total population impact." The former refers to the estimated increased lifetime risk from a source that is faced by an individual who spends his or her entire life at

[1] For a discussion of the important distinction between risk assessment and risk management and their role in government decision-making, see "Science, Risk, and Public Policy" by William D. Ruckelshaus, presented at the National Academy of Sciences, June 22, 1983, reprinted in Science, September 9, 1983.

the point where predicted concentrations of the pollutant are highest. Maximum individual risk is expressed as a probability; a risk of one in ten thousand, for example, means that a person spending a lifetime at the point of maximum exposure faces an estimated increased risk of cancer of one in 10,000. (For comparison, the average lifetime risk of contracting cancer in the United States is currently about 2.5 in ten, so eliminating a risk of one in ten thousand reduces the overall lifetime risk of contracting cancer by less than 0.1 percent.) Estimates of maximum individual risk must be interpreted cautiously, however, since few people reside at the points of maximum concentrations and even fewer spend their whole lives at such locations.

The second measure, "total population impact," takes account of people exposed at all concentrations, low as well as high. It is expressed in terms of annual number of cancer cases, and provides a measure of the overall impact on public health. A total population impact of 0.05 per year, for example, means that the modeling predicts that emissions of the specific pollutant from the source category will cause one case of cancer every 20 years. Such figures should not be viewed as precise, however, nor even as best estimates of the likely effects. They, together with the estimtes of maximum individual risk, are intended to give an indication of a plausible upper-limit situation. In the same vein, a plausible lowerbound estimate of the risk would be zero.

The two estimates taken together provide a better description of the magnitude and distribution of risk in a community than either number taken alone. "Maximum individual risk" tells us the worst risk, but not how many people bear that risk. "Total population impact" describes the overall health impact on to the entire exposed population, but not how much risk the most exposed persons bear. Two chemicals or regulations could have similar population impacts, but very different maximum individual risks, or vice versa. Consequently, any sensible "risk management" system cannot rely on either measure alone; both are important.

Risk Management

Given the linear no-threshold assumption regarding risks from pollutants such as benzene, the only absolutely risk-free approach to setting a standard would be to reduce exposures to zero. It does not appear that Congress intended Section 112 standards to cause widespread distribution of the national economy. Moreover, while Section 112 requires standards to protect the public health, this does not mean that EPA must eliminate all risks. For carcinogens (asbestos and vinyl chloride) EPA has reduced human health risks by setting Section 112 standards that reflect identified emission control techniques. Thus, EPA has sought to establish an approach to risk management that allows for an appropriate control of emissions of hazardous air pollutants without an automatic closing of all sources of the pollutant.

This risk management approach that EPA has adopted for Section 112 pollutants is as follows:

1) The agency should evaluate all source categories of the pollutant to determine which categories cause significant public health risks.

2) The source categories that are judged to cause significant risk are then evaluated. EPA examines the various options available to reduce emissions from these sources, including controls similar to those imposed under Section 111 of the Clean Air Act (New Source Performance Standards) and closing the plant. Options are examined in terms of control efficiency, technical feasibility, and costs and the reductions in risk that they achieve.

SUMMARY OF EPA'S INTENTIONS TO REGULATE BENZENE

EPA listed benzene as a hazardous air pollutant in 1977. In 1980 and 1981, EPA proposed emission standards for four source categories (maleic anhydride plants, ethylbenzene and styrene plants, benzene storage vessels and fugitive emissions from petroleum refineries and chemical manufacturing plants) and began work on a fifth standard for coke by-product recovery plants that will be proposed.

I. *Intent to promulgate final benzene standard for fugitive benzene emissions from petroleum refineries and chemical manufacturing plants:*

EPA estimates that the control of some 229 sources will reduce benzene fugitive emissions from existing petroleum refineries and chemical manufacturing plants from about 7900 megagrams per year to about 2500 megagrams per year. As a result of this emission reduction, the standard would reduce the estimated maximum lifetime risk for the most exposed individual from 15 chances in 10,000 to 4.5 in 10,000, and would reduce the estimated annual incidence of cancer from new and existing plants from an estimated 0.45 to 0.14, or an approximate 70 percent reduction. Benefits to air and water quality will result from the new standard because the controls utilized in implementing the standard will also reduce emissions of other potentially toxic hydrocarbons and because leak control techniques would reduce the amount of benzene and other organic compounds entering wastewater systems.

The standard will limit benzene emissions from new and existing fugitive emissions sources containing 10 or more percent by weight benzene in the petroleum refining and chemical manufacturing industries. The standard allows no detectable emissions due to leaks from safety/relief valves and product accumulator vessels; requires a leak detection and repair program for pipeline valves and existing pumps and compressors; and requires certain equipment for new pumps, new compressors, sampling connections, and open-ended valves.

Public hearings were held on the proposed standard for fugitive sources and the comments received are being considered in the final rule.

II. *Intent to propose benzene emission standard for coke by-product recovery plants:*

The proposed standard would reduce benzene emissions from several emission sources at new and existing coke by-product recovery plants through a combination of emission, equipment, work practice, and operational requirements. The 55 existing coke by-product plants account for an estimated 29,000 megagrams of benzene emissions yearly, or some 53 percent of all benzene emissions from stationary sources. EPA's proposal calls for a reduction of some 25,500 megagrams, or an 88 percent reduction in emissions. The proposed controls would reduce the maximum individual risk from 83 chances in 10,000 to 3.5 in 10,000. The number of cancer incidences would change from 2.60 per year to 0.23 per year.

In addition to the reduction of benzene emissions, the agency projects that nationwide emissions of nonbenzene organic pollutants, which include volatile organic compounds, naphthalene, polynuclear aromatic hydrocarbons, and lighter organic compounds, would also be reduced from their current estimated level of 165,000 megagrams per year to about 41,000 megagrams per year, a 75 percent reduction.

III. *Intent to Propose Withdrawal of Proposed Standards for Three Source Categories (maleic anhydride plants, ethylbenzene and styrene plants, and benzene storage vessels):*

EPA's decision to withdraw the proposed standards for these source categories is based on the conclusion that regulatory action is not warranted at the national level because the health risks from benzene from these categories in the absence of federal regulations appear small and they would not be appreciably reduced by the proposed regulation. For comparison, the risks from these sources to the most exposed individuals and the population as a whole are estimated to be 10 to 100 times lower than for the two benzene source categories which the agency intends to regulate.

Since the agency proposed standards for these source categories in 1980, the potential number of sources affected by the maleic anhydride standard, and the emission estimates for all three source categories, have declined significantly. These changes have occurred as a result of closures, process changes, improved estimates, and the voluntary application of controls from both regulatory and economic pressure. Many of the sources that would have been affected by the standards EPA proposes to withdraw would now be considered to be in compliance with the standard because of these changes. These changes have resulted in reductions in the estimated before-control individual and population health risks associated with each source category. For example, for benzene storage facilities, the estimated lifetime risk to the most exposed individual has declined over tenfold to 3.6 in 100,000. Expected cancer incidence from benzene exposure for all three source categories is only one case every 13 years. Moreover, were EPA to issue the proposed standards for these categories, it would eliminate only one cancer case every 30 years.

EPA estimated that issuance of the standard for the three source categories would affect only 3.3 percent of the total benzene emissions from stationary sources.

SUMMARY OF FIVE SOURCE CATEGORIES

INTENT TO REGULATE UNDER SECTION 112

Source Category	Number of Existing Facilities	Emissions (Megagrams/year) Before	After	Total Stationary Source Emissions	Maximum Lifetime Individual Risk Before	After	Annual Cancer Cases Before	After	Difference	Cost (Millions) Capital	Annual
Benzene fugitive	229	7,900	2,500	16%	15/10,000	4.5/10,000	0.45	0.14	0.31	85.5	0.4
Coke by-product	55	29,000	3,500	53%	91/10,000	3.5/10,000	2.60	0.23	2.37	30.9	(1.1)

INTENT TO PROPOSE WITHDRAWAL OF PROPOSED STANDARDS

Maleic anhydride	3	960	120	2%	76/million	5.1/million	0.029	0.016	0.013	6.4	2.8
Ethylbenzene/ styrene	13	210	68	0.4%	140/million	9.8/million	0.0057	0.00058	0.0051	2.7	0.97
Benzene storage	126	620	600	1%	3.6/100,000	2.3/100,000	0.043	0.029	0.015	7.3	1.3

orders will incorporate administrative requirements (i.e., record-keeping, monitoring) similar to those mandated by other environmental programs.

When an administrative order or consent decree is contemplated at a site where a removal action is indicated, the public participation process may be compressed or modified to allow timely response action by the responsible party or the government.

This policy is effective immediately and the NCP will be amended to reflect this policy.

If you have any questions on this policy or its implementation, contact Douglas Cohen (FTS-475-8112) or Bruce Clemens (FTS-382-2201) of OERR, Libby Scopino (FTS-382-2270) of OWPE, or Terry Grogan (FTS-382-2224) of OSW.

cc: Assistant Administrators
Superfund Community Relations Coordinators, Regions I-X
Office of Public Affairs, Regions I-X
Regional Counsels
Superfund Coordinators

OMB POSITION ON USE OF RISK ASSESSMENT, COST-EFFECTIVENESS ANALYSIS, BENEFIT-COST REVIEW IN SETTING STANDARDS FOR TOXIC AIR POLLUTANTS

(Dated Dec. 9, 1983)

Mr. Milton Russell
Assistant Administrator
for Policy, Planning
and Evaluation
Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

Dear Milt:

The Environmental Protection Agency's proposed standards for sources emitting two hazardous air pollutants, radionuclides and inorganic arsenic, raise several regulatory policy issues of great importance. EPA has solicited comments on, among other issues, the appropriate role of risk assessment, cost-effectiveness analysis, and benefit-cost analysis in setting emission standards. The enclosed paper discusses these issues in some detail. Our main conclusions are summarized in this letter.

EPA's proposed standards for these two pollutants would reduce the expected incidence of cancer by an estimated 4.06 cases per year at an annual total cost of $27.1 million. An alternative regulatory strategy would be to apply EPA's proposed control requriements only to those plants where the effectiveness of such controls would be relatively high; this alternative would lessen cancer incidence by 3.92 cases annually (96 percent of the expected reduction under EPA's proposal) at a cost of $7.4 million per year (27 percent of the expected cost of EPA's proposal). Going beyond the alternative strategy and extending controls to the remaining plants covered by EPA's proposed standards would achieve an estimated further reduction in cancer incidence of only 0.13 expected cases per year at an additional cost of $19.7 million per year.

Most of the public health gains from reducing these emissions can be achieved, in other words, by regulating a particular subset of the plants covered by EPA's proposed rules. This is because plants vary substantially in the nature of their production processes, the level of control already in place, and the population density in their immediate vicinity. As a result, the likely effectiveness in terms of public health gains of further control of these emissions varies across plants by several orders of magnitude.

The environmental policy advantages of greater attention to risk reduction in relation to control costs are clearly evident in the case of EPA's proposed standards for sources emitting inorganic arsenic. The proposed individual source controls have not been set with much regard to joint consideration of public health gains and control costs. As a result, the range across plants of compliance cost per cancer avoided is extremely wide: $7 million to $1.3 billion.

Greater emphasis on likely reductions in exposure and health risks in the standard-setting process would lessen such extreme variation and improve the standards. The following recommendations to that end are discussed more fully in our paper:

— Risk assessment information is not now used by EPA at all stages of its standard-setting process; we believe it can and should be.

— Not considering risk data in setting "Best Available Technology" standards has unfortunate consequnces. The likely public health gains per dollar of expenditure resulting fgrom EPA's regulatory decisions appear to vary across sources by a factor of more than 2000. The expected reduction in cancer incidence ranges from less than 0.001 to 2.000 expected cases avoided per million dollars of compliance expenditure. At some plants, EPA expects compliance with the proposed standards to yield public health improvements that are exceedingly small. We recommend consideration of the alternative regulatory strategy referred to above which, through greater attention to relative effectiveness, could achieve most of the expected public health gains at one-third of the cost or less.

— EPA's initial step in standard-setting identifies source categories posing a "significant" public health risk. We question the usefulness of this step as EPA has employed it in the past and see no clear pattern in its application (such as a common *de minimis* cutoff risk level). If EPA decides to retain this step, we recommend selection of numerical criteria for *de minimis* risk levels.

— To the extent that risk information is considered in setting standards, EPA has asked for comment on how individual risk should be measured. In our judgment annual individual risk is a far better measure for these purposes than maximum lifetime risk.

— EPA also has requested comment on how it should take into account aggregate population risk as distinct from individual risk. We believe population risk is the better measure of the likely public health gains of regulation. Separate consideration of individual risks is necessary only where such risks are unusually high.

Sincerely,

Christopher DeMuth
Administrator for Information
and Regulatory Affairs

Enclosure

EPA'S STANDARD-SETTING FOR TOXIC POLLUTANTS

December 1983

A. Introduction

The Clean Air Act requires the Environmental Protection Agency to establish national emission standards for hazardous air pollutants. Section 112 of the Act requires that EPA first "list" a pollutant as hazardous, and then set emission standards for industrial plants emitting the listed pollutant. By the end of 1980, EPA had listed seven pollutants as hazardous and set or proposed plant emissions standards for five of them. EPA recently proposed standards for plants emitting the remaining two pollutants — inorganic arsenic and radionuclides.[1] This paper considers the central policy issues raised by EPA's standard-setting approach in these proposed rules.

EPA's preamble to its proposed rules for inorganic arsenic and radionuclides outlines the following three-step approach for establishing standards for hazardous air pollutants:[2]

— Categories of pollution sources are classified according to whether they pose a "significant risk" to public health. In making such a determination, EPA considers that a source category poses a "significant risk" if there is a strong likelihood that it emits a carcinogen *and* that individuals or the general population receive significant exposure to the substance emitted by the source category.

— A source category judged by EPA as posing significant public health risks is then evaluated to determine the current level of control and the level of control constituting Best Available Technology (BAT) for plants or facilities in the source category. EPA's determination of BAT takes into account such factors as the potential for improved control, the economic effects of additional control requirements on the source category, and the age and remaining useful life of the facilities.

— EPA determines whether the public health risks posed by the residual emissions of a source category would be unreasonable after installation of BAT control. In making this determination, EPA considers the likely additional reduction in public health risks, the economic effects, and other effects of regulatory alternative that are more stringent than the selected BAT requirements.

We think there are important shortcomings in this process arising in large measure from the way in which EPA chooses to use — and not use — risk assessment information.[3] The critical step in this process is EPA's BAT approach to standard-setting. This approach explicitly excludes consideration of the likely public health effectiveness of BAT-level controls for source categories posing "significant" risks. At other points in its decision process, where EPA does consider risk assessment information, it does so in a way that imparts a large and inappropriate conservative bias to the ultimate regulatory decision.

In this paper we begin by considering the regulatory policy that results from the standard-setting approach used in EPA's proposed rules (Section B). We then discuss EPA's use of a BAT-approach and the possible modification of that approach described in EPA's proposed rule for limiting inorganic arsenic emissions from low arsenic feed copper smelters (Section C). Finally, we discuss the role of risk assessment information at other junctures in EPA's standard-setting process, and the relative weighting given to reductions in individual risk as opposed to population risks from exposure to these substances (Section D).

B. The Effectiveness of EPA's Regulatory Requirements

The objective of the Section 112 hazardous air pollutant standards is protection of public health, so it is important to assess the effectiveness of EPA's standard-setting decisions in terms of the likely public health gains. We have developed such information on the public health effectiveness of EPA's proposed BAT standards using available data for sources emitting radionuclides and inorganic arsenic. (See Table I.) In the case of EPA's proposed rule for sources emitting inorganic arsenic, for example, the public health gains per million dollars expenditure range from 2 expected cancers avoided per million dollars of expenditure for the high arsenic-feed copper smelter at Tacoma, Washington, to less than 0.001 expected cancer avoided per million dollars of expenditure for some of the other copper smelters and glass manufacturing plants regulated under the proposed rule. The effectiveness of EPA's proposed rules in terms of public health gains varies across individual plants by a factor of 2,000. To place in perspective an effectiveness of 0.001 expected cancer avoided per million dollars of expenditure, it would require an expenditure of one billion dollars to avoid a single expected case of cancer.

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[1] See FR 15076 and 48 FR 33112.

[2] See 48 FR 15076 and 48 FR 33112. EPA also has outlined this three-tiered standard-setting process in a draft staff paper describing a process for evaluating and controlling toxic pollutants. U.S. Environmental Protection Agency, *Proposed Process for Evaluation and Control of Toxic Pollutants*, External Staff Draft, March 23, 1983.

[3] Neither the statute nor the legislative history specifically address the role of risk assessment information in standard-setting or spells out the nature of the requirements to be applied under the "ample margin of safety" language for pollutants that may present health risks at any level of exposure. In the absence of specific statutory language, EPA's practice has been to rely on a technology-based approach in regulating these pollutants.

TABLE 1

Costs and Cost-Effectiveness of EPA's Proposed Rules for Radioactive and Toxic Substances

	Cost of Proposed Standard (Dollars in Millions) Capital	Annualized a/	Expected Change in Cancer Incidence (Cancers/Year)	Cancers Avoided Per Million Dollars of Expenditure: Average for Sources Regulated	Range for Sources Regulated
Radionuclides					
DOE Facilities	25.0	8.2	0.006	0.001	b/
NRC-Licensed Facilities	0.0	0.0	0.0	-	c/
Uranium Mines	-	4.0	0.7	0.18	d/
Elemental Phosphorous	6.0	3.0	0.017	0.006	b/
Inorganic Arsenic					
High Arsenic Feed					
Copper Smelters	3.5	1.5	3.0	2.0	e/
Low Arsenic Feed					
Copper Smelters	35.0	9.5	0.09	0.01	0.14 to 0.001
Glass Manufacturing Plants	27.4	4.9	0.25	0.05	0.17 to 0.001
Total	96.9	27.1	4.06		

a/ Stream of annual costs, including interest and depreciation.

b/ Only two sources regulated; both sources have similar characteristics in terms of population exposed and the cost of meeting the proposed standard.

c/ Not applicable.

d/ No data for individual sources.

e/ Only one source regulated.

Source: U.S. Environmental Protection Agency.

In fact, most of the public health gains projected for these rules result from the control of emissions at a distinct subset of these plants. Regulation of the remaining plants (or sites) yields relatively little in additional expected public health gains. In the case of the proposed rule for low arsenic-feed copper smelters, for example, regulation of the secondary emissions from converter operations at three smelters (ASARCO-EL Paso, ASARCO-Hayden, and Kennecott-McGill) accounts for 88 percent of the total reduction in cancer indcidence under EPA's proposed rule (covering both converter and matte and slag operations). Much of the cost of EPA's proposed standard (65 percent) is associated with the control of smelter operations contributing only 12 percent of the expected public health gains. In the case of radionuclides as well, 97 percent of the public health gains can be achieved at forty percent of the cost by only regulating underground uranium mines.

As a result, an alternative regulatory strategy that emphasizes the effectiveness of further control can achieve most of the public health gains at substantially lower cost. For example, EPA estimates that its proposed standards for sources emitting these two hazardous pollutants would achieve an expected aggregate reduction in cancer incidence of 4.06 cancers per year at an aggregate cost of $27.1 million per year. An alternative regulatory strategy establishing the proposed BAT level of control only for those plants where the effectiveness of further control is relatively high could achieve an estimated reduction in cancer incidence of 3.92 cancers per year at an aggregate cost of $7.4 million per year. In other words, 96 percent of the expected health benefits of EPA's proposed rules could be achieved under this alternative strategy at only 27 percent of the expected costs. EPA's proposed standards requiring further control for the remaining plants (not regulated under this alternative strategy) would achieve an additional estimated reduction in cancer incidence of only 0.13 cancers per year at a cost of $19.7 million per year.

C. Reliance on BAT Approach for Standard-Setting

In setting standards for source categories posing a significant risk, EPA relies on a BAT approach that focuses on the application of "feasible" control technologies taking into account such factors as the "economic impacts" of meeting the required level of control. Although EPA does not provide criteria specifying what might constitute unreasonable economic effects, EPA in its BAT determination typically considers a variety of factors, including:*

—the technical feasibility of the proposed control requirements; and

—the economic effects of the proposed requirements, including the effects on industry profitability, product prices, and likely plant closures.

As a part of its BAT determination, EPA may also establish subcategories reflecting a variety of factors including differences in technology, age of plants, or economic characteristics.

*In its proposed rule for source categories emitting inorganic arsenic, for example, EPA cites each of these factors in its decision not to regulate individual source categories. 48 FR 33112.

The various environmental statutes envision BAT determination as a fairly straightforward "engineering problem" of identifying readily available control technologies that every well-operated plant should have in place. In fact, it has become a much more complicated standard-setting process of identifying "feasible" control technologies, evaluating their effectiveness, and assessing the character of the burdens their required use places on society — that is, economic effects such as likely plant closures and price increases, energy consumption, or other adverse environmental effects.

As part of this process, for example, EPA identifies source categories and subcategories as a way of differentiating the stringency of BAT control requirements across plants and obtaining more reasonable regulatory standards. Certainly, it would not be feasible (or sensible) to establish a single standard for, say, both copper smelters and glass manufacturing plants. As a result, EPA establishes standards for specific industry source categories and often uses a further subcategorization within specific industries as a way of tailoring its standards. In its proposed rule limiting inorganic arsenic emissions from various industrial sources, for example, EPA proposed a regulatory strategy involving a further categorization (and subcategorization) within specific industrial categories based on the "potential" of these facilities to emit inorganic arsenic. Thus, EPA proposed to establish separate categories for "high" and "low" arsenic-feed copper smelters. In addition, EPA discusses and requests comments on two alternative approaches that would establish subcategories based on population exposure or public health risk.

We think EPA should instead establish a more explicit approach that considers the effectiveness of alternative control requirements in terms of the *likely public health gains in light of the costs of achieving further control.* To illustrate this point, we first discuss EPA's BAT approach in setting proposed standards for sources emitting inorganic arsenic, and then consider the alternative approaches discussed by EPA for subcategorization using information on population exposure or public health risk.

1. *EPA's BAT Determination in the Proposed Rule*

In making its BAT determination, EPA uses the categorization (and subcategorization) of sources to differentiate the stringency of BAT-level control requirements across plants. In the case of copper smelters, for example, EPA proposes to establish two distinct source categories—"high feed arsenic" and "low feed arsenic" copper smelters—and proceeds with a separate determination of BAT-level control requirements for each of these source categories.

EPA is also proposing to establish what are in effect subcategories of plants within the low arsenic feed copper smelter and glass manufacturing source categories in order to differentiate the stringency of BAT-level controls within these source categories. In the case of control requirements for secondary emissions from converter operations, for example, EPA concluded that BAT required further control at the six copper smelters with a feed material arsenic content greater than 6.5 kilograms per hour. For the remaining eight smelters, EPA concluded that BAT does not require the control of these secondary emissions.[3] Similarly, in setting BAT standards for secondary emissions from the matte and slag operations of these copper smelters and the furnace emissions from glass manufacturing plants, EPA concluded that the control cost for plants with a relatively low potential to emit was unreasonable in light of the small emission reduction achieved. As a result, EPA concluded that BAT required the control of secondary emissions from matte and slag operations at only four of the fourteen low arsenic feed copper smelters and the control of arsenic emissions from fourteen of nineteen glass furnances.

In discussing these proposed regulatory cutoffs, EPA noted that its analysis did not provide a clear cutoff—a "knee" in the cost curve—at which the costs of control were clearly "unreasonable" in comparison with the likely emission reductions.[4] Indeed, EPA's emissions and removal cost data for both the low arsenic feed copper smelters and glass manufacturing plants suggest a continuum with increasing removal costs as the potential emissions of these plants decline. (See Tables II and III.)

[3] 48 FR 33143.
[4] 48 FR 33143 and 33157.

Table II

Removal Costs for Secondary Inorganic Arsenic Emissions from the Operations of Low Feed Arsenic Copper Smelters

	Converter Operations		Matte and Slag Operations	
	Potential Arsenic Emissions (Mg/year)	Cost per Unit Emission Reduction ($/Mg As)	Potential Arsenic Emissions (Mg/year)	Cost per Unit Emission Reduction ($/Mg As)
ASARCO-El Paso	98.0	16,200	6.5	382,500
ASARCO-Hayden	58.5	16,400	13.8	-
Kennecott-McGill	45.9	64,800	4.5	65,900
Kennecott-Garfield	7.7	185,400	2.0	302,600 a/
Phelps Dodge-Morenci	6.9	302,900	0.9	642,500
Kennecott-Hayden	6.5	335,900 a/	0.9	321,300
Phelps Dodge-Douglas	6.3	710,800	0.6	1,469,000
Phelps Dodge-Ajo	2.6	679,100	0.6	494,300
Inspiration-Miami	1.7	1,777,000	0.8	372,900
Phelps Dodge-Hidalgo	1.2	1,586,000	0.2	1,512,000
Kennecott-Hurley	0.5	5,861,000	0.1	3,313,000
Tennessee Copper-Copperhill	0.7	2,130,000	0.09	3,671,000
Magma-San Manuel	0.5	8,842,000	0.09	6,425,000
White Pine	0.3	4,733,000	0.05	6,425,000

a/ Plants with potential arsenic emissions above this cutoff would be required to install controls under EPA's proposed rule.

Source: 48 FR 33143-33144.

Table III

Removal Costs for the Inorganic Arsenic Emissions from Glass Manufacturing Furnaces

Existing Furnaces Without Add-on Control Devices	Uncontrolled Arsenic Emissions (Mg/Year)	Cost per Unit Emission Reduction ($/Mg)	
1	15.20	36,100	
2	3.35	112,300	
3	3.09	132,400	
4	3.09	123,000	
5	1.99	194,000	
6	1.83	299,400	
7	1.83	137,800	
8	1.27	236,000	
9	0.91	295,100	
10	0.76	726,500	
11	0.73	447,000	
12	0.55	652,000	
13	0.55	714,000	
14	0.45	795,000	a/
15	0.12	1,200,000	
16	0.04 b/	9,666,700	
17	0.04 b/	9,666,700	
18	0.04 b/	9,666,700	
19	0.04 b/	9,666,700	

a/ Plants with uncontrolled arsenic emissions above this cutoff would be required to install controls under EPA's proposed rule.

b/ These four furnaces are vented through a single stack.

Source: 48 FR 33157.

Although EPA cites cost-effectiveness as one of the major criteria used in setting BAT,[1] there are important differences across source categories in the level of removal costs that EPA finds to be reasonable. Thus, the BAT removal costs for controlling secondary emissions at copper smelters generally fall below $400,000 per megagram of arsenic removed.[2] In the case of glass manufacturing plants, however, EPA finds that removal costs up to $800,000 per megagram are "reasonable."[3] As a result, we could not identify a clear set of criteria applied in a consistent fashion that differentiates those facilities subject to the proposed more stringent BAT requirements from the remaining plants.

Because the purpose of these regulations is improved public health, it is difficult to know what would be a "cost-effective" or a "reasonable" removal cost without considering information on the public health effects of alternative control strategies. For example, an emphasis on adjusting a particular mix of regulatory requirements to yield more "cost-effective" reductions in arsenic emissions may not be

[1] 48 FR 33116.

[2] The estimated removal costs of controlling secondary emissions for matte and slag operations at the ASARCO-El Paso plant are $382,000 per Mg removed; however, the proposed rule exempts these operations at two smelters with estimated removal costs of roughly $350,000 per Mg.

[3] Emission standards imposing removal costs on some plants in one source category double the maximum costs imposed on plants in another source category are unlikely to be cost-effective. In fact, EPA could achieve a more cost-effective outcome by using a removal cost ceiling of $500,000 per Mg arsenic removed. Under this cost-effectiveness cutoff, the secondary emissions from the matte and slag operations of these additional low arsenic feed copper smelters would be controlled at an additional cost (annualized) of $780,000; but, four glass manufacturing furnaces would no longer be required to control emissions at a cost savings of $1,500,000. This regulatory approach would achieve the same reduction in inorganic arsenic emissions as that proposed by EPA at a net cost savings of $700,000 per year. EPA did not consider public exposure in selecting its cutoff levels and this outcome is "cost-effective" only in terms of a reduction in emissions. As outlined below, an alternative decision process giving explicit consideration to public health gains might well result in a different regulatory outcome.

the best way to improve public health protection because of the substantial differences in population densities in the vicinity of plants. In addition, of course, even a "cost-effective" emission reduction when appraised in terms of public health gains achieved may involve too much or too little control of these plants; this is because the initial level of control was determined without reference to levels of control that would be considered "reasonable."

2. *Subcategorization by Population Exposure*

EPA recognizes that its reliance on a BAT approach focuses on the "feasibility" of installing specific control technologies and that little consideration is given to the likely exposure and health risks associated with emissions from these plants.[10] As EPA notes in its preamble, there are substantial variations across plants in terms of public exposure and health risk. As a result, EPA discusses two alternative ways of taking this information into consideration in setting standards for source categories posing "significant" risks. One alternative would be to subdivide source categories on the basis of population density before determining BAT. Within high population density areas (for illustrative purposes, EPA uses a population cutoff of 10,000 persons within 20 kilometers), BAT level controls would be more stringent than for plants within low population density areas. EPA's second alternative would subdivide sources into higher-risk, lower-risk categories by using risk assessment information for both individual risk and aggregate cancer incidence (see Table IV for the risk-exposure cutoffs used by EPA). Under this alternative, higher-risk facilities would be required to install BAT while lower-risk smelters would not be regulated.

We support EPA's effort to consider additional information on public exposure and health risk in setting standards. We think that consideration of this kind of information is essential to sound public health regulation. However, we are concerned about the way in which EPA proposes to use this information as a part of the standard-setting process. Under EPA's two alternative approaches, exposure and health risk information would be used to establish separate subcategories of sources, and EPA would then determine the level of control representing BAT for each "risk" subcategory. For example, EPA suggests that it might establish a lower feed rate cutoff—that is, a more stringent regulatory cutoff—for plants located in high density population areas. This would require some plants in high density areas to control emissions while plants with similar operating characteristics in low density areas would not be required to control their emissions further. Again, it is unclear what criteria EPA would rely upon in setting BAT standards for plants falling in one or the other subcategory.[11] It appears, though, that EPA would continue to rely on a technology-based approach in determining the appropriate level of control within the "high" and "low" risk subcategories.

[10] 48 FR 33145.

[11] In setting BAT requirements for copper smelters in high population density areas, EPA would require control of the secondary emissions from matte and slag operations at the Kennecott-Garfield plant at an estimated removal cost of $302,000 per Mg of arsenic removed; but, EPA would not require control of the smelter's secondary emissions from converter operations even though the estimated removal cost is only $185,000 per Mg. 48 FR 33143-33144.

Table IV

Risk and Exposure Cutoffs Under EPA's Alternative Approach

A. Population Density

If the Population Density within 20 km	THEN	The Smelter Would be Classified
is Greater than 10,000		"Higher Risk"

B. Risk/Health Effects Cutoffs

If the Maximum Individual Risk is Greater than:	AND	The Expected Annual Cancer Incidence is Greater than:	THEN	The Smelter Would be Classified "Higher Risk"
10^{-1}		0.0014		
10^{-2}		0.0014		
10^{-3}		0.0140		
10^{-4}		0.0140		
10^{-5}		0.1400		
10^{-6}		1.4000		

Source: 48 FR 33146-33147.

If EPA relies on technology-based criteria in making this decision, it is likely to require "too much" or "too little" control of individual plants. The problem arises because the use of "high" and "low" risk subcategories, as discussed by EPA retains a formal separation of the consideration of public exposure and health risk information from the determination of the level of control constituting BAT. In our view, this information ought to be considered jointly by weighing both the public health gains and the costs of a further control of these plants. This approach would lead, we believe, to more sensible regulatory decisions than the several approaches outlined by EPA.

The problems with each of the alternative approaches considered by EPA can be illustrated by considering the cost-effectiveness in terms of expected public health gains of the required further control for individual plants. Under EPA's proposed rule, the average cost of the expected reduction in population risk for the "low" arsenic copper smelters is roughly $100 million per cancer avoided and the cost-effectiveness of the required control for individual sources varies from $7 million per cancer avoided to $1.3 billion per cancer avoided. (See Tables V and VI.) The wide variation in the effectiveness of the control of these emissions occurs because of the variation across individual smelters in the amount of pollutant discharged to the air at current levels of operation, the size and location of the exposed population, and the costs of achieving further reductions in emissions.

Under the alternative approaches outlined by EPA, the average cost of the expected reduction in population risk is somewhat reduced and the range in cost-effectiveness across copper smelters is generally narrowed. (See Table VII.) However, the average cost of the expected reduction in population risk under these alternative approaches remains extremely large — the average cost is roughly $70 million per cancer avoided under the population cutoff approach and $85 million per cancer avoided under the risk-exposure cutoff approach. Risk-reduction investments in this range would go far beyond those customarily required by EPA and other public health agencies, and far beyond those customarily assumed by individuals in private decisions involving health risks.[13] Moreover, cost-effectiveness under EPA's risk-exposure approach still ranges from $7.0 million to $312 million per cancer avoided, while EPA's population density approach does not reduce the variation in cost-effectiveness in the proposed rule at all — it continues to range from $7.0 million to $1.3 billion per cancer avoided.

[13] For example, these costs are substantially above current estimates of the willingness-to-pay for small reductions in the risk of death. These estimates yield a willingness-to-pay for a reduction in the aggregate risk of cancer incidence ranging from roughly $500 thousand to $7 million per death avoided. For a summary of this literature see: U.S. Environmental Protection Agency, *Valuing Reductions in Risks: A Review of the Empirical Estimates*, Washington, D.C., 1983; Martin J. Bailey, *Measuring the Benefits of Life-Savings*, Washington, D.C.: American Enterprise Institute, 1979.

TABLE V

Arsenic Emission Control Systems for Converter Operations

	Annualized Control Costs ($1000)	Cost Per Unit Emission Reduction ($/Mg As)	Change in Annual Incidence of Fatal Cancers (Cancers/year)	Cost Per Unit Reduction of Fatal Cancer ($/Cancer)
ASARCO - El Paso a/	307	16,200	0.043	7,000,000
ASARCO - Hayden a/	403	16,400	0.019	21,000,000
Kennecott - McGill a/	2,696	64,800	0.019	140,000,000
Kennecott - Garfield a/	1,300	185,400	0.0015	870,000,000
Phelps Dodge - Morenci a/	1,908	302,900	0.0027	710,000,000
Kennecott - Hayden a/	1,902	335,900	0.004	500,000,000
Phelps Dodge Douglas	2,943	710,800	0.003	980,000,000
Phelps Dodge Ajo	1,562	679,100	0.005	310,400,000
Inspiration - Miami	2,943	1,777,000	0.011	270,500,000
Phelps Dodge - Hidalgo	1,745	1,586,000	0.000001	b/
Tennessee - Copperhill	1,278	2,130,000	0.0015	850,000,000
Magma - San Manuel	3,979	8,842,000	0.00066	6,000,000,000
Kennecott - Hurley	2,296	5,861,000	0.0004	5,700,000,000
White Pine	1,278	4,733,000	0.0001	12,800,000,000

a/ Regulated under EPA's rule.

b/ Greater than a trillion dollars per cancer avoided.

Source: U.S. Environmental Protection Agency.

Table VII

Public Health Gains and Cost Under Alternative Regulatory Approaches

	Number of Regulated Smelters	Annualized Cost of Required Controls (dollars in million)	Reduction in Annual Incidence of Cancer (cancers/year)	Average Cost Per Cancer Avoided ($millions/cancer)	Range in Cost Per Cancer Avoided ($million/cancer) Low	High
Converter-Operations:						
EPA's Proposed Rule	6	8.6	0.089	96.6	7.0	870.0
EPA's Alternative Population Cutoff	3	3.4	0.081	42.0	7.0	140.0
EPA's Alternative Risk/Exposure Cutoff	5	7.9	0.097	81.4	7.0	310.0
Matte and Slag Operations:						
EPA's Proposed Rule	4	0.92	0.003	298.0	7.0	1,300.0
EPA's Alternative Population Cutoff	5	1.2	0.0075	158.7	7.0	1,300.0
EPA's Alternative Risk/Exposure Cutoff	5	0.93	0.008	116.0	7.0	296.0

As these examples illustrate, taking risk and population exposure into consideration by subcategorizing sources into high and low population or risk groups does not automatically yield a sensible result. Subcategorization of a source category on the basis of population exposure or public health risk may serve to narrow the range in the cost-effectiveness of control requirements; but a sensible result depends on the determination of the level of control constituting BAT for each plant within a subcategory."

D. Use of Risk Assessment Information in Standard-Setting

The use of risk assessment information is critical, in our view, to making reasonable regulatory judgments. As outlined above, ignoring information about public health risks at a critical juncture in the standard-setting process results in standards with costs per health risk reduction that vary widely across plants and across hazardous substances. In this section, we discuss the issue of risk assessment more generally and consider the use of risk information at other stages of the standard-setting process. We conclude with recommendations on the relative weighting to be given to reduction in individual risk as opposed to the population risks from exposure to hazardous air pollutants.

1. *EPA's Use of Risk Assessment Information*

EPA offers the following rationale for its use (and nonuse) of risk assessment information at various stages in the standard-setting process."

> The use of risk estimates generally has been confined to areas of broad comparisons, e.g., in selecting source categories to evaluate, and in assessing the incremental change in risk that results from application of various control options. The use of risk estimates in an absolute sense is avoided because of the many uncertainties of the estimates. These uncertainties are compounded as the focus is narrowed. In other words, in evaluating specific sources, as opposed to source categories, the uncertainties associated with the risk estimates increase dramatically.

Although EPA stresses the uncertainty associated with its risk information, it nevertheless uses this information both in its initial screening of source categories to determine whether they pose a significant public health risk and in its residual risk assessment. At the residual risk assessment stage, in particular, EPA relies heavily on risk assessment information by explicitly weighing the likely additional public health gains of going beyond BAT with the costs of a more stringent standard. The residual risk assessment step in the standard-setting process directly considers whether more stringent controls resulting in plant closures are warranted — the issue that appears, at least to outsiders, to be the major economic concern in EPA's decision process.

Since EPA uses risk information at this critical juncture in the decision process, it should use risk information at other stages as well. After all, the risk information is the best information available on the public health effects of alternative regulatory actions, which presumably is the issue of primary concern. Acting without such information in setting technology-based (BAT) standards is to risk imposing regulatory requirements arbitrarily, and expending scarce resources without any commensurate gains in public health.

There is, of course, some uncertainty associated with the risk information, just as there is some uncertainty with EPA's cost estimates." We believe that the decision-making process should proceed on the basis of the best information available for both the public health gains and the economic costs. A choice can then be made among regulatory alternatives by explicitly considering both the best estimates of the likely effects of these alternatives and the uncertainties associated with these estimates.

This approach is superior to a conservative approach that relies on "worst case" estimates of health and economic effects, because it provides a clear statement of the likely effects and uncertainties of the available regulatory alternatives for those making the ultimate policy decisions. Policy decisions based solely on "worst case" assumptions about health risks yield "margins of safety" of unknown magnitude — making it impossible to assess the likely gains of selecting successively more stringent regulatory alternatives.

In addition, the direct weighing of the likely public health gains with the costs in assessing alternatives is superior to obscuring the likely effects of regulation by neglecting information at important steps in the standard-setting process." As we have noted above, EPA's present BAT approach imparts a conservative bias to the standard-setting process because it implicitly assumes that the benefits of a BAT level of control exceed the costs without regard for the estimated public health gains, however negligible. In many cases, however, this implicit assumption appears to be wrong. An alternative approach that considered both the

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" The wide range in cost-effectiveness using high and low population subcategories results from EPA's determination that BAT requires the control of the secondary emissions from matte and slag operations at the Kennecott-Garfield smelter. We noted above that this BAT determination appeared to be inconsistent with EPA's determination that no further control of emissions from converter operations would be considered to be BAT at this smelter, even though control of these latter emissions would be more cost-effective. We are not certain, however, of the criteria EPA uses in arriving at its BAT determinations, and therefore cannot be certain EPA has been inconsistent in using these criteria.

" 48 FR 33116.

" EPA uses conservative assumptions in developing its risk information. For example, the quantitative risk estimates developed by EPA for these three substances are based on a linear no-threshold model. EPA states that the resulting risk estimate "... represents a plausible upper-limit estimate in the sense that the risk is probably not higher than the calculated level and could be much lower." 48 FR 33114. However, EPA's quantitative risk assessment is generally based on a specific health effect, e.g., leukemia, without considering other likely health effects, these ought to be considered as well in assessing the likely public health gains from regulation.

" This emphasis on the use of "best" estimates accompanied by explanations of surrounding uncertainties is an extension of the recent National Academy of Sciences report recommending a clear "...distinction between assessment of risks and consideration of risk management alternatives; that is, the scientific findings and policy judgments embodied in risk assessments should be explicitly distinguished from the political, economic, and technical considerations that influence the design and choice of regulatory strategies." National Academy of Sciences, Committee on the Institutional Means for Assessment of Risks to Public Health, *Risk Assessment in the Federal Government: Managing the Process*, NAS-NRC, March 1983. In our view, this distinction should be maintained in the analysis of alternative standards. Margin of safety considerations should be deferred to a later stage in the decision process where the uncertainties involved can be explicitly considered in designing a regulatory strategy.

public health gains and costs would yield a more effective use of resources for public health (or other) purposes.

2. *Designation of a Significant Risk*

At the initial stage in its standard-setting process, EPA determines whether the emissions from a source category pose a "significant" public health risk. In doing so, EPA considers whether the substance emitted is a human carcinogen and whether individuals or larger populations are significantly exposed to the substance. However, EPA reports that it has not used a "numerical target level" of significant exposures because of the uncertainties associated with its risk estimates."

There is indeed no pattern in EPA's proposed rules that suggests the use of a systematic cutoff in regulating source categories emitting hazardous pollutants. In its proposed rules for source categories emitting radionuclides and inorganic arsenic, EPA propose standards for seven source categories. In addition, EPA specifically considered and decided not to propose standards for ten other source categories it had identified at the time of listing these pollutants." EPA reached its decision on whether to propose standards for these source categories only after making a BAT determination and a residual risk assessment for each source category.

By deferring to a later stage in the standard-setting process the decision whether to propose standards, EPA was able to consider a variety of other factors, including the potential for further reductions in emissions (taking into account current regulatory requirements), the likely reduction in public health risk, and the costs and other economic effects of requiring more stringent control of these source categories. The deferral of a decision whether to propose a standard until a later stage in the standard-setting process represents, in our view, a tacit recognition that an informed decision on the need for further regulation can be made only after weighing the likely public health gains with the costs and other economic effects (e.g., plant closures) of further regulation.

In general, this appears to be a good way to proceed. It is difficult to establish *a priori* a cutoff point that distinguishes "significant" public health risks from "acceptable" risks. The health risks posed by the various source categories identified by EPA as emitting inorganic arsenic and radionuclides illustrate the problem. There is no pronounced gap or clustering in the risks posed by the various source categories identified by EPA—rather, there appears to be a continuum from the highest risk sources to those sources posing lower risks. (See Figure 1.)

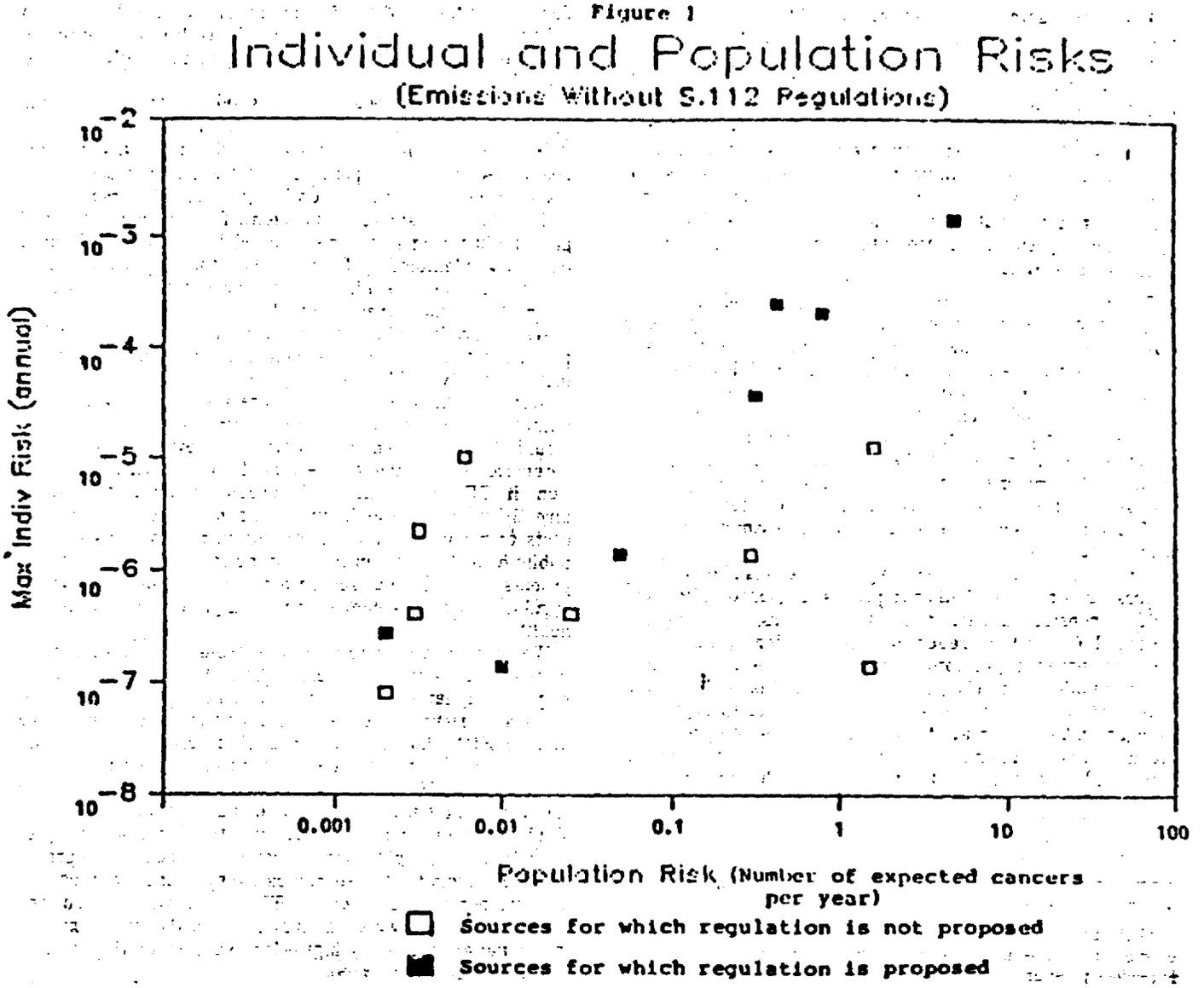
We believe it is difficult to identify a *de minimis* level of public health risk without considering other factors influencing the likely public health gains of further regulation. However, EPA may find that there are administrative advantages to establishing a *de minimis* risk level. This would allow EPA to direct its attention toward those source categories posing the greatest public health risks. In addition, if EPA finds that it is precluded by statute from directly weighing the likely public health gains with the costs of regulation, an explicit *de minimis* threshold for public health risk at an initial stage in the standard-setting process could serve to screen out a number of cases where regulation would achieve only negligible gains in public health.

We encourage EPA to review the role of this initial stage in its standard-setting process. If EPA decides that an initial step of designating source categories posing significant public health risks serves a useful administrative role, we believe EPA should establish explicit criteria identifying levels of public health risk warranting further regulatory consideration. If EPA should do so, we would suggest the following as *de minimis* levels of public health risk: EPA would consider further regulatory action for a source category if the aggregate annual cancer incidence at current emission levels for the source category is one likely cancer or more per year. In addition, EPA might want to consider regulatory action where annual risks to the most exposed individual are relatively high—for example, on the order of one in ten thousand or more.

" 48 FR 33116.

" EPA has taken no action for one source category — fossil fuel-fired combustion — identified in the listing of inorganic arsenic as a hazardous pollutant.

Figure 1



Source: U.S. Environmental Protection Agency.

Our suggested cutoff for aggregate population risk is based on the following observation: where the annual cancer incidence at current emission levels is less than one cancer per year, any additional regulatory requirements would likely impose costs of several million dollars per year while only negligible public health gains would be achieved. Our suggested cutoff for individual risk is based on our argument (outlined below) that annual risks to the most exposed individual that are smaller than other risks generally encountered in the course of daily life need not be considered independently of aggregate population risk.

3. *The Measure of Individual Risk*

In its preamble discussion, EPA outlines its concern for the individual risks to the most exposed members of the population and requests comments on the best way to consider individual risk in its decision process.[17] We believe that annual individual risk is a better measure than EPA's measure of "maximum individual lifetime" risk. "Maximum individual lifetime" risk incorporates several important assumptions that overstate actual individual risks.[18]

First, maximum lifetime estimates of individual risk assume that the individual receives the maximum exposure to the substance--in effect, at the fenceline of the "worst" facility--continuously for the full 70 years. The population in the United States is highly mobile, however, and it is extremely unlikely that any individual would remain in a single location for a lifetime. In addition, many of these facilities have a limited life and are unlikely to operate for an additional 70 years. Second, a maximum individual lifetime risk estimate incorrectly assumes that the last year of

[17] 48 FR 33116.

[18] This conservatism in the risk estimate is independent of the extent to which EPA has adopted conservative assumptions in its risk assessment.

exposure (the seventieth year) contributes as much to the individual's health risk as earlier years of exposure; in general, there is a long latency period between exposure and the onset of cancer.

For these reasons, annual risk to the most exposed person is a truer measure of maximum individual risk than EPA's measure of "maximum individual lifetime" risk. The "maximum individual lifetime" risk estimate may convey some additional information as a "worst case" estimate, but in such cases it should be clearly treated as such.

4. *Individual Risks Versus Population Risks*

EPA has not yet decided what weighting to give in the standard-setting process to the estimated risk for the most exposed individual (or the more exposed individuals) *vis-a-vis* the estimated aggregate population risk. The issue is an important one because many of the facilities likely to be regulated under Section 112 are located at a distance from population centers. Although these facilities may pose some health risk to a limited population in the immediate vicinity, they pose only a relatively small aggregate population risk. As explained below, a decision to give extra weighting in the standard-setting process to individual risk for the most exposed members of the population would likely result in a more extensive regulatory intervention without commensurate public health gains.

EPA typically develops two measures of public health risk as a part of its standard-setting approach: the maximum individual lifetime risk and the population risk. EPA's estimate of maximum individual risk, as noted above, is the cumulative risk to the most exposed individual over a lifetime (70 years) of continuous exposure, and overstates the likely actual risk to the most exposed individual.[21] Population risk is the aggregate of the individual statistical risks for the total exposed population–that is, the expected annual incidence of death for the exposed population due to the environmental hazard under consideration.

Population risk is, of course, the more comprehensive measure; we believe that in most cases it is also the better measure for purposes of establishing general public health standards such as hazardous air pollution controls. By definition, the aggregate of all individual risks in calculating the annual incidence of cancer for an exposed population provides the best estimate of the total public health gains to be expected from a regulatory standard. Risk management decisions should be based upon such best estimates of the likely effects of alternative standards. Particularly where risk information is uncertain and incomplete, basing each individual regulatory decision on population risk will tend to produce the greatest public benefits from the resources claimed by a succession of such regulations.

In our view, going beyond population risk to give additional weight to the (annual) risk to the most exposed individual is appropriate only where individual risk is greater than other risks routinely encountered in daily life. We do not know how frequently this might occur in the case of environmental regulation at the federal level, but it is not the case for many Section 112 rules. As shown in Table VIII, even those individuals who are *most* exposed to these environmental hazards face health risks that are *lower* than the *average* annual risk of death from an automobile accident (two in ten thousand), an occupational accident (one in ten thousand), a household accident (one in ten thousand), or a homicide (one in ten thousand). In circumstances such as this, regulations need not entail *relatively* greater risk-reduction investments for the most exposed individuals than EPA would otherwise require based upon the risks faced by the exposed population as a whole.

In the range from one in ten thousand to one in a million, the empirical evidence indicates there is little change in the valuation of small risk reductions with respect to the level of risk.[22] This suggests that population risk gives an accurate weighting to the risks faced by those who are relatively more exposed as compared to those who are less exposed. Much of this evidence is based on studies of risk behavior in labor markets (reflecting the tradeoffs between worker salaries and workplace safety); there are also a few pertinent studies of consumer behavior yielding similar estimates of willingness-to-pay for small reductions in risk.[23]

The maximumn individual risks for many of the source categories subject to these proposed regulations are less than the average annual level of risk considered in the cited studies. In referring to the evidence from the labor market studies, for example, we are making comparisons to a setting where the magnitude of risk exposure — roughly one in ten thousand — frequently exceeds that calculated by EPA for the most exposed individual in the environmental setting. In cases where the risk exposure in the environmental setting is substantially greater than the average level of risk considered in the cited studies, however, such a comparison would likely be invalid and and it might well be appropriate to give extra weighting in the decision process to individual health risks.

It may be argued that these studies are irrelevant to environmental exposures because the risk exposures involved in the studies were incurred "voluntarily," while environmental exposures are "involuntary". We think, though, that this argument overstates what are in effect relatively small differences across various types of risk exposure. For example, there is also an element of "involuntariness" associated with occupational exposures to risk — a factor emphasized by advocates of government regulation in the workplace. At the same time, there is an element of volition for the most exposed individual in accepting or avoiding the health risks from environmental exposures; because the level of exposure to these pollutants is highly

[21] In addition, where EPA applies this measure for a source category as a whole, the measure represents the maximum individual risk associated with the *worst* plant or facility in the source category. For many of the other facilities in the source category, maximum individual risk is often one to three *orders of magnitude* lower.

[22] Viscusi, W.K., *Risk by Choice: Regulating Health and Safety in the Workplace*, Cambridge, Mass.: Harvard University Press (1983), pp. 102-113. This is one of the studies reviewed in the literature surveys cited in footnote 12 above.

[23] These estimates provide a direct way of weighting individual risk in estimating population exposure. The available studies indicate a willingness to pay for a small reduction in risk ranging from $0.50 to $5.00 for a reduction in risk of one chance in a million per year. For example, these estimates indicate the willingness to pay for an annual reduction in risk of one chance in a million would range from $500,000 to $5,000,000 for a population of one million. If regulatory action yielded a reduction in risk of one in ten thousand for a population of 10,000 living near the regulated facility and a reduction in risk of one in a million for a larger population (of 990,000) located at greater distance from the facility, the willingness-to-pay for the resulting risk reduction would range from $995,000 to $9,950,000. See U.S. Environmental Protection Agency, *Valuing Reductions in Risks*, *op. cit.*

location specific, the most exposed individuals can generally dramatically reduce their risks by slightly increasing the distance from the facility.

A more important point is that the labor market studies contain evidence on the effect of differences in the degree of volition on estimates of the willingness to pay to achieve small reductions in risk. For example, Viscusi has examined in a recent study the effect of differences in risk averseness across the workforce on the willingness-to-pay estimates.[24] To do this, he estimated willingness to pay to avoid risk within each quartile of risk averseness. Viscusi reports that the least risk averse quartile (i.e., the most willing to accept additional risk) of the workforce has a willingness to pay for a reduction in risk that is roughly one-half that for the remaining workforce. Further, he reports that for the more risk averse individuals (in the remaining three quartiles) there is very little variation from quartile to quartile in willingness to pay for small reductions in risk. Because there is less volition associated with job choice for the remaining three quartiles,[25] and the willingness-to-pay estimates are almost the same (asymptotic) across these quartiles, Viscusi argues that the willingness-to-pay estimates for this more risk averse part of the population constitutes a "best" estimate of the willingness to pay for a small reduction in involuntary risk for the general population.

Finally, the willingness-to-pay estimates from the labor market studies involve a small reduction in the risk of immediate death. But reduced environmental exposure to a carcinogen, for example, yields a small reduction in the statistical probability of death at some time in the future (twenty or more years). There is reason to believe that the willingness to pay to reduce the risk of immediate death is greater than the willingness to pay to reduce the risk of contracting cancer at some distant point in the future. Because the adverse health effects are delayed, the loss in years of useful life associated with contracting cancer at some point in the future is substantially smaller than the loss resulting from an immediate accidental death. In addition, of course, the adverse health effects of contracting cancer are deferred and time preference considerations alone reduce the willingness to pay.[26]

This evidence suggests that, over a broad range of environmental exposures where health risks are roughly comparable to other risks encountered in daily life, EPA need not give an additional weighting to any individual risks — maximum individual risks will be accounted for, as they are included in population risk estimates. Only in cases where the annual risks to individuals are exceptional — that is, substantially greater than the other risks of daily life — is there good reason to weight more heavily individual risk to the most exposed individual.

E. Summary

Greater attention to risk reduction in relation to control costs would substantially improve EPA's process of setting emissions standards for hazardous air pollutants. In particular, changing EPA's current practice of not considering risk information in setting "Best Available Technology" standards could produce major improvements in regulatory policy, and would be a logical extension of EPA's current use of risk information at other stages of the standard-setting process.

Under the current practice of using risk information only for limited purposes, the likely public health gains per dollar of expenditure resulting from recent EPA regulatory proposals could vary across sources by a factor of more than 2000. The expected reduction in cancer incidence ranges from less than 0.001 to 2.000 expected cases avoided per million dollars of compliance expenditures. At some plants, EPA expects compliance with its proposed standards to yield exceedingly small public health gains. Increased emphasis on likely reduction in exposure and health risks would lessen such extreme variation and improve EPA standards. This paper has discussed alternative regulatory strategies that could achieve most of EPA's intended public health gains at one-third of the cost or less.

The paper has made several other suggestions concerning the use of risk and cost data that are intended to strengthen the EPA regulatory process.

[24] See Viscusi, cited in footnote 22.

[25] There is clearly a greater degree of volition involving such higher-risk occupational choices as deep sea diver or structural steel worker than in choosing the more routine occupations comprising the least risky occupational groupings.

[26] For example, the present worth of a benefit delayed for twenty years is roughly half the current value at a real discount rate of three percent and it is roughly one tenth the current value at a real discount rate of ten percent.

EXECUTIVE BRANCH

Departments and Agencies

Environmental Protection Agency Jan. 3 amended regulations governing selective enforcement auditing of new gasoline and diesel light-duty vehicles and trucks to clarify which rules apply for light-duty trucks, effective Feb. 2 (49 FR 68).

EPA Jan. 5 extended until Feb. 1 Maryland's deadline for submitting a complete application for interim authorization for Phase II, Components B and C of its hazardous waste management program under the Resource Conservation and Recovery Act (RCRA) (49 FR 585).

EPA's Science Advisory Board announced it will hold a public meeting on biological effects of radiofrequency radiation on Jan. 24-25 at 9 a.m. at EPA Research Center, Research Triangle Park, N.C. (49 FR 662); for information or to submit comments, contact Terry F. Yosie, Director, by calling (202) 382-4126; or Douglas B. Seba, Executive Secretary, at (202) 382-2552.

0013-9211/84/$0+.50

TRANSURANIUM ELEMENTS AROUND THE ROCKY FLATS PLANT

C. T. Illsley

January 1984

TRANSURANIUM ELEMENTS AROUND THE ROCKY FLATS PLANT

From the beginning of operations of the Rocky Flats Plant, organic liquids contaminated with radioactive materials, were generated in various manufacturing processes. It was initially assumed that this material could be either burned or packaged in some manner and shipped offsite for disposal as low level waste. Since no method of disposal was available research was initiated to develop a procedure to process these materials.

In the meantime, with the stockpile of contaminated oil increasing rapidly, an area on the Plant Site was designated in July 1958 as a temporary storage area for the uranium and plutonium contaminated oil drums. During subsequent years, drums were continually added which contained mostly plutonium contaminated machine oils.

The first drum leakage was discovered in July 1959 and a rust inhibitor, ethanolamine was added to the drums to minimize corrosion. The first evidence of deterioration of drums was discovered in 1964 and soil contamination was becoming a problem.

The recovery process to treat the contaminated oils, became operational in January 1967 and removal of the drums from the storage area began. At this time the field contained 5240 drums, of which approximately 3570 contained plutonium oil. The oldest drums and those containing plutonium were processed first. The last of the plutonium-contaminated oil was removed in January 1968 and final shipment of uranium-contaminated oil was moved to the disposal plant in June 1968.

An estimate of leakage, based upon a material balance from recovered materials and soil samples, indicated that 5000 gallons of oil containing about 86 grams (5 curies) of plutonium leaked from the drums into the soil. This was about 3% of the plutonium-contaminated oil. Radiation monitoring and mapping of the area in July 1968 showed levels of 2×10^5 to over 3×10^7 d/m/g alpha radioactivity. An asphalt containment cover was constructed

to prevent spread of the plutonium bearing soil and four water sample wells for confirmation that no downward migration was occuring were completed in November 1969.

After a fire on May 11, 1969 at Rocky Flats, studies were conducted by the Colorado Committee on Environmental Information (CCEI) and by the Health and Safety Laboratory (HASL) of the USAEC, concerning the possible release of plutonium from the fire. These investigations detected measurable quantities of plutonium in the soil around the Rocky Flats Plant. Concentrations of plutonium in soil at Rocky Flats have also been estimated by the Colorado Department of Health (CDH), Rockwell International, Jefferson County Health Department, and private housing developers. In general, measurements made by the different groups have shown similar (but not identical) results for surface plutonium levels.

The HASL data indicate that releases from past operations have amounted to about 11 curies of plutonium, approximately 99% of which was leakage from drums in the storage area. The epicenter of the isopleth map shows that the contamination can not be attributed to the May 1969 fire but is due to resuspension and redistribution of contaminated soil from the oil drum storage area.

During the removal of the corroded drums and the subsequent covering operations, some radioactive material was resuspended and distributed by wind action to the east of the storage area. The HASL estimate of the total amount of plutonium dispersed by the oil leaks (11 Ci) is higher than the estimate of the total amount of plutonium available to be dispersed. The potential amount was estimated by Rocky Flats on the basis that the 5000 gallons of oil that leaked from the drums contained 86 grams (5.3 Ci) of plutonium. To reduce conflicting estimates, the HASL data is considered to be the most accurate.

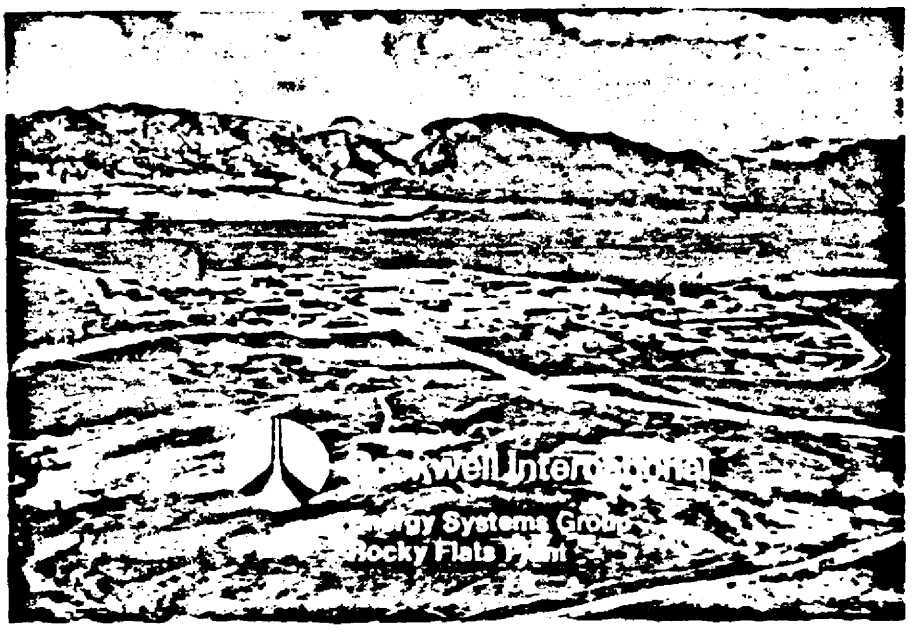
The HASL data suggest that of the 11 Ci released, 8.6 Ci are on site. Of the amount off site, the HASL data indicate that about 1.5 Ci are included in the area above 0.003 mCi/m2 (3mCi/km^2) which extends to about 5 miles

from the Plant boundary. About 1.9 Ci are spread at distances far from the Plant at levels equal to or below fallout of 0.0015 mCi/m^2 (1.5 mCi/km^2). Of the total 8.6 Ci included on-site, the HASL data indicate that about 1.7 Ci are included in the area that was covered with asphalt.

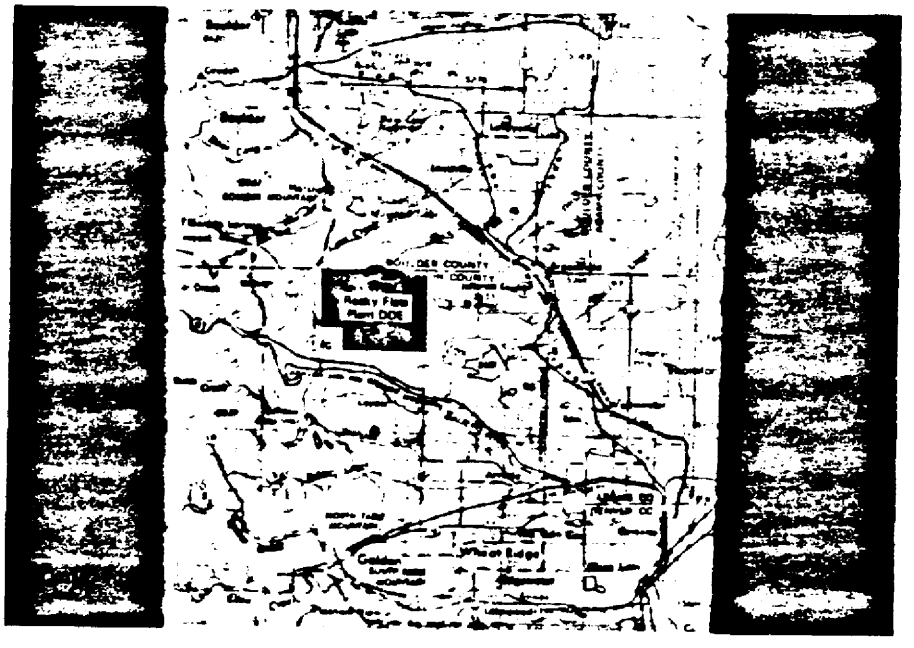
Analyses for plutonium and americium in 175 soil samples collected on private and municipal lands around the Rocky Flats Plant have not revealed concentrations greater than the EPA Proposed Screening Level. Evaluation of analyses of 27 soil samples, collected for purposes of certain land litigation indicates that soil on private land east of the Plant contains levels less than 50% of the screening level. One sample from 14 collected on City of Broomfield land west of Great Western Reservoir contains 118 mCi/km^2 plutonium, which is 59% of the screening level, but adjacent samples indicate less than 50 mCi/km^2.

The HASL data indicate plutonium levels in the range between 50 and 500 mCi/km^2 for the soil in the area near the Plant's eastern boundary. Access to this area is not open to the general public and is controlled by a barbed wire fence and locked gates. Analyses of soil samples by Rockwell at 7 sites in this area confirm the HASL measurements which indicate the presence of plutonium greater than the EPA screening level. The plutonium concentrations in the soil from one 10 acre site are in the range from 80 to 252 mCi/km^2 with a median of 108 mCi/km^2. The median values for the other sites fall within the range from 3 to 34 mCi/km^2.

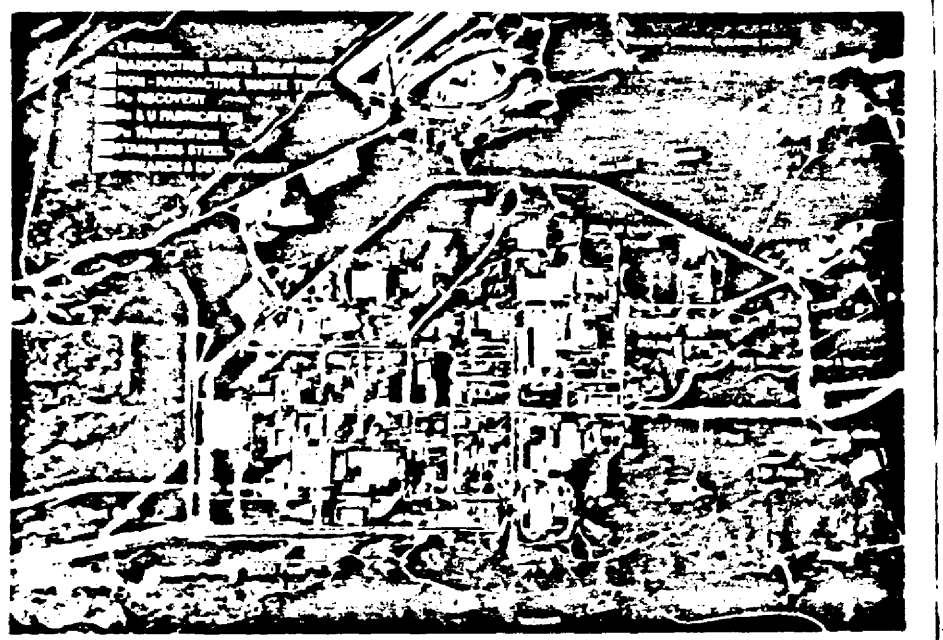
On the basis of the EPA Guidance Technical Assessment, the above-mentioned evaluation of additional soil data and airborne plutonium concentration data, there will be no impact on current operations at Rocky Flats if the Proposed Guidance is finalized. There is no need (based on EPA criteria) for decontamination of onsite lands other than those actions currently planned for other reasons. If the EPA guidance were ever to apply to onsite property then the cost could be substantial if removal were required.



Aerial View of the Rocky Flats Plant

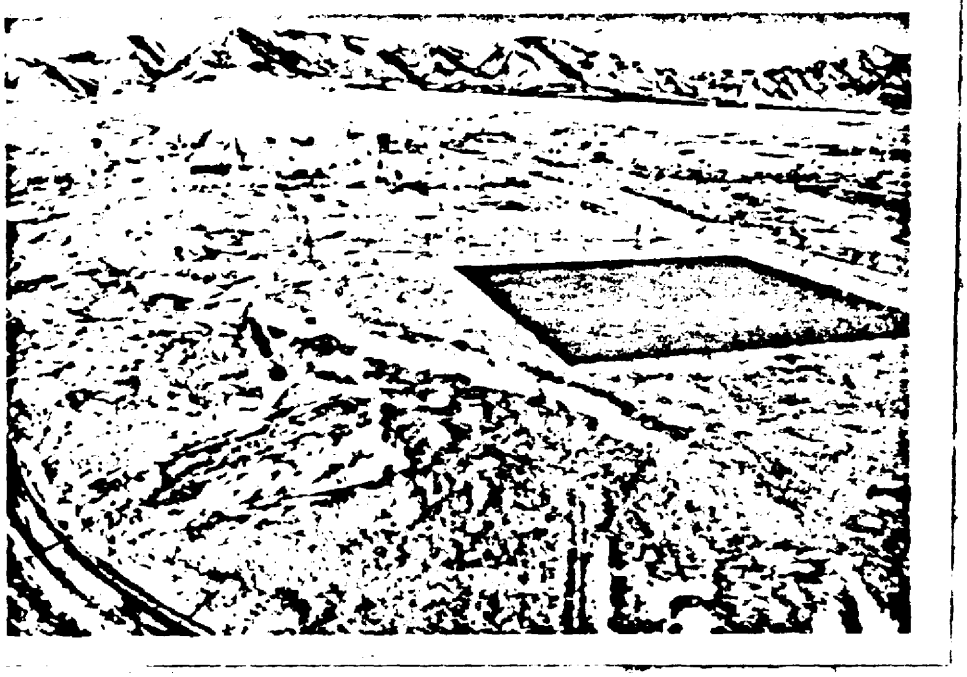


Map Showing Location of the Rocky Flats Plant

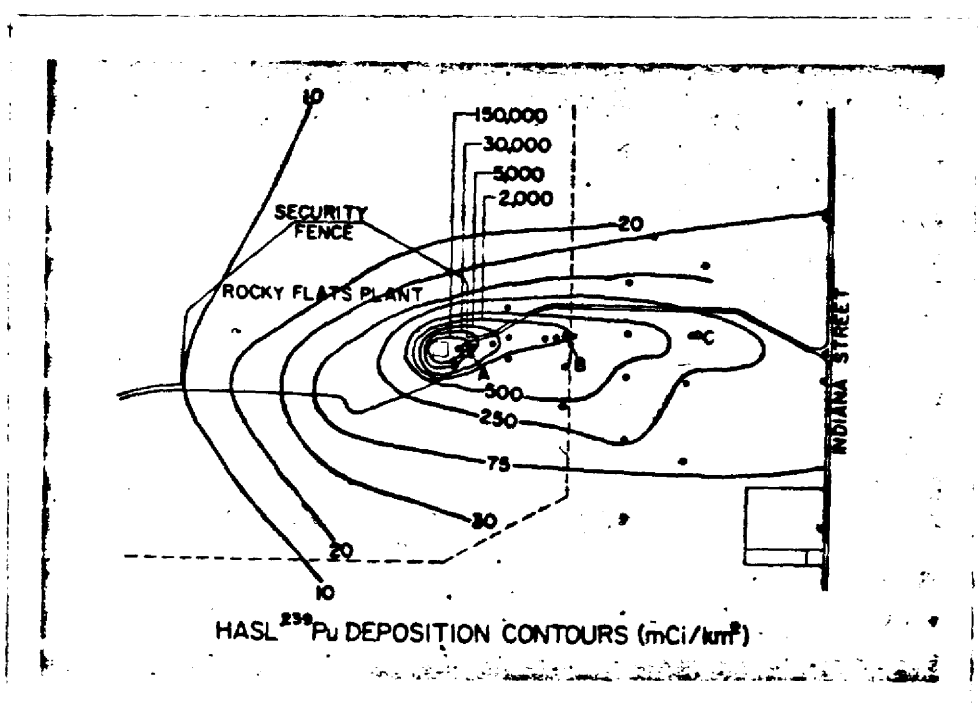


Aerial Photo Showing Major Facilities at Rocky Flats

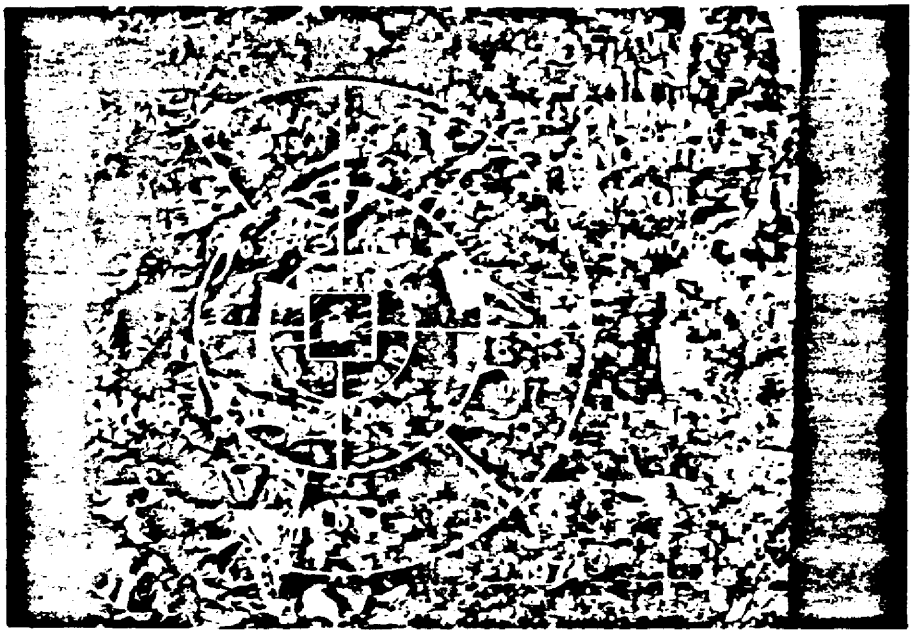
Drum Storage Area at Rocky Flats in 1967



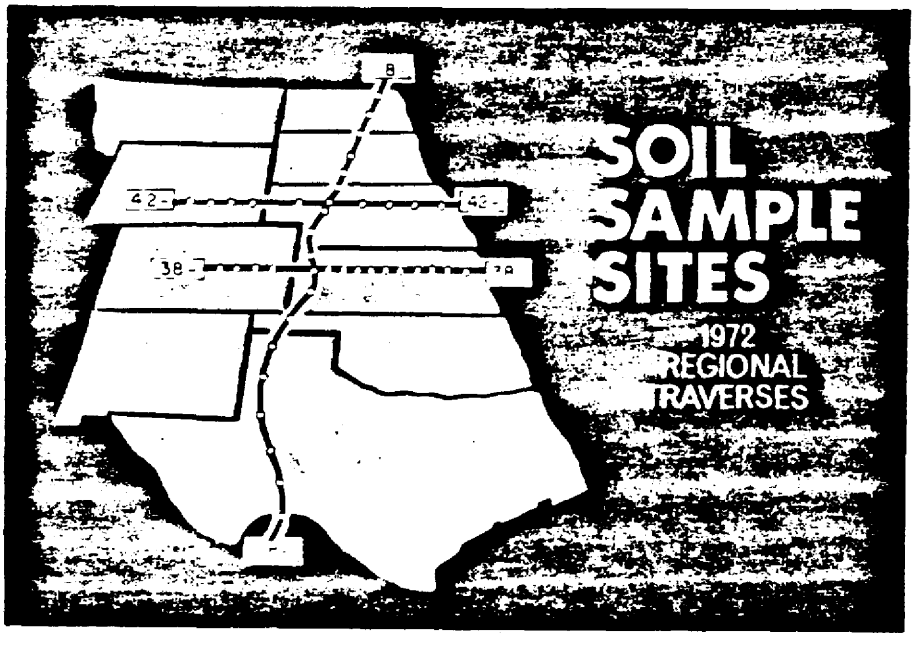
Asphalt Pad Over Abandoned Storage Area in 1970



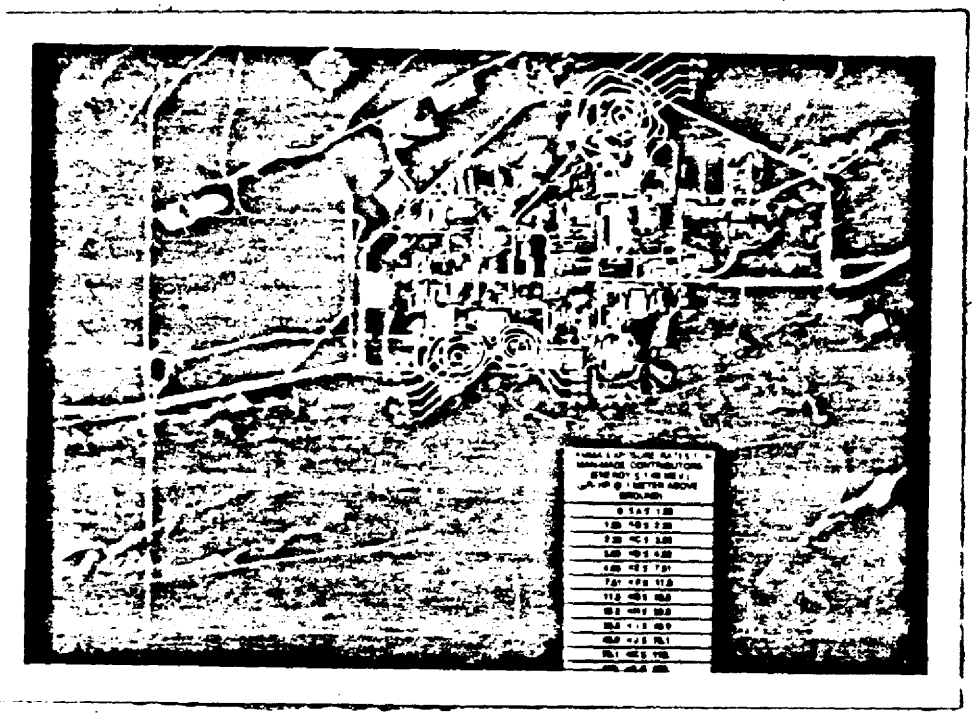
HASL Map Showing Plutonium Deposition Contours



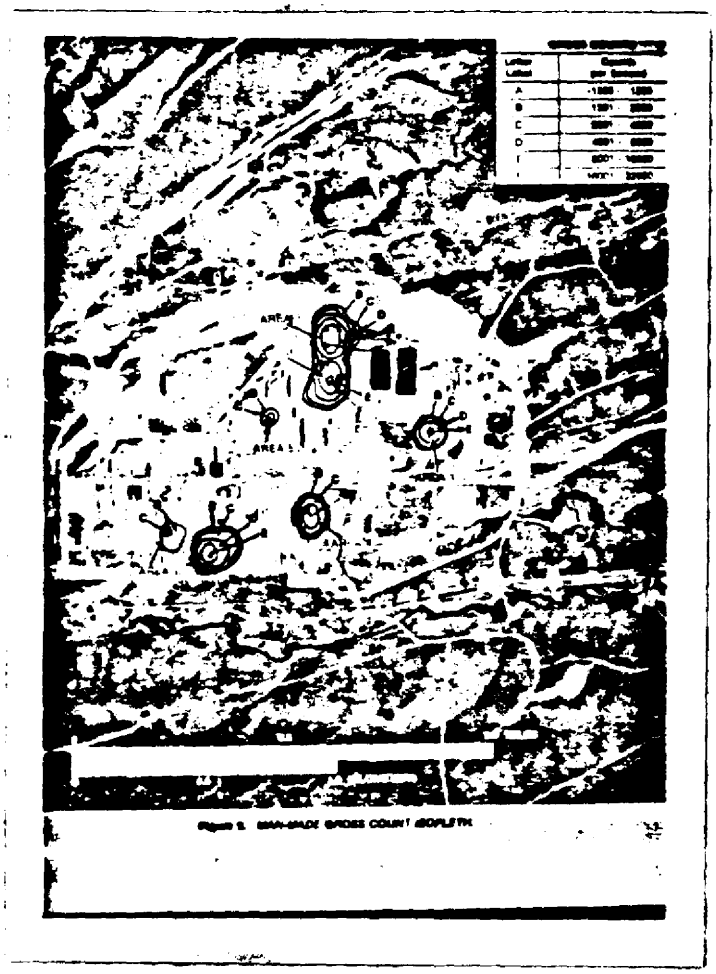
Colorado Department of Health Plutonium Sectors Map



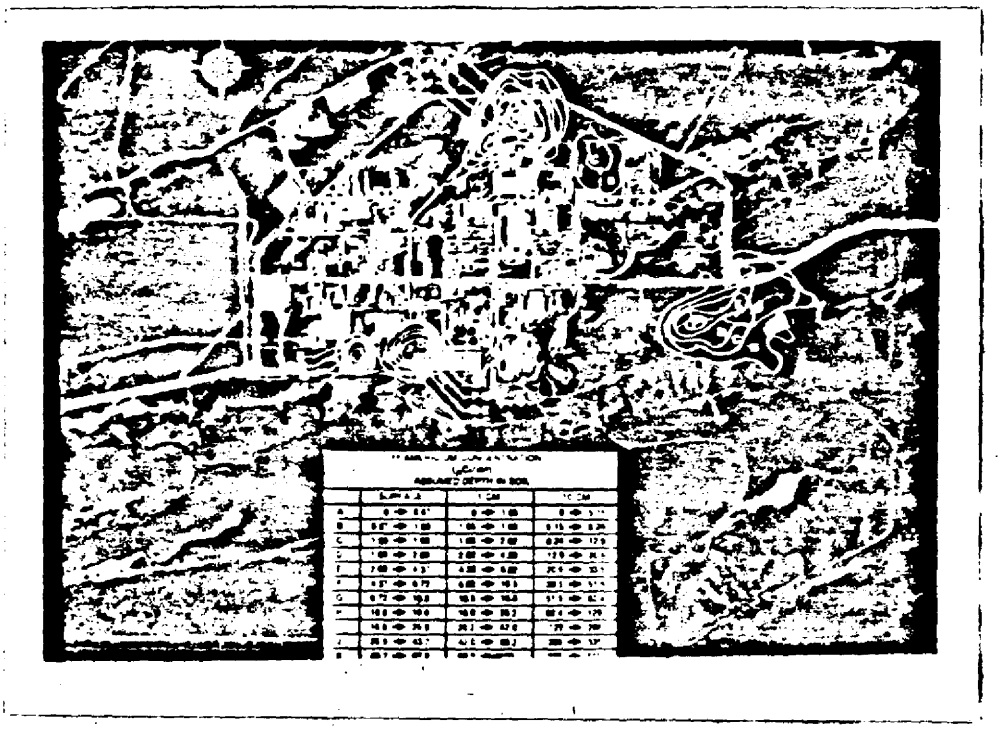
Soil Sample Sites of Regional Traverses



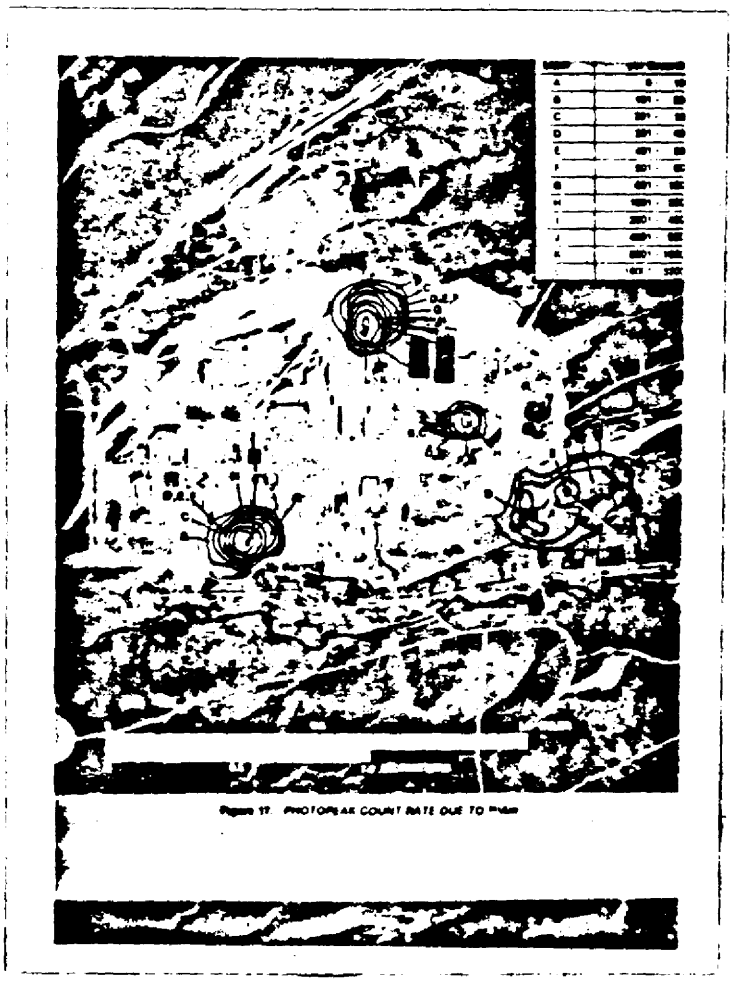
EG&G Aerial Radiometric Survey of Total Gamma in 1973



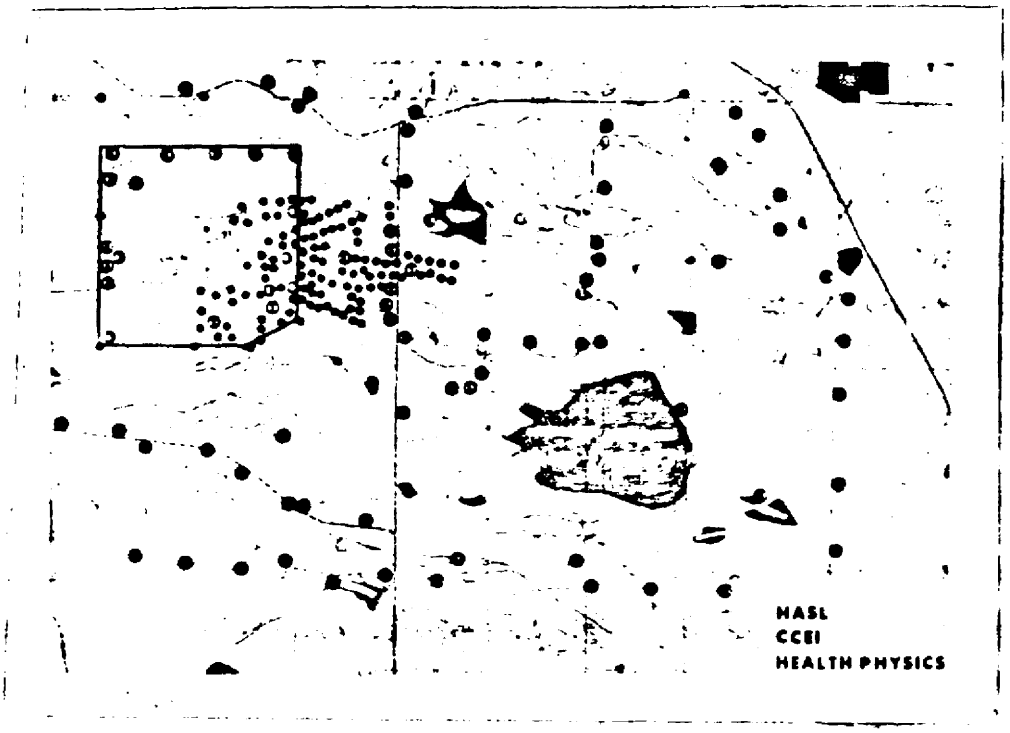
EG&G Aerial Radiometric Survey of Total Gamma in 1981



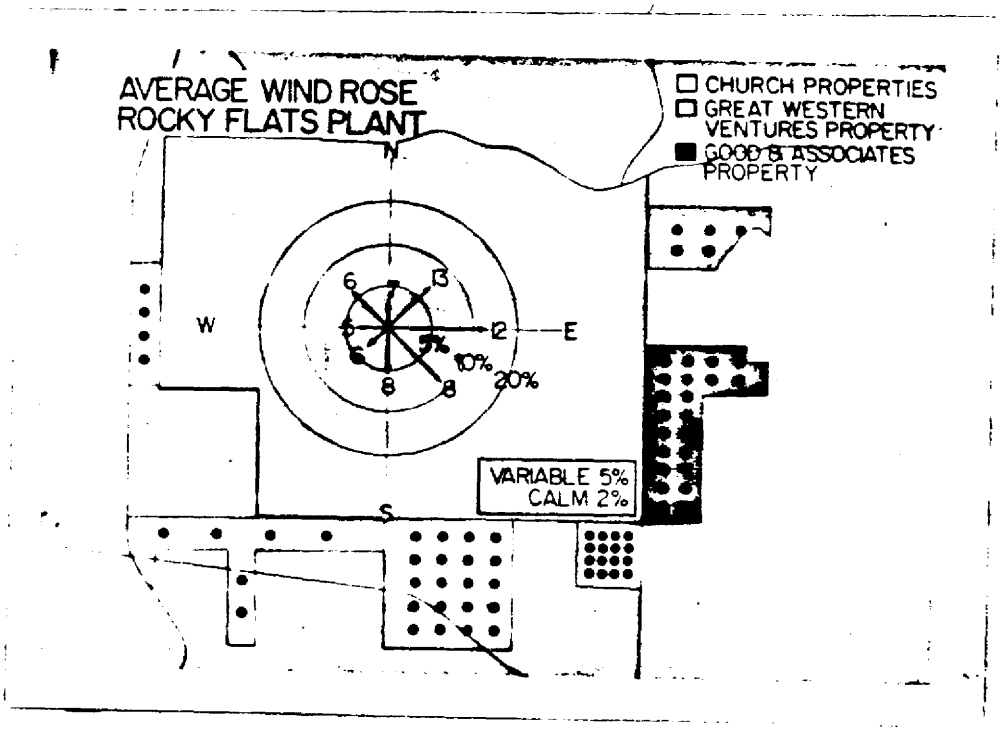
EG&G Aerial Radiometric Survey of ^{24}/Am Activity in 1973



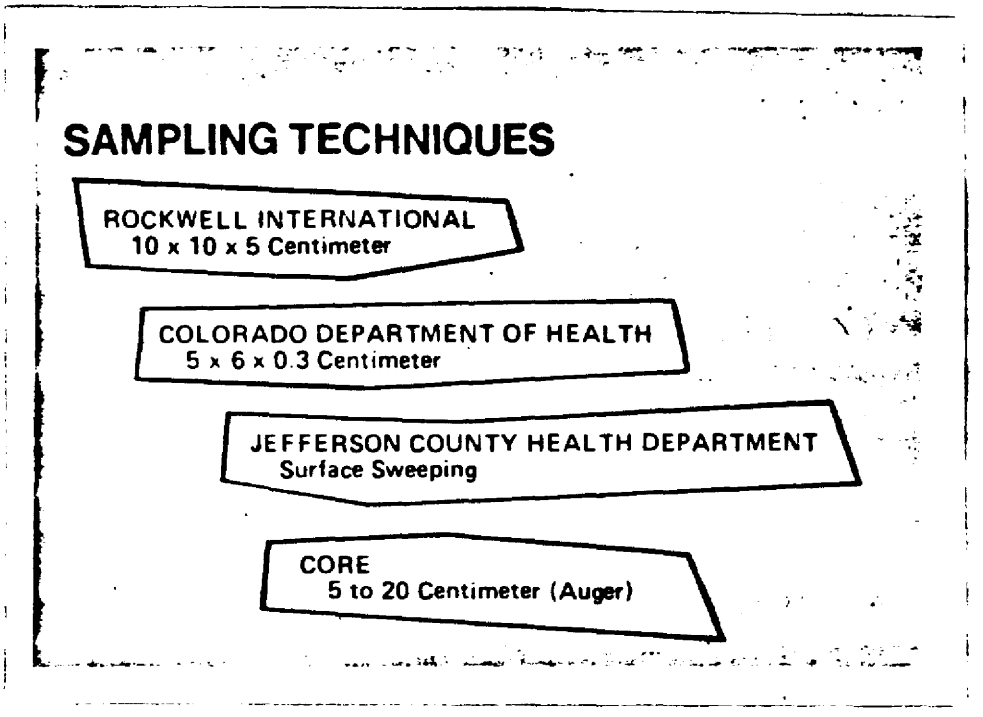
EG&G Aerial Radiometric Survey of ^{24}/Am Activity in 1981



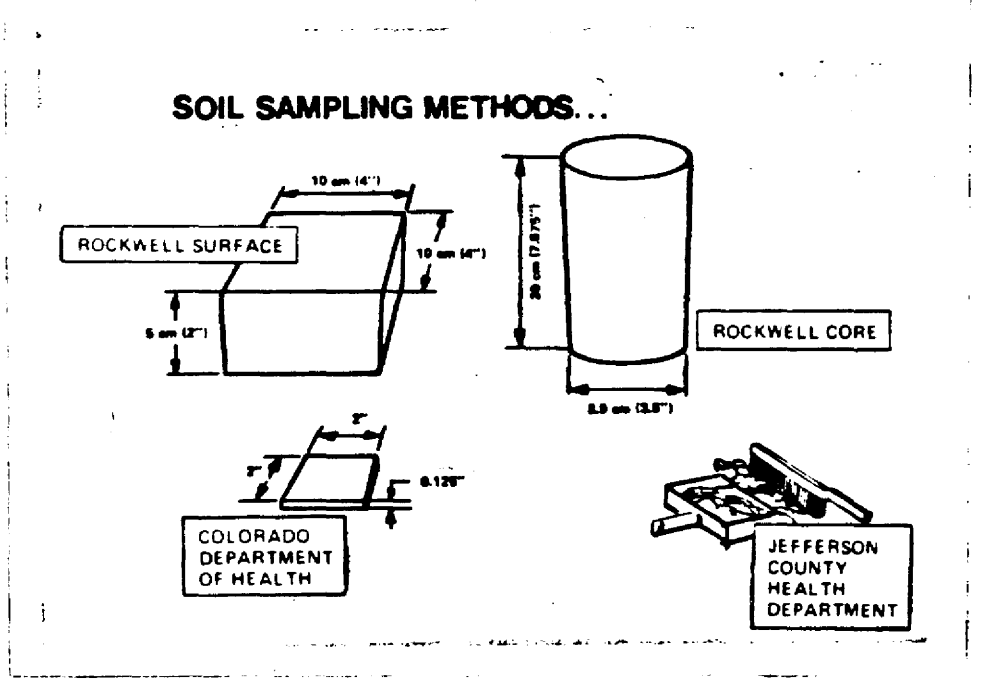
Composite Map Showing Locations of Several Soil Sample Surveys



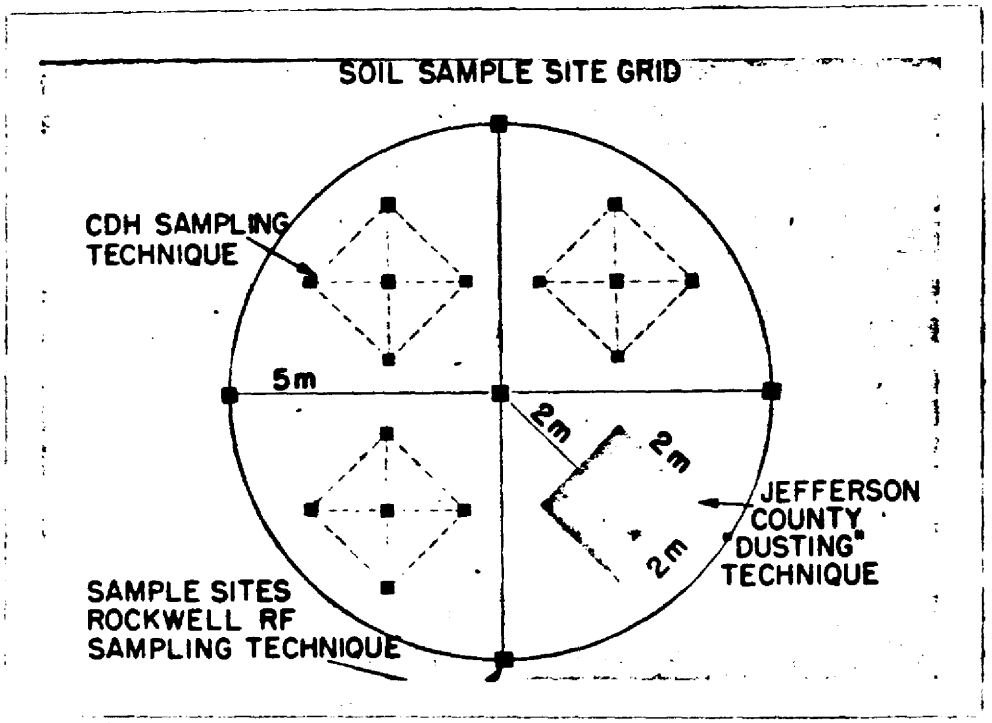
Average Wind Rose at the Rocky Flats Plant Site



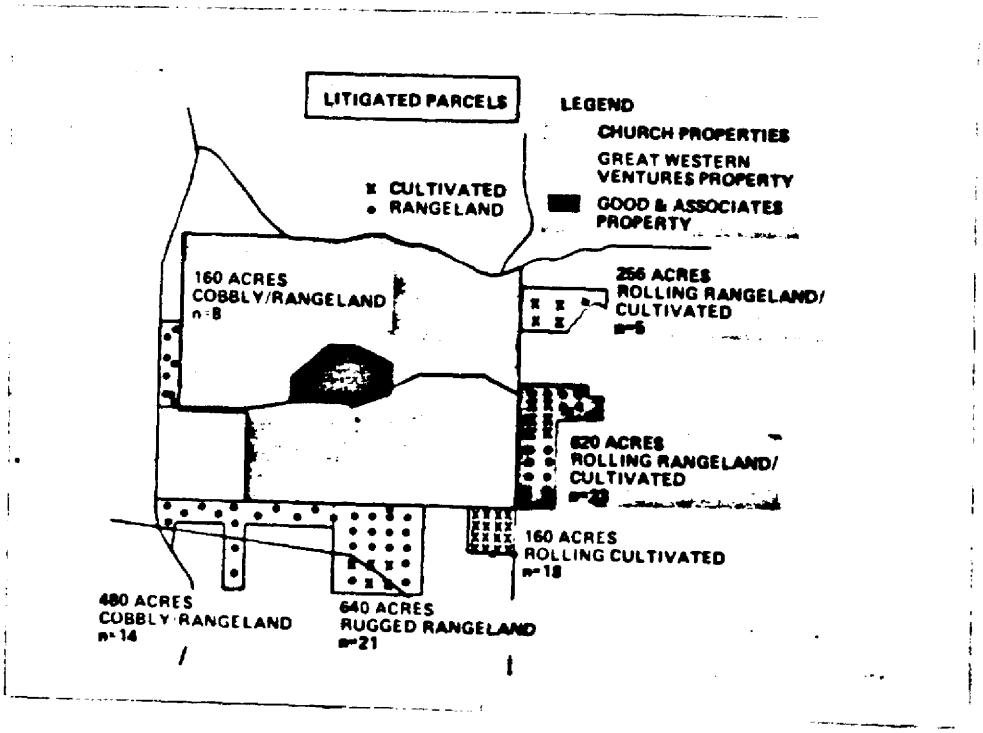
Soil Sampling Techniques Used for Litigation Samples



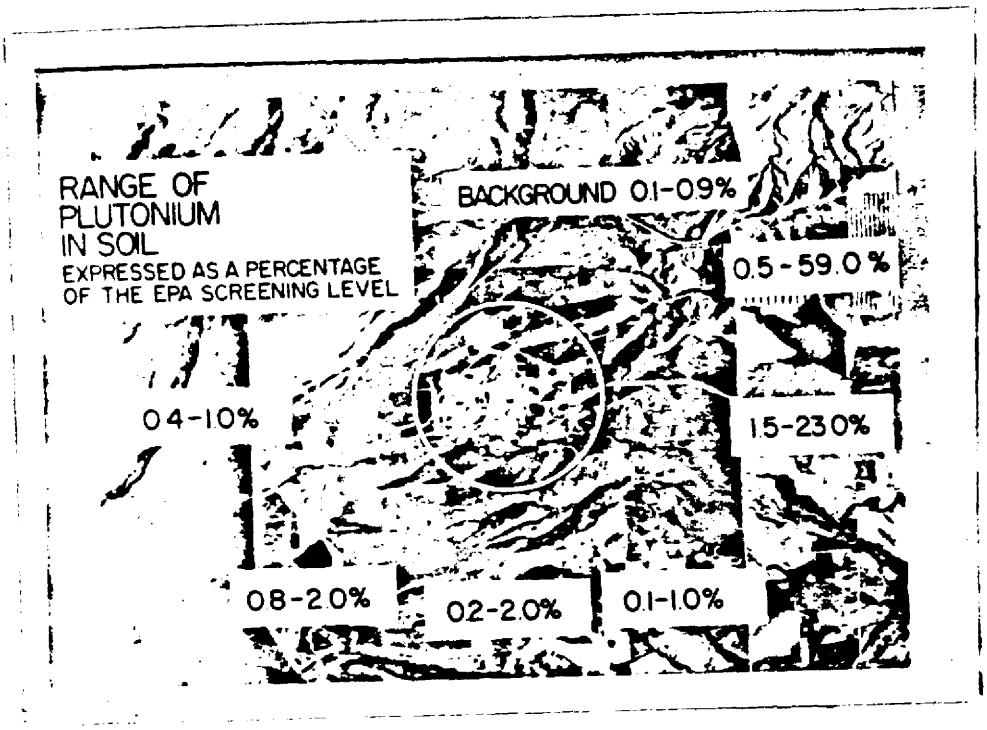
Soil Sampling Methods Used for Litigation Samples



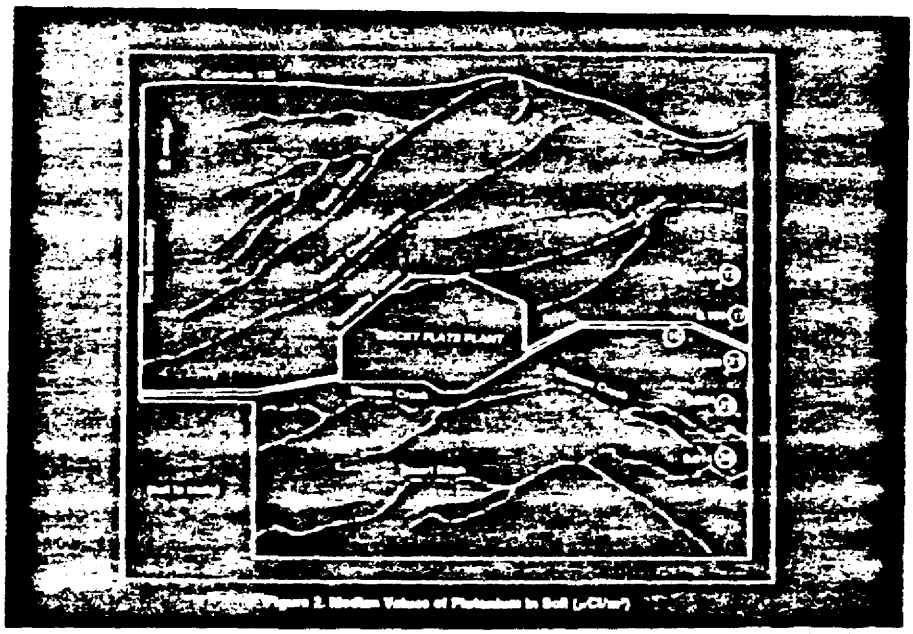
Soil Sample Site Grid Used at Each Litigation Location



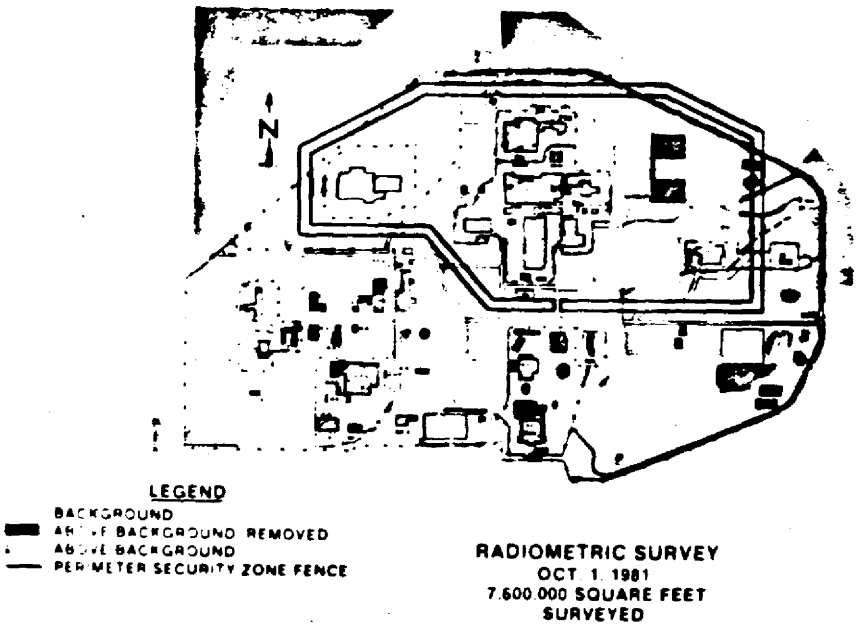
Map Showing Types of Land Involved in Litigation



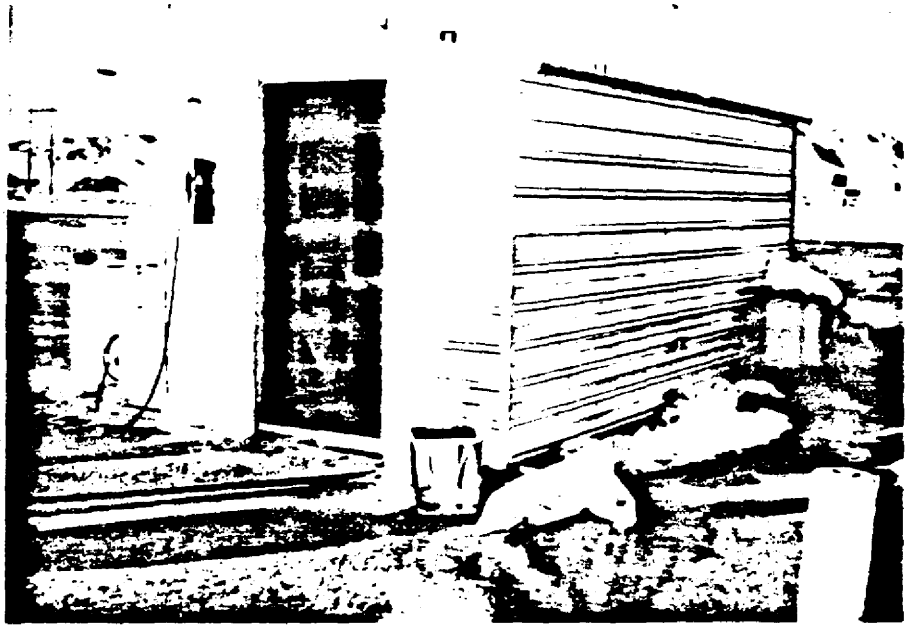
Map Summary of Plutonium Concentrations Around Rocky Flats



Map Showing Plutonium Concentrations Inside Eastern Boundary



Radiometric Survey of Rocky Flats Plant Site



Portable Building Used In Contaminated Soil Removal

Health Physics Technician Monitoring Bag of Contaminated Soil

Decontamination Workers Manually Removing Soil

ROCKY FLATS SOIL CONTAMINATION

HISTORICAL SEQUENCE

JULY 1958

DRUM STORAGE AREA ESTABLISHED, DRUMS CONTAINING PLUTONIUM CONTAMINATED OILS WERE ADDED DURING SUBSEQUENT YEARS

1959

FIRST DRUM LEAKAGE DISCOVERED AND RUST INHIBITOR, ETHANOLAMINE, WAS ADDED TO DRUMS PRIOR TO STORAGE TO MINIMIZE CORROSION

JANUARY 1964

FIRST EVIDENCE OF LAYER SCALE DETERIORATION OF DRUMS WAS REPORTED. SOIL CONTAMINATION WAS REPORTED TO BE INCREASING.

JANUARY 1967

LAST DRUMS WERE ADDED TO STORAGE AREA AND REMOVAL TO PROCESS AREA BEGAN. OLDEST DRUMS WERE SHIPPED FIRST.

JUNE 1968

LAST DRUMS WERE SHIPPED FOR PROCESSING. HIGH WINDS SPREAD SOME CONTAMINATION.

JULY 1968

RADIATION MONITORING AND MAPPING OF AREA WAS COMPLETED. LEVELS FROM 2×10^5 TO 3×10^7 D/M/GM AND PENETRATION FROM 1 TO 8 INCHES WERE REPORTED.

SEPTEMBER 1968

Preliminary Proposal For Containment Cover Was Prepared By Rocky Flats Engineering.

JULY 1969

First Coat of Fill Material Was Applied.

AUGUST 1969

Fill Work Was Completed, Paving Contract Was Let.

SEPTEMBER 1969

Overlay Material, Soil Sterilant And Asphalt Prime Coat Were Completed.

NOVEMBER 1969

Asphalt Containment Cover Was Completed. Four Sampling Wells Were Installed.

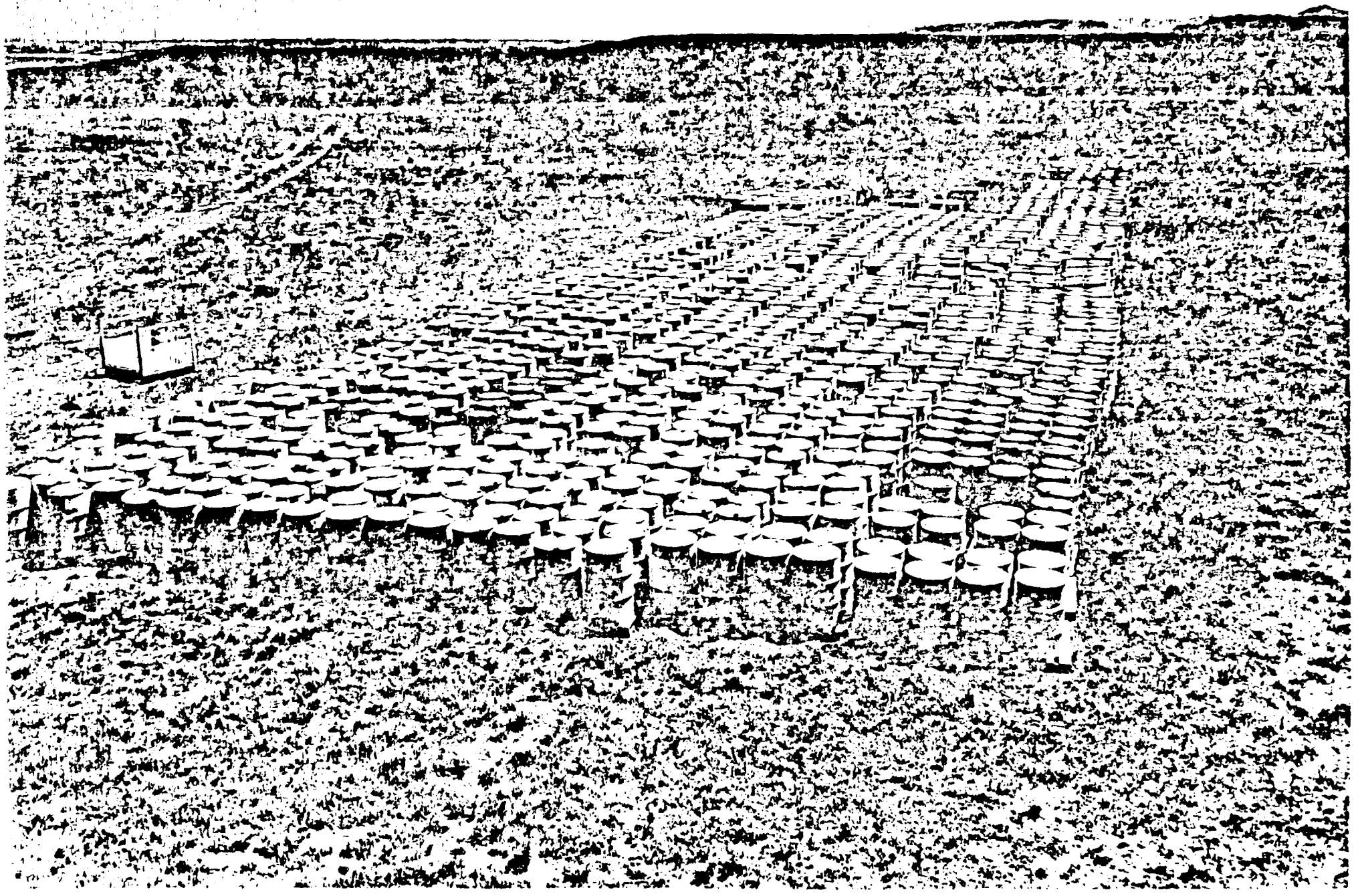
ACCIDENT SUMMARY

DRUM STORAGE AREA

TOTAL DRUMS IN STORAGE		5240
DRUMS CONTAINING URANIUM		1670
DRUMS CONTAINING PLUTONIUM		3570
ESTIMATED MATERIAL		7000-9000 GRAMS
RECOVERED	600 GRAMS	
PROCESSED WITH OIL	2500 GRAMS	
RESIDUE IN DRUMS	5200 GRAMS	
SUBTOTAL		8300 GRAMS
ESTIMATED OIL LEAKAGE		5000 GALLONS

ESTIMATED PLUTONIUM LOSS

1.	DOW CHEMICAL	.01-.02 G/GALLON	86 GRAMS
2.	HASL		176 GRAMS
			(11 CURIES)
		UNDER PAD	1.7 CURIES
		IN SOIL	6.9 CURIES
		ONSITE	8.6 CURIES
		OFFSITE	2.4 CURIES



SOIL CONTAMINATION-EARLY STUDIES

JANUARY 1970

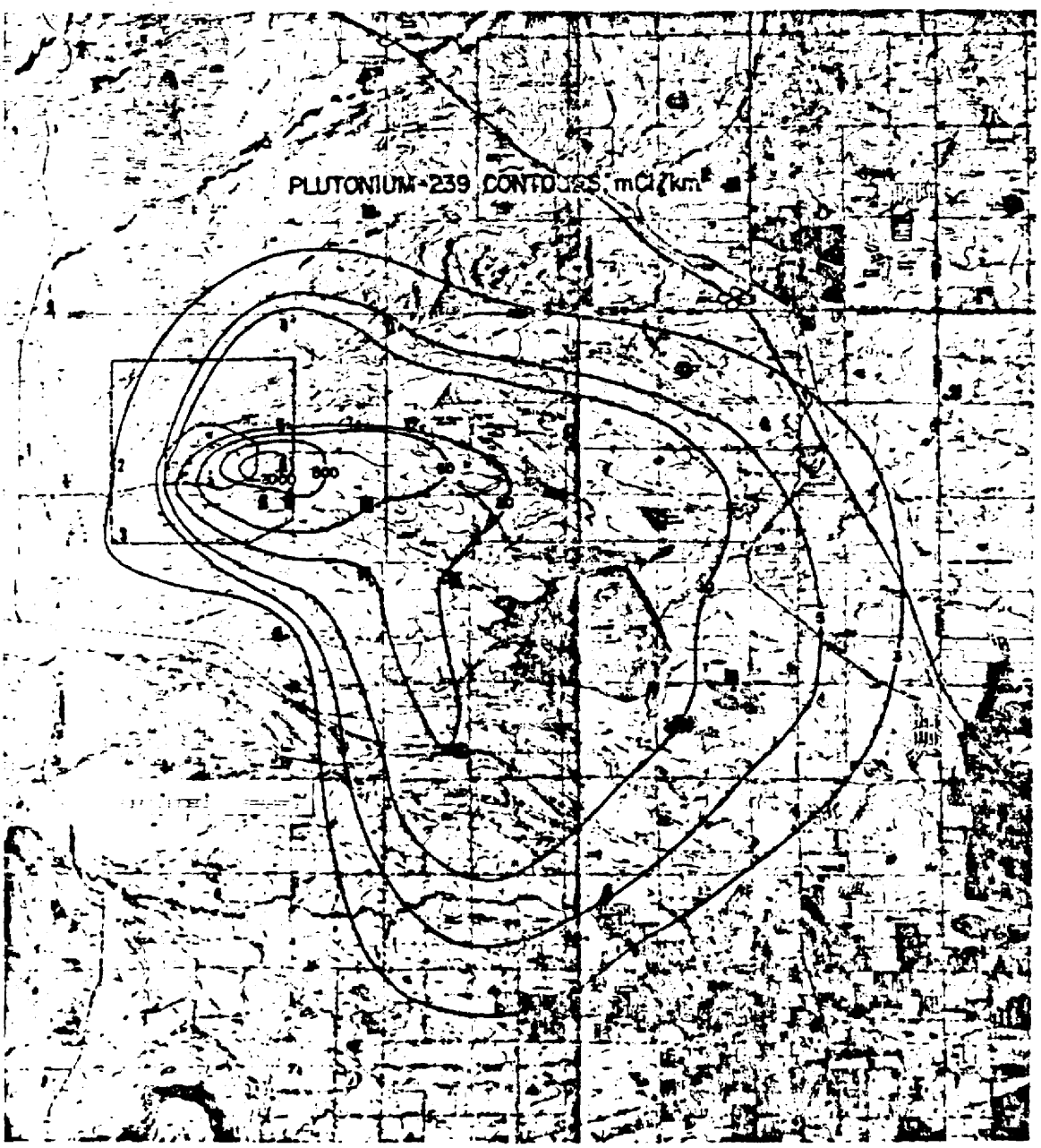
REPORT BY DR. MARTELL (COLO. COMM. FOR ENVIRONMENTAL INFORMATION) ON PLUTONIUM IN SOIL AROUND ROCKY FLATS

AUGUST 1970

REPORT BY HASL ON PLUTONIUM IN SOIL AROUND THE ROCKY FLATS PLANT

JULY 1971

REPORT BY DOW CHEMICAL ON PLUTONIUM LEVELS IN SOIL WITHIN AND SURROUNDING ROCKY FLATS


PLUTONIUM-239 CONTOURS mCi/km²
2000
800

LATER STUDIES OF OFFSITE SOIL CONTAMINATION

MAY 1977

DEFENDENT'S EXHIBIT "A" ON SOIL
SAMPLING AND TESTING PROGRAM DATA

MARCH 1979

PLUTONIUM CONCENTRATIONS IN SOIL ON
LANDS ADJACENT TO THE ROCKY FLATS PLANT

JUNE 1983

PLUTONIUM IN SOIL FROM A RANCH
SOUTHEAST OF ROCKY FLATS

OCTOBER 1983

PLUTONIUM IN SOIL FROM THE EASTERN
BORDERS OF BROOMFIELD'S GREAT WESTERN
RESERVOIR

STUDIES OF ONSITE SOIL CONTAMINATION

JULY 1971

DOW CHEMICAL REPORT (PREVIOUSLY NOTED)

MAY 1978

SOIL STUDIES FOR DAM CONSTRUCTION PROJECT

1979-1982

ANNUAL ENVIRONMENTAL MONITORING REPORTS

CRITERIA FOR CLEANUP(ONSITE)

SOIL DECONTAMINATION CRITERIA >5000 D/M/G

>30000 MCI/KM^2

>30 μCI/M^2

RATIONALE

1) LIMITED ACCESS AREA 40000 MCI/KM^2 *

* PROPOSED BY KATHREN (BNWL-SA-1510-1968)

2) RESEARCH SITE FOR ECOLOGICAL STUDIES

3) COST OF REMOVAL <$500,000

4) FIELD MEASUREMENT METHODS 500 D/M/G

5. ENVIRONMENTAL ASSESSMENT DOCUMENT

COST AND CLEANUP METHODOLOGY

YEAR	LOCATION	AREA(FT^2)	METHOD	COST
1968	903 Area	266,000	Removed Top Three Inches Into Central Area	$ 30,00
1969	Pad (903 Area)	170,000	Area Covered With 10 Inches Fill Material and 3 Inches Asphalt	$100,000
1976	Lip (903 Area)	7,750	Manual Excavation in Floorless Bldg.	$ 43,500
1977	Pond-Area (207 Solar Ponds)	38,950	Front-End Loader Excavation of Moistened Material	$327,000
1978	Oil Burning Pit	2,000 (5 Foot Deep)	Front End Loader Excavation of Moistened Soil	$101,000
1978	Lip (903 Area)	45,500	Front End Loader Excavation of Moistened Soil	$410,000

SOIL REMOVAL UNIT COSTS

YEAR	LOCATION	COST PER FT^2	COST PER BOX	COST PER CWT
1976	903 AREA	$ 5.61	$1243	$34.86
1977	SOLAR PONDS	$ 8.40	$ 623	$14.92
1978	OIL PIT	$50.50	$ 289	$10.10
1978	903 AREA	$ 6.79	$ 281	$ 8.35

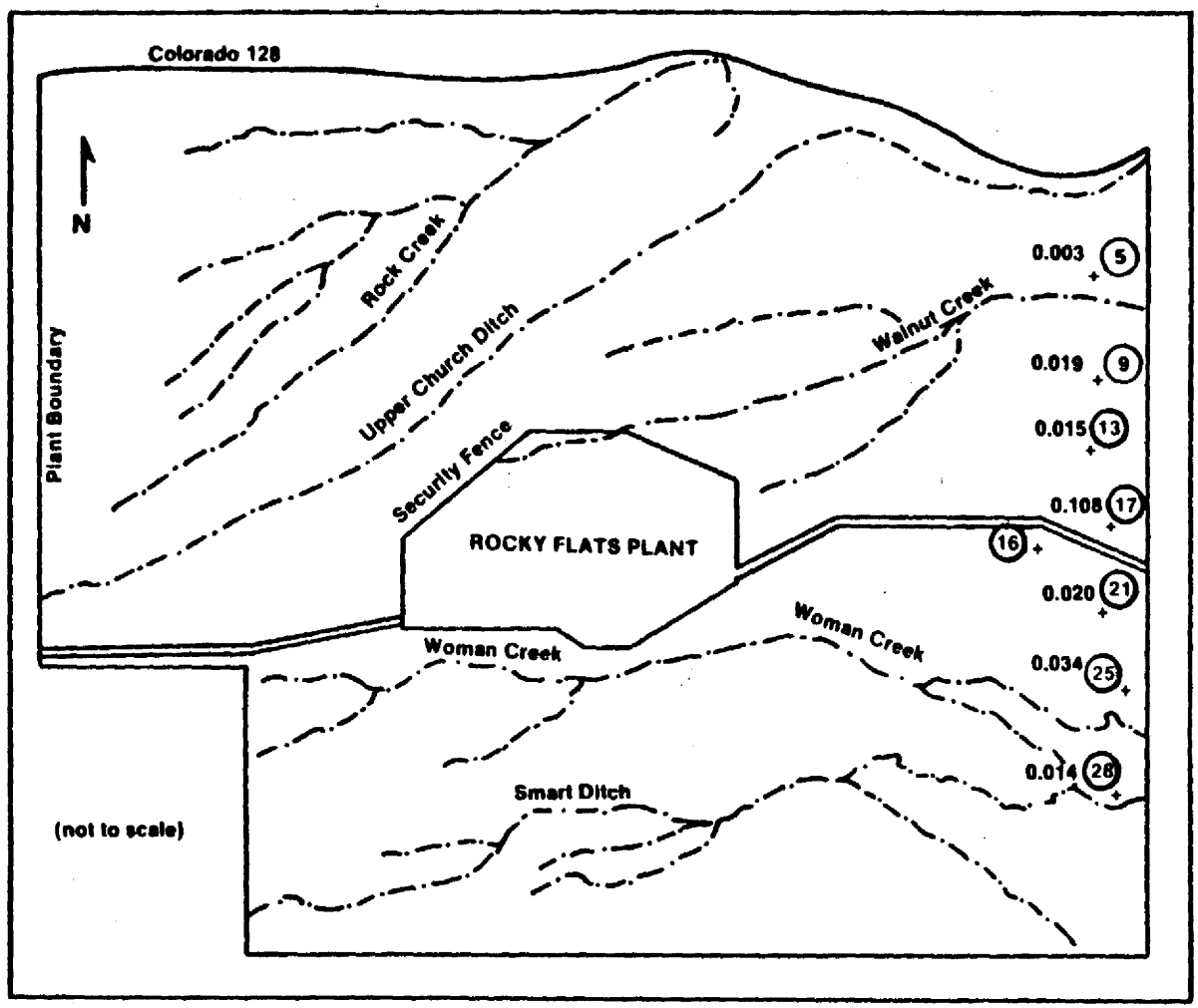


Figure 2. Median Values of Plutonium in Soil (μCi/m^2)

IMPACT OF PROPOSED GUIDELINES

AREA REQUIRING CLEANUP

OFF SITE	NONE
ON SITE	300 ACRES

ESTIMATED COSTS

ASPHALT PAD	$20 MILLION
ADJACENT LAND	11 MILLION
HOLDING PONDS	40 MILLION
BUFFER ZONE	1 MILLION
TOTAL	72 MILLION

PLUTONIUM CONTAMINATION AT THULE

Summary of Notes for Talk

Given at DOE Meeting on Proposed

EPA Guidelines for Transuranium

Elements in the Environment

January 17, 1984

David S. Myers

Lawrence Livermore National Laboratory

PLUTONIUM CONTAMINATION AT THULE

On January 21, 1968, a B-52 carrying 4 nuclear weapons crashed and burned on the ice near Thule, Greenland. The 7 crew members bailed out before the crash and 6 survived. At the time of the crash, the plane was carrying about 225,000 pounds of JP-4 jet fuel. The resultant fire produced a blackened area on the ice of about 500 feet wide by 2100 feet long. The ice was cracked for about 100 yards in all directions from the point of the impact.

At the time of the crash, the temperature was -24°F and a 7 knot wind reduced this to an equivalent -53°F reading. It would be about 3 weeks yet until the sun made its first appearance after the long Artic night. During the next few weeks, several storms swept the area. The combination of darkness, storms, severe cold, and the remote location would make recovery operations extremely difficult.

Within a few days, members of the U.S. Air Force, scientific experts from LASL and Livermore, and Danish scientists were assembled at Thule to assess the accident situation. It quickly became clear that there was plutonium contamination around the crash site, but there was no evidenace of any nuclear yield. Also, it was determined that the ice at the crash site was 2 to 4 feet thick and sufficient to support vehicles and structures as long as adequate spacing was maintained.

One of the first priorities was to establish the extent of the contamination around the crash site and determine a zero line outside of which no contamination was detectible. The most valuable instrument for mapping the contamination level was the FIDLER detector developed at Livermore. This instrument is designed to detect the low energy x-rays (14 keV to 20 keV) from plutonium and the 60 keV photon from Am-241. Because of the snow cover, the 60 keV photons from ^{241}Am produced better sensitivity and were used for contamination contour mapping and hot-spot identification.

Thorough surveys of the contaminated area produced the isocontamination contour map shown in Figure 1. It was estimated that there were about 3150 g ($\pm$ 20%) of plutonium on the surface of the ice. About 99% of the contamination was confined to the blackened crust where the fuel had burned. The edge of the blackened crust was closely coincident with the 0.9 mg/m^2 isocontour line. This level is about 400 times greater than the proposed EPA "screening level" of 0.2 uCi/m^2 for transuranic contamination in soil.

Snow samples were taken by Danish scientists at numerous locations (primarily to the south and west) away from the immediate crash site. The maximum contamination level observed was 0.4 uCi/m^2. The geometric mean of all the samples was about 0.004 uCi/m^2.

One of the major constraints in the clean up operation was that whatever actions that were going to be taken on the ice had to be finished by the later part of April when the ice would become unsafe to work on. Whatever plutonium

contamination remained on or in the ice at that time would disappear into the bay.

It was decided to remove all of the snow inside of the blackened zone which included an area of about 60,000 m^2. With an average snow depth of 10 cm, this would produce a volume of 6000 m^3. Assuming that the volume ratio of packed snow to water would be about 2.5, this would produce about 6×10^5 gallons of water. After all of the aircraft debris had been removed from the ice, the snow in the blackened area was scraped into rows, picked up and transferred into sixty-seven 25,000 gallon tanks.

In the area of the aircraft impact, the ice had been broken, melted, and refrozen. To assess the level of contamination in the ice, 85 core samples were taken in the fractured area. There was plutonium contamination associated with black bands distributed in the ice which were produced by burned fuel. It was estimated that about 350 g of plutonium were contained in the roughly 2000 tons of ice. Studies showed that when samples of the ice were melted, essentially all of the plutonium contamination sank to the bottom. Another 48 core samples were taken outside the fractured area. They disclosed no contamination in or under the ice.

A decision was made to let the contaminated ice melt in place for three reasons. First, even if the plutonium were to stay suspended in water, it would rapidly be reduced to non-hazardous levels by dispersion. Second, it was likely that the plutonium would settle into the sediment layer on the

bottom of the bay and become effectively isolated from the inhabitants in the area. And third, the clean-up operations which had already taken place were not completed until the end of March, which left only a few weeks before the ice would become unsafe to work on.

Many environmental surveys have been conducted by Danish scientists in the years since the accident. These surveys have focused on determining the levels and distribution of plutonium contamination in the marine environment and investigating the possible impact that might be transmitted through the food chain to the Greenlanders (see Figure 2). The surveys have produced the following major conclusions:

1. The inventory of plutonium in the sediment on the bottom of the bay is about 30 Ci. The maximum concentration under the crash site is about 50 pCi/g (see Figure 3). The vertical displacement of the plutonium is about 7-8 mm/y which indicates that it will become increasingly unavailable to the biota in the sediments.

2. Plutonium has been found in increased quantities (up to 6 pCi/g) in the organisms (mussels, starfish, and shrimp) that live in the sediment, but the concentrations are decreasing with time.

3. Certain seaplants have been found to concentrate plutonium by a factor of about 13,000.

4. In 1979, seawater did not contain measurable amounts of plutonium from the accident, except in particles just above the seabed at the point of impact.

5. In the most recent environmental survey completed in 1979, plutonium from the accident was not detected in any of the higher animals (birds, fish, mammals) with any certainty. The contamination has been confined to the sediment and those organisms that live in or on the sediment.

The only direct link between the Greenlanders and the portion of the foodchain with detectable plutonium contamination is through the mussels (bivalves). In 1974, the average concentration of plutonium in the soft parts of the mussels found within a radius of 20 km of the crash site was about 20 pCi/kg. If we asume that a Greenlander eats 100 grams of mussels a day from this region for 70 years, the estimated annual dose rate to the bone at the end of 70 years would be .075 mrad (from EPA 520/-77-016, Table A3-6). Even with this extremely conservative scenario, the projected maximum annual dose rate is less than 3% of the proposed EPA limit.

I was unable to find any cost estimates for the clean up operation at Thule. It involved the resources and people of many organizations and would be difficult to reconstruct. However, since the clean up operations apparently were sufficient to meet the requirements for limiting exposures to individuals as currently proposed by the EPA, it is my opinion that the clean up costs wouldn't be appreciably different today than they were then, save the adjustment for inflation.

REFERENCES

1. "Project Crested Ice", USAF Nuclear Safety, Volume 65 (Part 2) Special Edition, Jan/Feb/Mar 1970.

2. Aarkrog, A, "Environmental Behavior of Plutonium Accidentally Released at Thule, Greenland", Health Physics, Volume 32, No. 4, April 1977.

3. Aarkrog, A, et al., "Radioecological Investigations of an Environmental Contamination with Transuranic Elements", 1980 Progress Report, Radiation Protection, Commission of European Communities.

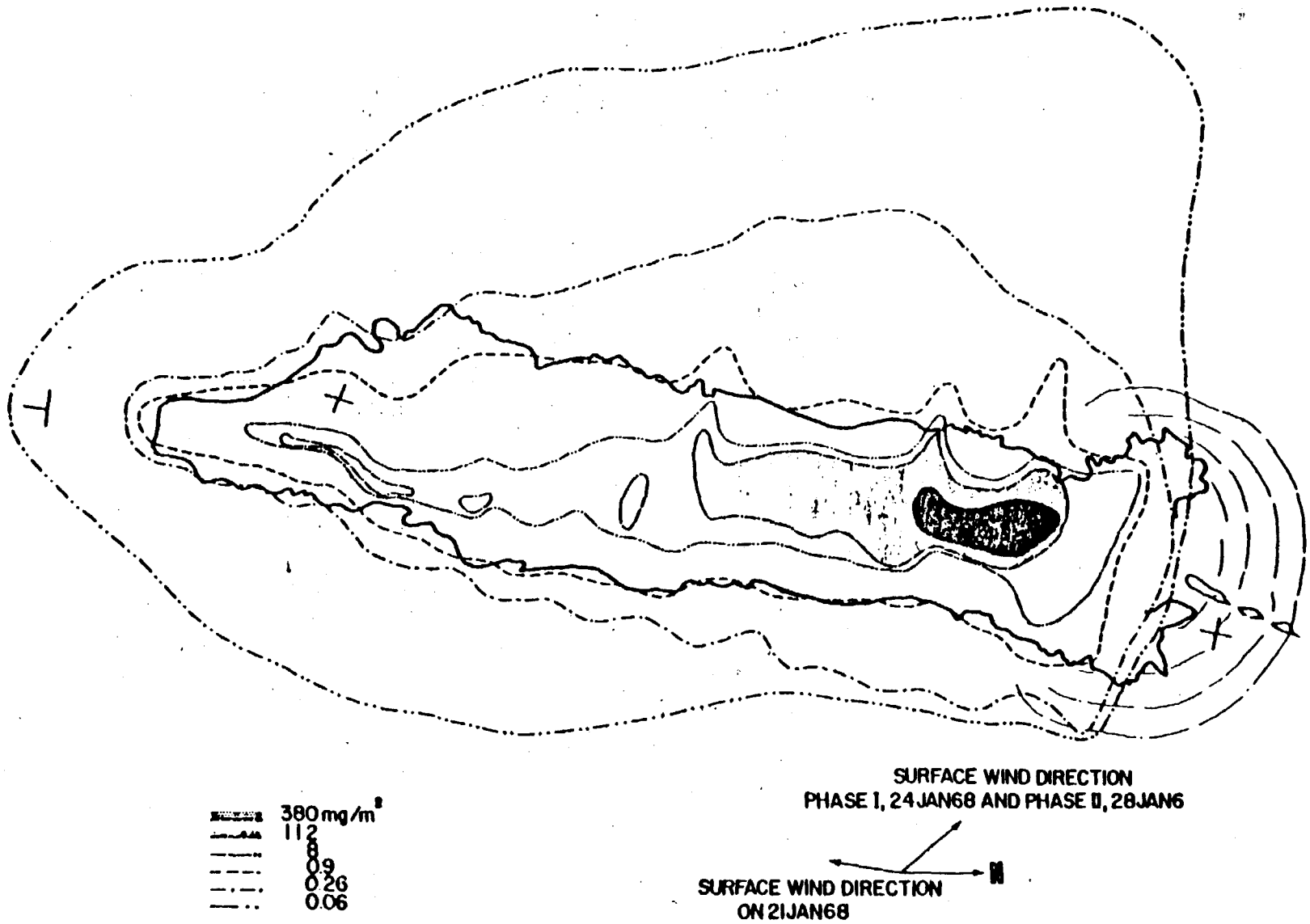


Figure 1 Plutonium contamination levels observed.

Taken from reference 1

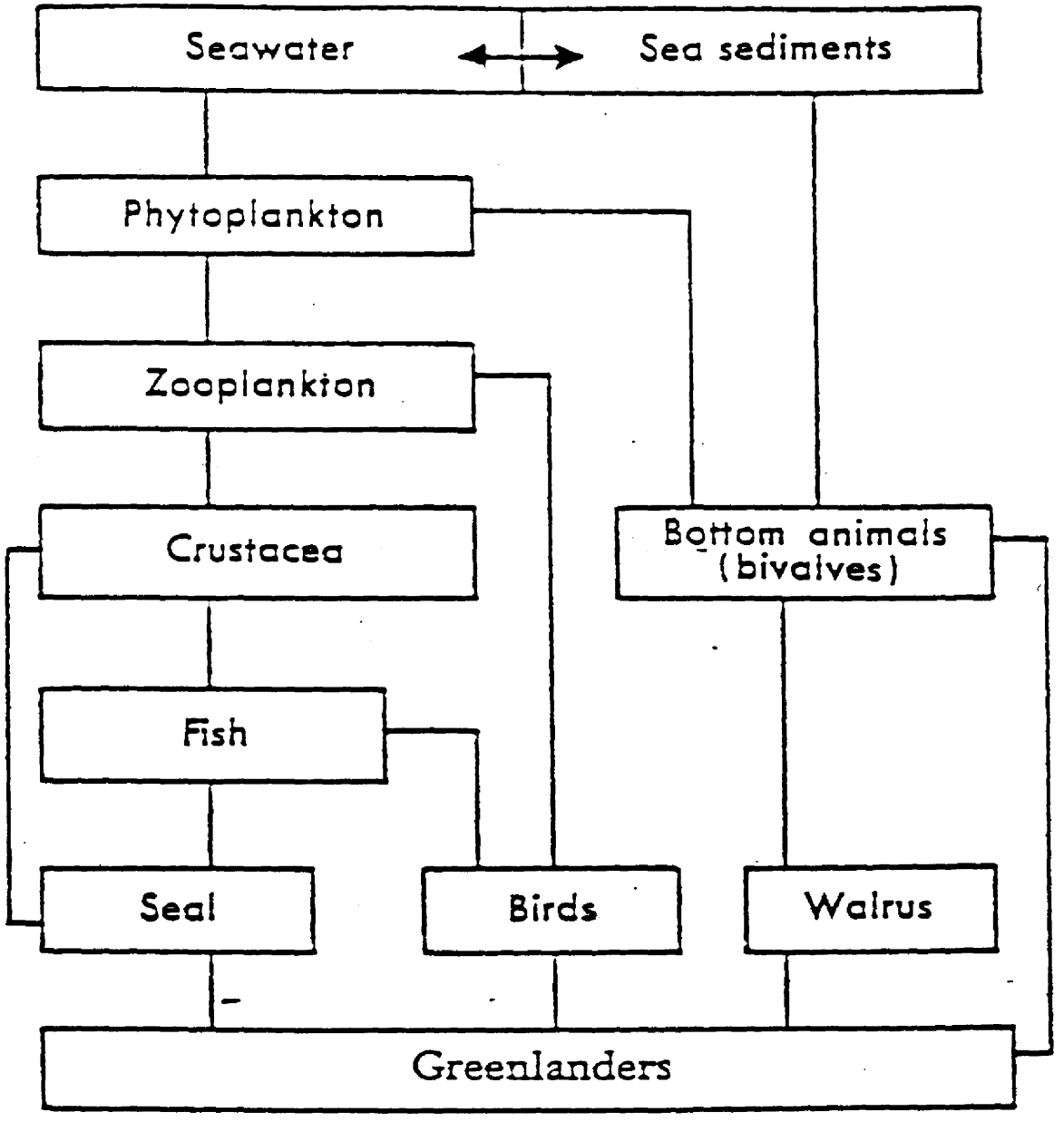


Figure 2 Food chains in an arctic, marine environment.

Taken from reference 1

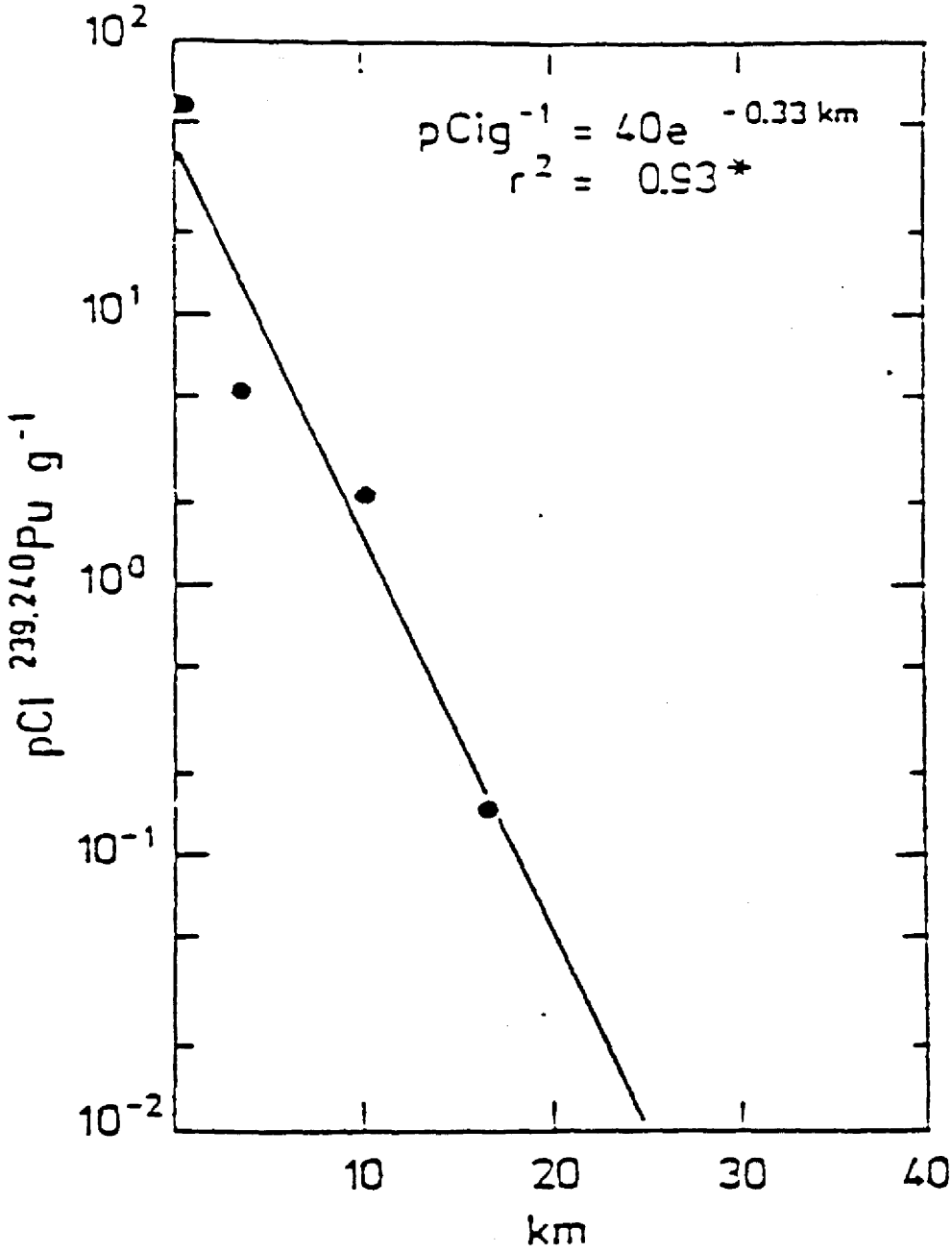


FIG. 3. The $^{239,240}Pu$ concentration in the sediment surface (0 cm depth) related to the distance (in km) from the point of impact.

Taken from reference 3

JAN 10 1984

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Proposed Environmental Protection Agency (EPA) Dose Limits for Persons Exposed to Transuranium Elements in the General Environment
Major Robert H. Wank, DOE/HQ, DP-226.1

As requested by your memorandum of November 23, 1983, we and our contractors have reviewed the materials provided concerning the subject regulation and offer the following comments:

(1) The dose limits in the proposed regulation (1 millirad per year to the pulmonary lung, or 3 millirad per year to the bone, or 40 millirad per year to the bone surfaces) appear to be unreasonably conservative. The EPA purports to base the proposed limits on guidance provided in ICRP report 26 concerning acceptable risk limits to the public. It would therefore seem appropriate for the EPA to use the risk, quality and weighting factors and general methodology also presented in ICRP 26. Although we were not given their methodology or assumptions, it appears that EPA arrived at their limits through a more conservative approach than is presented in ICRP 26 without an obvious justification for so doing.

(2) From the guidance presented, the impact upon current AL sites and operations are expected to be minimal. Based upon preliminary information, the soil screening levels are exceeded only on a small area near LANL in Acid Canyon where average transuranic levels are about 60 pCi/g. However, in this particular instance, a pathway analysis would indoubtably show the levels from the site to be less than the dose limits in the proposed regulation. Of more serious concern to AL would be the regulation's impact upon future accident situations wherein the guidance from EPA seems inadequate.

(3) We are also concerned about the potential applications of the soil screening level. It would be costly if, through inappropriate use, the soil screening level were ultimately to become a soil cleanup level. The origins of Appendix B of 10 CFR 20 are a case in point, wherein ICRP guidance was eventually promulgated as regulation. We fear that other Federal and/or State regulatory agencies may adopt the screening level as a regulation to provide

WANK

a basis for future legal actions in the event of a contamination incident. Also, should the guidance be translated at some future date to cleanup criteria based on the soil screening level and apply to Federal property as well as non-Federal property, the cost of implementation could be enormous without a commensurate benefit to the health of the public.

P. M. Ramey
Director
Operational Safety Division

cc:
L. J. Deal, DOE/HQ, EP-342

DRAFT

IDAHO OPERATIONS OFFICE (ID) COMMENTS PERTAINING TO PROPOSED ENVIRONMENTAL PROTECTION AGENCY (EPA) DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT

William W. Hoover, Major General, USAF
Director of Military Application
DOE Headquarters

As requested in W. W. Hoover's memorandum of November 28, 1983, comments on the proposed EPA guidance are attached for your use and consideration. The majority of the comments are philosophical rather than technical in nature and were formulated by Mr. B. L. Rich, who is employed by EG&G Idaho, Inc., an ID contractor, and the ID Operational Safety Division.

Please direct any questions or concerns you may have to J. H. Barry (FTS 583-0193) of my staff.

Troy E. Wade II
Manager

Attachment

cc: T. O. Pflaum, DP-226.1, w/attach.

DRAFT

COMMENTS ON THE PROPOSED EPA DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT

A. The conservatism associated with the numerical limits are far too great.

1. The population dose limit of 500 mrem per year to a target organ was established by the advisory bodies (ICRP, NCRP, etc.) with significant safety factors applied.

2. There are multiple assumptions necessary in the uptake pathways to man. Each has been conservatively estimated which procuces an unrealistic total conservative overestimate.

3. Linear dose response curves have now been demonstrated to be overly conservative. In addition, the internal organ dose response curves are less well defined from exposure to internal uptake/dose.

4. The assumption of 10^{-6} acceptable risk is in itself unrealistically conservative considering the cumulative conservatism enumerated above.

5. The size and location of the population at risk is unrealistically estimated.

6. The availability of the radioactive contaminants after 100 years or so (the loss of federal reserve protection) has been assumed at levels reflective of earlier times. It has been shown that plutonium availability decreases with time.

B. The explanatory text repeatedly emphasizes that these guides are just that and that technical judgment must be exercised. However, these will be the only guidance available and will be applied by regulators and interpreted by the public as strict limits. Site specific application will be impractical since the uninformed and those with ulterior social motives will point to apparent discrepancy between sites as a cavalier approach. The general public will be led to believe that levels exceeding the published limits are injury-producing levels. Few read the "fine print."

It is important to recognize the obvious conflict in the statements directing "judgment by the implementing agencies" and in the same paragraph (#4, page 3) pointing out that exemptions must be granted only by the President of the United States on the basis of "national security or paramount interest of the U.S."

C. The reasons listed for lowering the recommended dose limits (guides?) by a factor of 25 (in reference to the proposed average annual dose rate to the pulmonary tissue of 1 mrad/year) are scientifically baseless. The reasons (paragraph #1, page 95) are stated as "deemed unnecessarily high and capable of being reduced."

DRAFT

D. Years of experience have demonstrated the good faith of the industry (primarily DOE) in conservative application of existing guides in the spirit of ALARA. In fact when it can be easily and economically justified (at considerable expense in most cases), activity is removed to "nondetectable" levels to avoid public concern.

E. Reducing the limits to levels approaching background and/or minimum detectable, places the industry under unnecessary pressure which in addition destroys the flexibility to effectively work ALARA programs.

F. The current limits are so low that the limit of detection sensitivity is reached. Sampling and analyses require extended time and detailed chemical separation and counting technology. The limits placed at these low levels multiply the number of the extensive analyses.

G. The minimum cost ($500 per acre) assumed for estimating the total costs for bringing contaminated areas into compliance with the guidance is unrealistically low. It is a generally accepted fact that the costs associated with decontamination rapidly escalate when the desired incremental reduction is small. In addition, the costs attributable to decontamination efforts include planning and engineering; labor; equipment use and decontamination; waste packaging, handling, transport, and disposal; and radiation monitoring.

H. When dealing with very low annual dose rates, the assumptions and/or models used when computing doses have a significant impact on the dose rate estimates resulting from a given set of data points. Consideration should be given to standardizing the dose computation and pathways analysis methodologies and to referencing specific methodologies in the proposed guidance.

I. The "screening levels" discussed in the proposed guidance should be removed. Quantifying these levels may constitute establishment of a separate set of dose limits. That is, each site has unique environmental and demographic parameters which may result in different screening levels than those proposed, but still correspond to the annual dose rates specified in the guidance.

J. We would suggest a more appropriate approach for the FRC function to take would be in the following options:

1. First and Preferred Option

   Establish technically based limits which are consistent with those recommended by ICRP and NCRP with a strong ALARA requirement.

2. Second Option

   List the limits/guides in tables with two columns, the first with the technically based limits and the second with the ALARA based guides as goals to be used with discretion and judgment. This

would at least more clearly communicate the basis upon which the lower limits were being proposed and provide a more understandable base for making cost/benefit evaluations.

In both of these options, the text should clearly treat the philosophy of multiple conservatism in the parameters leading to calculation of numerical limits.

DOE Form AD 321
(6-78)
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U. S. DEPARTMENT OF ENERGY
ARGONNE, ILLINOIS 60439

7. _____
(Signature of authorizing official)

8. DATE
JANUARY 6, 1984

9. TO
WILLIAM W. HOOVER, MAJOR GENERAL, USAF
DIRECTOR OF MILITARY APPLICATION, HQ
DP-226.1/GERMANTOWN

4446

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SUBJECT: PROPOSED ENVIRONMENTAL PROTECTION AGENCY (EPA) DOSE LIMITS FOR PERSONS EXPOSED TO TRANSURANIUM ELEMENTS IN THE GENERAL ENVIRONMENT

REFERENCE: MEMORANDUM, HOOVER TO MULTIPLE ADDRESSEES, DATED NOVEMBER 23, 1983

IN RESPONSE TO YOUR MEMORANDUM OF NOVEMBER 23, 1983, REQUESTING COMMENTS ON PROPOSED EPA LIMITS ON TRU IN THE ENVIRONMENT, WE HAVE PROVIDED COMMENTS DIRECTLY TO MAJOR WANK ON AGENDA TOPICS SUGGESTING A DISCUSSION OF INSTRUMENTATION AND METHODOLOGIES IN USE AT FIELD OFFICE FACILITIES.

000316

BE BRIEF--ELIMINATE UNNECESSARY WORDS

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WE ARE PROVIDING BELOW SUBSTANTIVE COMMENTS ON THE PROPOSED REGULATIONS AND DOE IMPACT: A COMMENT SHOULD BE MADE ON THE HAZARD STATEMENT ON PAGE 9, THAT "INHALATION OF TRANSURANIUM ELEMENTS MAY CAUSE LUNG CANCERS, AND INGESTION MAY CAUSE BONE AND LIVER CANCERS." WHILE THIS IS NO DOUBT TRUE FOR HUMANS, IT HAS ONLY BEEN ACTUALLY DEMONSTRATED FOR LABORATORY ANIMALS, AND THE ONE-IN-A-MILLION RISK FOR HUMANS IS ONLY CALCULATED. THIS HAZARD STATEMENT SHOULD ALSO STATE THAT THE PURPOSE OF THE STANDARD IS TO PREVENT FUTURE CANCERS IN HUMANS FROM TRANSPLUTONIUM ELEMENTS, SINCE WE EXPECT THE SAME EFFECT FROM THESE ELEMENTS AS WE HAVE EXPERIENCED FROM RADIUM. WE SHOULD NOT GIVE THE FALSE IMPRESSION TO LAY PERSONS THAT WE BELIEVE PRESENT AND PAST ENVIRONMENTAL PLUTONIUM LEVELS ARE A CAUSE OF HUMAN CANCERS.

THE DOSE LIMITS ARE INTENDED TO BE BASED ON A CANCER RISK OF 10(E-6) PER YEAR. STATEMENTS IN THE DOCUMENT (E.G., PAGE 3, PARAGRAPH 2) SUCH AS "LESS THAN ONE ADDITIONAL DEATH PER MILLION..." ARE NOT DEFINITE. THIS SHOULD BE CHANGED TO "NOT TO EXCEED ONE...", SINCE LESS THAN ONE COULD MEAN 10(E-7) OR LOWER, AND IS OPEN AT ONE END. DOSE LIMITS BASED ON A RISK OF 10(E-6) PER YEAR ARE GENERALLY ACCEPTABLE BY MOST MEMBERS OF SOCIETY, AND COULD BE ACCEPTABLE TO DOE.

THE PRINCIPAL PROBLEM IS TO ESTABLISH THAT THE DOSE CORRESPONDING TO THIS RISK IS NOT EXCEEDED AT A SPECIFIC CONTAMINATED SITE. THE CONCEPT OF SCREENING LEVELS PROPOSED IN THE DOCUMENT IS VERY USEFUL AND SHOULD BE SUPPORTED AND ACCEPTED. THE SOIL SCREENING LEVEL IS 0.2 uCI/SQ. M FOR THE TOP ONE INCH OF SOIL FOR PARTICLES SMALLER THAN 2MM. PRESUMABLY IF THE TOTAL SURFACE ACTIVITY WERE LESS THAN 02. uCI/SQ. M PARTICLE SIZING WOULD NOT BE NECESSARY, BUT THIS SHOULD BE CONFIRMED. THE SCREENING LEVEL EQUATES TO ABOUT 4PCI/G OF SOIL. AN EVALUATION IF THIS LEVEL CAN BE MEASURED BY READILY AVAILABLE FIELD INSTRUMENTS SHOULD BE MADE. OTHERWISE, SAMPLING AND LABORATORY ANALYSIS MUST BE DONE. THE AIR PARTICULATE SCREENING LEVEL, 1 FCI/CU. M, WILL REQUIRE SAMPLING AND

ANALYSIS, BUT THIS IS TO BE EXPECTED FOR EVALUATING DOSE RATES FROM ALPHA EMITTERS AT THE PROPOSED LIMITS. THE AMBIENT LEVELS IN THE MIDWEST ARE 200-300 TIMES LESS THAN THE SCREENING LEVELS.

METHODS FOR ESTIMATING DOSE RATES BY THE PROCEDURES GIVEN IN THE DOCUMENT SHOULD BE CAREFULLY REVIEWED BEFORE THEY ARE AGREED TO AND ACCEPTED. THE DIRECT PROCEDURE CALLS FOR CONSIDERABLE INFORMATION OTHER THAN ENVIRONMENTAL TRANSURANIUM CONCENTRATIONS. THIS INCLUDES PARTICLE SIZE DISTRIBUTION, SOLUBILITY CLASS, AND RESUSPENSION FACTOR - DATA THAT IS QUITE DIFFICULT TO OBTAIN. IF IT IS TRUE, AS THE DOCUMENT STATES, THAT VERY FEW SITES WILL APPROACH THE SCREENING LEVELS, THESE REQUIREMENTS WILL IMPOSE LITTLE BURDEN ON DOE.

END/JJN/PM

United States Government Department of Energy

memorandum

DATE: January 12, 1984

REPLY TO ATTN OF: GC-30

SUBJECT: EPA Proposed Emission Standards for Radionuclides

TO: T. Garrish
A. Trivelpiece
J. Kane
E. Patterson
B. Siebert
W. Thiessen
T. Williams

Attached for your review and comment is a draft letter from Secretary Hodel to William Ruckelshaus recommending that EPA withdraw its proposed regulations for radionuclide emissions from DOE facilities.

Based upon EPA's criteria for its recent decision on regulating sources of benzene emissions under section 112 of the Clean Air Act, the regulation of radionuclide emissions from DOE facilities is not justified. Similar to the three sources of emissions of benzene for which EPA decided to withdraw its proposed regulations, the health risks (both the maximum lifetime individual risk and the annual increased incidence of cancer in the exposed population) from current radionuclide emissions from DOE facilities are exceedingly small and would not be appreciably reduced by the costly proposed regulations.

I would appreciate receiving your comments by close of business Monday, January 16, 1984.

for Stephen H. Greenleigh

Attachment:
As stated

Mr. William D. Ruckelshaus
Administrator
U.S. Environmental Protection Agency
Washington, D.C. 20460

Dear Mr. Ruckelshaus:

As you are aware, I have a strong personal interest in assuring that the activities of the Department of Energy (DOE) are conducted so as to protect the public health and safety and to minimize any adverse environmental impacts. I share your view that environmental standards must have a sound scientific base and offer the scientific expertise of this Department to assist the Environmental Protection Agency (EPA) in assuring the existence of such sound scientific bases for the regulation of energy facilities.

Your application of risk assessment and the concept of risk management to regulatory decisionmaking is particularly laudable. Of special interest was your recently announced risk assessment rationale for controlling sources of emissions of benzene under section 112 of the Clean Air Act. This approach outlined in the EPA Background Paper dated December 15, 1983 (BNA Environmental Reporter 1435, December 16, 1983) (hereinafter cited as EPA Background Paper) would limit federal regulation to sources that present a significant risk to the public health. This approach seems inherently reasonable and an appropriate management of limited ~~federal~~ national resources.

DRAFT

In this regard, I would like to call to your attention a proposed EPA rulemaking of interest to this Department (DOE) which on its face appears inconsistent with your announced policy. I am referring to EPA's proposed National Emission Standards for Radionuclides, in particular the proposed standards for radionuclide emissions from DOE facilities. 48 FR 15076 (April 6, 1983). 1/ As discussed below, the maximum lifetime individual risk and the annual increased incidence of cancer from current radionuclide emissions from DOE facilities are similar to the risk values for the three sources of benzene for which EPA has announced its intent to withdraw proposed regulations. It is, therefore, recommended that the proposed rulemaking for radionuclide emissions be reviewed under the criteria announced for the benzene decision. I am confident that based upon this review, EPA will decide to withdraw the proposed indirect emission standards for DOE facilities.

1/ DOE provided written comments on the proposed rulemaking in a letter dated July 14, 1983 to Charles L. Elkins. In addition, DOE provided oral comments at the public hearing held in Washington, D.C. on April 28, 1983.

Using the linear dose response model 2/ and EPA's own estimates of exposures, 3/ the lifetime risk to the maximally exposed individual from current radionuclide emissions from DOE facilities is less than 2 in 10,000. 48 FR 15080 (April 6, 1983). For comparison, the maximum lifetime individual risks from exposure to benzene from the two sources proposed to be regulated by EPA currently are estimated to be 15 in 10,000 and 83 in 10,000; the maximum individual risks from the benzene sources which EPA proposes not to regulate are 1.4 in 10,000 (ethylbenzene and styrene plants), .76 in 10,000 (maleic anhydride plants), and .36 in 10,000 (benzene storage

2/ While appreciating the need for conservatism in rulemaking, DOE questions EPA's reliance on the linear dose response estimates for radionuclides recommended by the Committee on Biological Effects of Ionizing Radiation (BEIR) 1972 rather than utilizing the more current dose response estimates of BEIR 1980. The BEIR 1980 report, prepared by a group of experts in the National Academy of Sciences, is the most recent compilation of data on the biological effects of ionizing radiation and yet is not even cited in the Preamble to proposed 40 CFR Part 61. See Testimony of Warren K. Sinclair, President, National Council on Radiation Protection and Measurements at EPA hearings on proposed 40 CFR Part 61, April 29, 1983. If this more current scientifically accepted dose response data were used, the risk figures for radionuclide emissions from DOE facilities would be even lower.

3/ A recalculation of the maximum individual lifetime risk by the Oak Ridge National Laboratory (ORNL) using EPA prescribed models determined that the EPA estimate of 2 in 10,000 is too high and that the maximum lifetime risk from DOE facilities is approximately .3 in 10,000. This risk estimate is equivalent to the extremely low maximum lifetime individual risk estimated for benzene storage vessels (i.e., the lowest maximum lifetime individual risk from those benzene sources that EPA has decided not to regulate) and substantially less than the maximum lifetime individual risk from those benzene sources EPA proposes to regulate.

vessels). EPA Background Paper, supra. The maximum lifetime individual risk after imposition of the regulations proposed by EPA for benzene fugitive sources and coke by-product recovery plants are estimated to be 4.5 in 10,000 and 3.5 in 10,000, respectively. Id. The maximum individual lifetime risks from these sources after regulation are estimated to be higher than even EPA's estimate of maximum lifetime risks from emissions of radionuclides from DOE facilities. 4/

Further, the maximum lifetime individual risk from current radionuclide emissions from DOE facilities is well below the maximum lifetime individual risks estimated for the three sources of inorganic arsenic that EPA has proposed to regulate under section 112. 48 FR 33112 (July 20, 1983). For these three sources of inorganic arsenic, the maximum individual lifetime risks are estimated to range between 43 and 690 in 10,000 for low-arsenic copper smelters, between 230 and 3,500 in 10,000 for high-arsenic copper smelters, and between 6.4 and 100 in 10,000 for glass manufacturing plants. Id. Even after imposition of the proposed EPA regulations for these sources of inorganic arsenic emissions, the maximum lifetime individual risks from two of these source categories (i.e., between 9.4 and 150 in 10,000 for low-arsenic copper smelters

4/ The risks from these benzene sources after regulation would be 15 to 20 times higher than the ORNL risk estimates for unregulated DOE facilities.

and between 58 and 920 in 10,000 for high-arsenic copper smelters) would remain considerably above the EPA estimated maximum individual lifetime risk of less than 2 in 10,000 from current radionuclide emissions from DOE facilities. See id. Further, the maximum individual lifetime risk from current emissions at DOE facilities are roughly equivalent to those estimated for four sources of inorganic arsenic that EPA determined should not be regulated (i.e., zinc oxide plants, between 1.7 and 28 in 10,000; arsenic chemical manufacturing, between 0.4 and 6.4 in 10,000; cotton gins, between 0.17 and 2.8; and secondary lead smelters, between 2.0 and 3.2 in 10,000). See id.

The other measure of risk that EPA considers important for sensible risk management is "total population impact". EPA Background Paper, supra. This risk estimate which takes account of all persons exposed provides a measure of the "overall impact on public health" and is expressed in terms of the annual number of cancer fatalities. See id. The annual increased total population impact from current radionuclide emissions from DOE facilities is estimated by EPA to be about 1 cancer death in 15 years or 0.07 per year. 48 FR 15080 (April 6, 1983). This is considerably less than the annual population impact from benzene emissions from the two benzene sources proposed to be regulated even after the imposition of the proposed regulations (i.e., 0.14 for fugitive benzene and .23 for coke by-product recovery plants). EPA Background Paper, supra. This annual population

incidence from DOE facilities is also less than the annual population impact from inorganic arsenic emissions from secondary lead smelters (i.e., between .20 and 3.3) which EPA has decided not to regulate. See 48 FR 33112 (July 20, 1983). It is also less than or approximately equivalent to the annual population impact after imposition of proposed EPA regulations for low-arsenic copper smelters (i.e., between 0.21 and 3.4) and glass manufacturing plants (i.e., between 0.01 and 0.21). See id.

Also indicative of the low risk associated with current emissions from DOE facilities is the fact that radionuclide emissions from the two DOE facilities with the highest emissions and which are the only two DOE facilities which currently violate the EPA proposed standard (i.e., a dose equivalent rate of 10 mrem/year to whole body, 30 mrem/year to any organ) produce an increased radiation dose to the surrounding populations of only 0.08 percent above natural background radiation. 5/ Using the BEIR 1980 cancer death risk numbers, 6/ the additional risk to the average individual

5/ Releases from all DOE facilities result in a total offsite whole body dose equivalent to residents within 50 miles of those facilities of approximately 400 person-rem per year. See EPA Draft Background Information Document, PROPOSED STANDARDS FOR RADIONUCLIDES (March 1983) (hereinafter cited as EPA Draft Background Information Document). One half of this 400 person-rem per year results from emissions from the Feed Materials Production Center (FMPC) at Fernald, Ohio (approximately 132 person-rem) and the Oak Ridge Reservation (approximately 70 person-rem). See EPA Draft Background Information Document, supra. The 3.2 million people residing within 50 miles of these two facilities receive a dose equivalent from natural background of 262,000 person-rem per year. See id.; NCRP Report No. 45, NATURAL BACKGROUND RADIATION IN THE UNITED STATES (November 15, 1975). Background radiation exposures in the United States vary from about 60 mrem/year to 125 mrem/year excluding radon. See NCRP Report No. 45, supra.

6/ See footnote 2.

in the populations surrounding these two DOE facilities from exposure to radionuclide emissions is calculated to be ~~only~~ approximately 4 tenthousandths of one percent of the risk of cancer mortality from other causes.

Based on these extremely low risk figures, it is clear that radionuclide emissions from DOE facilities do not cause significant public health risks and, therefore, should not be regulated by EPA under section 112 of the Clean Air Act.

Moreover, the already low risks from radionuclide emissions from DOE facilities would not be appreciably reduced by the EPA proposed regulations. Under the proposed EPA standard, EPA has estimated that the maximum lifetime individual risk from radionuclide emissions from DOE facilities would be reduced from 2 in 10,000 to 2 in 50,000 or 0.4 in 10,000. 46 FR 15081 (April 6, 1983). Although the annual population impact under the proposed EPA standard for DOE facilities has not been calculated by EPA, it can roughly be estimated that the current annual population impact of .07 would be reduced by approximately ~~50~~ 75 percent so that the resulting annual population impact after imposition of the proposed EPA standard would be approximately ~~.035~~ .05. Thus, imposition of the proposed EPA standards for DOE facilities might optimistically result in the reduction of 1 cancer death every ~~30~~ 40 years. This reduction in the incidence of cancer is precisely the same as that which would have been achieved

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under the proposed regulations for the three benzene source categories that EPA recently determined should be withdrawn, in part because the risks from these sources would not be appreciably reduced by the proposed regulations. See EPA Background Paper, supra.

Finally, the proposed EPA regulations are clearly not cost effective. EPA has estimated the capital costs of compliance with the proposed standard for DOE facilities to be approximately $25 million. 48 FR 15081 (April 6, 1983). 7/ Assuming the control technology installed for this $25 million would be effective for 30 years, the most optimistic benefit from the capital outlay of $25 million would be saving 1 life in 30 years. See EPA Draft Background Information Document, supra. The costs estimated for compliance with the proposed regulations for DOE facilities are roughly equivalent to those required by proposed standards for benzene emissions from coke by-product recovery plants, but the capital outlay of $30.9 million for compliance with the proposed benzene emission standards would result in saving 2.37 lives per year as opposed to 1 in 30 years. See EPA Background Paper, supra. Further, the estimate of $25 million in capital costs is considerably greater than the $16.4 million in capital outlay estimated to have been required to comply with the proposed benzene emission standards that EPA has announced its intent to withdrawn. See id. With respect to emissions of benzene, EPA determined that an expenditure of $16.4

7/ Although EPA has not estimated the annual operating costs and DOE has no hard estimates, such costs no doubt would substantially increase the total costs of compliance.

million was not justified to save 1 life in 30 years. Id. If the expenditure of $16.4 million is not warranted to save 1 life in 30 years, then clearly the expenditure of $25 million would be even less justified.

Based on the above discussion, it is apparent that regulation of DOE facilities as a source category of radionuclide emissions is not warranted since the health risks from emissions from such facilities currently are exceedingly small and would not be appreciably reduced by the costly proposed regulations. The risks from radionuclide emissions from DOE facilities to the most exposed individual and to the population as a whole are considerably lower than for the two benzene source categories EPA proposes to regulate and roughly similar to the risks from the three benzene source categories that EPA has determined not to regulate. Consequently, it is this Department's position that EPA should withdraw the proposed emission standards for radionuclide emissions from DOE facilities in accordance with its announced prudent risk management policy under section 112 of the Clean Air Act.

Sincerely,

DONALD PAUL HODEL

RECOMMENDED APPLICATIONS
- RETROSPECTIVE -

WORKER

- **1st OPTION:**
  - **STAY WITH ORGAN BURDEN CONCEPT**

- **2nd OPTION:**
  - **ANNUAL EFFECTIVE DOSE EQUIVALENTS**

GENERAL POPULATION

- **COMMITED EFFECTIVE DOSE EQUIVALENT OVER 70 YEAR PERIOD**

DOE RECOM ARE AS FOLLOWS

APPLICATION - WORKERS

- PROSPECTIVE:
  - RECOMMENDATIONS INVOLVE LITTLE TO NO CHANGE. ALI's ARE ESSENTIALLY THE SAME AS MPC's

- RETROSPECTIVE:
  - SIGNIFICANT CHANGE INVOLVED [PREVIOUSLY BASED ON PERMISSIBLE ORGAN DOSE OR ORGAN BURDENS. ICRP 26 WOULD CHANGE TO 50-yr COMMITTED DOSE CONCEPT]

RECORDS WOULD BE COMPLICATED

WOULD REQUIRE INCREASED RECORDS TO SATISFY VARIOUS NEEDS:

- ACTUAL DOSE EQUIVALENT
- COMMITTED EFFECTIVE DOSE EQUIVALENT
- ORGAN BURDENS
- ORGAN DOSES

DIFFICULT TO EXPLAIN

- TO WORKERS
- TO PUBLIC
- TO MEDIA

WORKER PROTECTION

MODES OF INTAKE FOR WELL RETAINED NUCLIDES

FACILITY	% INHALATION	% OTHER
A	76	24
B	40	60
C	53	47

OFTEN DEPOS DETECTED W/O AIR S.

WORKER PROTECTION

DEPOSITIONS DETERMINED BY BIOASSAY WITHOUT ASSOCIATED TRIGGERS (AIR SAMPLES)

AB 1/3 WO NO DET AI SAM

FOR FACILITY A

CURRENT EMPLOYEES	33 PERCENT
ALL TIME EMPLOYEES	36 PERCENT

MANAGEMENT OF WORKER EXPOSURE

EXAMPLE: AN UPTAKE OR 20 μCi Pu

CURRENT PRACTICE:

- **ANNUAL DOSE EQUIVALENT TO BONE OF 15 rem (50% OF LIMIT)**
- **EXPOSURE WILL CONTINUE FOR SEVERAL YEARS**
- **FUTURE EXPOSURE (BOTH EXT AND INT) MUST BE RESTRICTED THEREAFTER**

PROPOSED BY ICRP:

- **1ST YEAR COMMITTED (50-yr) DOSE OF 150 rem**
- **EXPOSURE ALL ASSIGNED TO YEAR OF INTAKE**
- **NO ADDITIONAL RESTRICTIONS THEREAFTER EVEN THOUGH WORKER WOULD BE RECEIVING 15 rem/yr TO BONE**

STATE-OF-THE-ART (PLUTONIUM)

INVIVO: ~ 30 ηCi

URINE: 0.01 TO 0.1

FECES: 0.02 TO 0.5

L-4M1-61

PLUTONIUM

OLD: ORGAN DOSE CONCEPT
40 ηCi UPTAKE → 30 rem/yr

NEW: DOSE EQUIV. CONCEPT

STOCHASTIC
0.63 ηCi → 5 rem (W_T 50)

NON-STOCHASTIC
0.65 ηCi → 50 rem

WORKER PROTECTION

- **INTERNAL DOSE ASSESSMENT**

  SURFACE MEASURES
  NASAL MEASURES
  AIR SAMPLES

  → INTAKE
  → STANDARD MODEL → INTAKE → DOSE ASSESSMENT

  INVIVO MEASURES
  INVITRO MEASURES
  INDIVIDUAL METABOLIC FACTORS
  MATERIAL CHARACTERISTICS

  → DEPOSITION → DOSE ASSESSMENT

- **EXTERNAL DOSE ASSESSMENT**

  DOSE METERS
  AREA SURVEYS

  → DOSE ASSESSMENT

50 YEAR COMMITTED EFFECTIVE DOSE EQUIVALENT

ISSUES:

- EXTRAPOLATION OF 50 YEAR DOSE TO 1st YEAR- AFFORDS NO GREATER PROTECTION (PERHAPS EVEN LESS PROTECTION)
- MEASUREMENT SYSTEMS ARE INADEQUATE
  - ENVIRONMENTAL AIR MONITORING
  - IN VIVO ASSESSMENT
  - BIOASSAY
- LOW EXPOSURES BECOME TECHNICAL OVER EXPOSURES
- MANAGEMENT OF SUBSEQUENT YEARS EXPOSURE MORE COMPLICATED

MAIN PROBLEM

DOSE EQUIVILANT (50 YEAR DOSE COMMITMENT) CONCEPT IS NOT PRACTICAL FOR LONG-LIVED, WELL-RETAINED RADIONUCLIDES SUCH AS PLUTONIUM

RETROSPECTIVE APPLICATION - WORKERS PROBLEMS

- COMMITTED EFFECTIVE DOSE EQUIVILANT
- SIGNIFICANTLY REDUCED LIMITS
- REDUCED WORKER PROTECTION
- DOSE ASSESSMENTS NOT REALISTIC
- DIFFICULTY IN EXPLAINING CONCEPT
- COMPLICATED RECORD KEEPING
- INCREASED COSTS W/O INCREASED BENEFITS

APPLICATION - WORKERS

- PROSPECTIVE:
  - RECOMMENDATIONS INVOLVE LITTLE TO NO CHANGE. ALI's ARE ESSENTIALLY THE SAME AS MPC's

- RETROSPECTIVE:
  - SIGNIFICANT CHANGE INVOLVED PREVIOUSLY BASED ON PERMISSIBLE ORGAN DOSE OR ORGAN BURDENS. ICRP 26 WOULD CHANGE TO 50-yr COMMITTED DOSE CONCEPT

APPLICATION

- WORKERS
- GENERAL POPULATION

PROSPECTIVE VS RETROSPECTIVE

- PROSPECTIVE:
  - USED FOR PLANNING PURPOSES, DESIGN OF NEW FACILITIES, AND CONTROL OF THE WORK ENVIRONMENT. (ALI VS MPC)

- RETROSPECTIVE:
  - USED FOR ASSESSMENT OF DOSE ACTUALLY RECEIVED BY WORKERS. (ORGAN DOSE VS DOSE COMMITMENT)

EFF DOSE EQ = ABS DOSE X EFF WT. FACTOR = DOSE EQ

WEIGHTING FACTORS

	ICRP
GONADS	0.25
BREAST	0.15
RED BONE M.	0.12
LUNG	0.12
THYROID	0.03
BONE SURF.	0.03
REMAINDER	0.30

STOCHASTIC

- HEREDITY:
  - THE PROBABILITY OF AN EFFECT OCCURRING RATHER THAN ITS SEVERITY - A FUNCTION OF DOSE WITHOUT THRESHOLD

NON-STOCHASTIC

- SOMATIC:
  - THE SEVERITY OF THE EFFECT VARIES WITH THE DOSE. MUST EXCEED A THRESHOLD

COMMITTED DOSE EQUIV.

H_{50}

THE DOSE EQUIVILANT THAT WILL BE ACCUMULATED OVER PERIOD OF 50 YEARS FOLLOWING THE INTAKE

BASIC DOSE LIMITATION SYSTEM

- JUSTIFICATION
- OPTIMIZATION
- DOSE EQUIVALENT LIMITS

ICRP PUBLICATIONS

- REPORT 26:
  - RECOMMENDATIONS OF ICRP ON RADIATION PROTECTION (1977)

- REPORT 30:
  - LIMITS ON INTAKES OF RADIO-NUCLIDES BY WORKERS

TRANSURANIUM ELEMENTS AROUND THE ROCKY FLATS PLANT

C. T. Illsley

January 1984

TRANSURANIUM ELEMENTS AROUND THE ROCKY FLATS PLANT

From the beginning of operations of the Rocky Flats Plant, organic liquids contaminated with radioactive materials, were generated in various manufacturing processes. It was initially assumed that this material could be either burned or packaged in some manner and shipped offsite for disposal as low level waste. Since no method of disposal was available research was initiated to develop a procedure to process these materials.

In the meantime, with the stockpile of contaminated oil increasing rapidly, an area on the Plant Site was designated in July 1958 as a temporary storage area for the uranium and plutonium contaminated oil drums. During subsequent years, drums were continually added which contained mostly plutonium contaminated machine oils.

The first drum leakage was discovered in July 1959 and a rust inhibitor, ethanolamine was added to the drums to minimize corrosion. The first evidence of deterioration of drums was discovered in 1964 and soil contamination was becoming a problem.

The recovery process to treat the contaminated oils, became operational in January 1967 and removal of the drums from the storage area began. At this time the field contained 5240 drums, of which approximately 3570 contained plutonium oil. The oldest drums and those containing plutonium were processed first. The last of the plutonium-contaminated oil was removed in January 1968 and final shipment of uranium-contaminated oil was moved to the disposal plant in June 1968.

An estimate of leakage, based upon a material balance from recovered materials and soil samples, indicated that 5000 gallons of oil containing about 86 grams (5 curies) of plutonium leaked from the drums into the soil. This was about 3% of the plutonium-contaminated oil. Radiation monitoring and mapping of the area in July 1968 showed levels of 2×10^5 to over 3×10^7 d/m/g alpha radioactivity. An asphalt containment cover was constructed

to prevent spread of the plutonium bearing soil and four water sample wells for confirmation that no downward migration was occuring were completed in November 1969.

After a fire on May 11, 1969 at Rocky Flats, studies were conducted by the Colorado Committee on Environmental Information (CCEI) and by the Health and Safety Laboratory (HASL) of the USAEC, concerning the possible release of plutonium from the fire. These investigations detected measurable quantities of plutonium in the soil around the Rocky Flats Plant. Concentrations of plutonium in soil at Rocky Flats have also been estimated by the Colorado Department of Health (CDH), Rockwell International, Jefferson County Health Department, and private housing developers. In general, measurements made by the different groups have shown similar (but not identical) results for surface plutonium levels.

The HASL data indicate that releases from past operations have amounted to about 11 curies of plutonium, approximately 99% of which was leakage from drums in the storage area. The epicenter of the isopleth map shows that the contamination can not be attributed to the May 1969 fire but is due to resuspension and redistribution of contaminated soil from the oil drum storage area.

During the removal of the corroded drums and the subsequent covering operations, some radioactive material was resuspended and distributed by wind action to the east of the storage area. The HASL estimate of the total amount of plutonium dispersed by the oil leaks (11 Ci) is higher than the estimate of the total amount of plutonium available to be dispersed. The potential amount was estimated by Rocky Flats on the basis that the 5000 gallons of oil that leaked from the drums contained 86 grams (5.3 Ci) of plutonium. To reduce conflicting estimates, the HASL data is considered to be the most accurate.

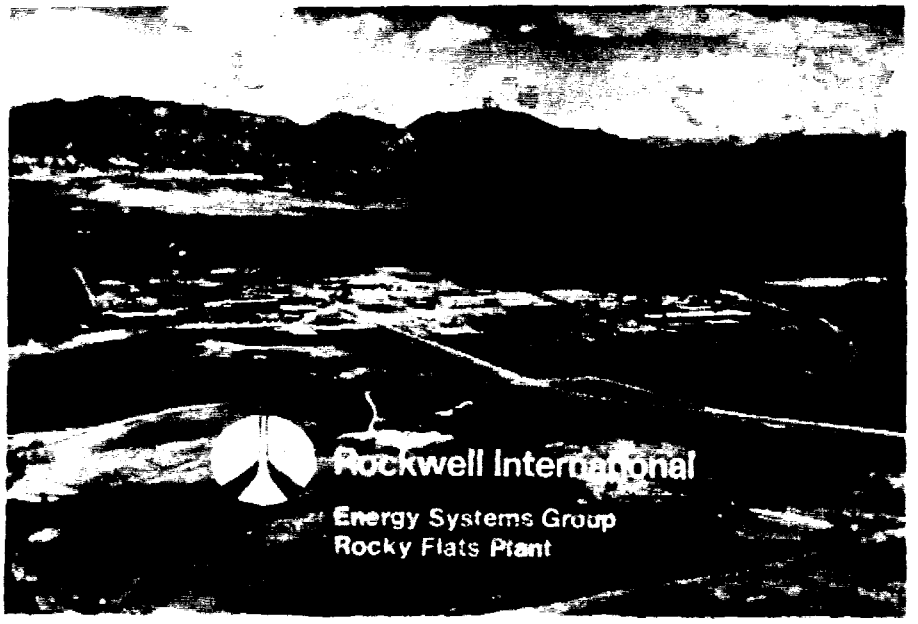
The HASL data suggest that of the 11 Ci released, 8.6 Ci are on site. Of the amount off site, the HASL data indicate that about 1.5 Ci are included in the area above 0.003 mCi/m2 (3mCi/km^2) which extends to about 5 miles

from the Plant boundary. About 1.9 Ci are spread at distances far from the Plant at levels equal to or below fallout of 0.0015 mCi/m^2 (1.5 mCi/km^2). Of the total 8.6 Ci included on-site, the HASL data indicate that about 1.7 Ci are included in the area that was covered with asphalt.

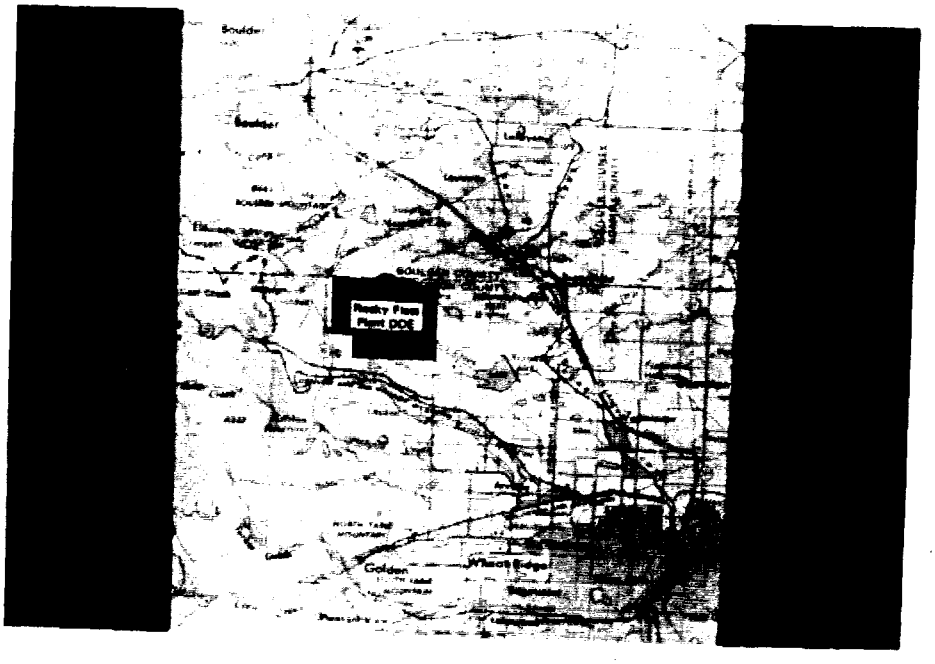
Analyses for plutonium and americium in 175 soil samples collected on private and municipal lands around the Rocky Flats Plant have not revealed concentrations greater than the EPA Proposed Screening Level. Evaluation of analyses of 27 soil samples, collected for purposes of certain land litigation indicates that soil on private land east of the Plant contains levels less than 50% of the screening level. One sample from 14 collected on City of Broomfield land west of Great Western Reservoir contains 118 mCi/km^2 plutonium, which is 59% of the screening level, but adjacent samples indicate less than 50 mCi/km^2.

The HASL data indicate plutonium levels in the range between 50 and 500 mCi/km^2 for the soil in the area near the Plant's eastern boundary. Access to this area is not open to the general public and is controlled by a barbed wire fence and locked gates. Analyses of soil samples by Rockwell at 7 sites in this area confirm the HASL measurements which indicate the presence of plutonium greater than the EPA screening level. The plutonium concentrations in the soil from one 10 acre site are in the range from 80 to 252 mCi/km^2 with a median of 108 mCi/km^2. The median values for the other sites fall within the range from 3 to 34 mCi/km^2.

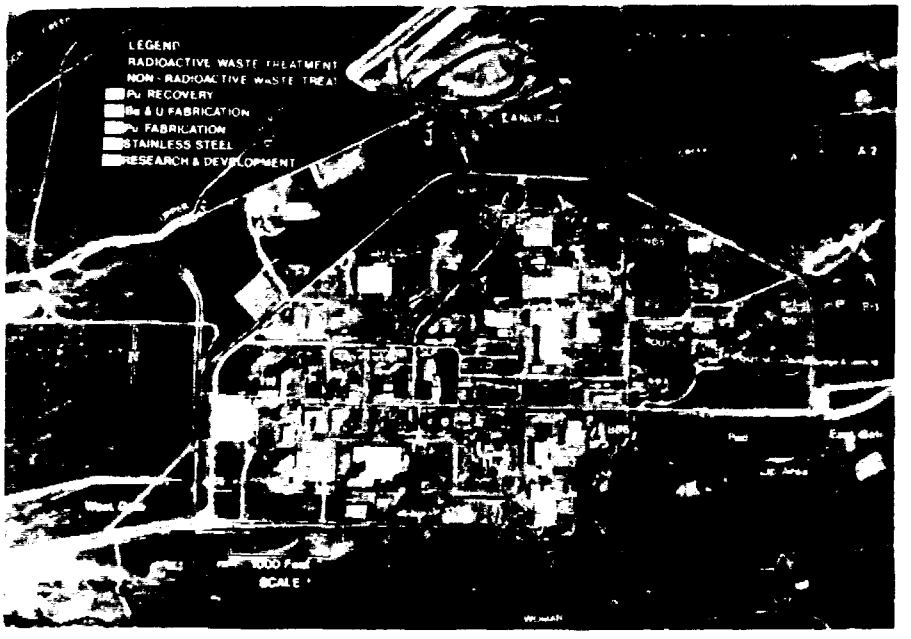
On the basis of the EPA Guidance Technical Assessment, the above-mentioned evaluation of additional soil data and airborne plutonium concentration data, there will be no impact on current operations at Rocky Flats if the Proposed Guidance is finalized. There is no need (based on EPA criteria) for decontamination of onsite lands other than those actions currently planned for other reasons. If the EPA guidance were ever to apply to onsite property then the cost could be substantial if removal were required.



Aerial View of the Rocky Flats Plant



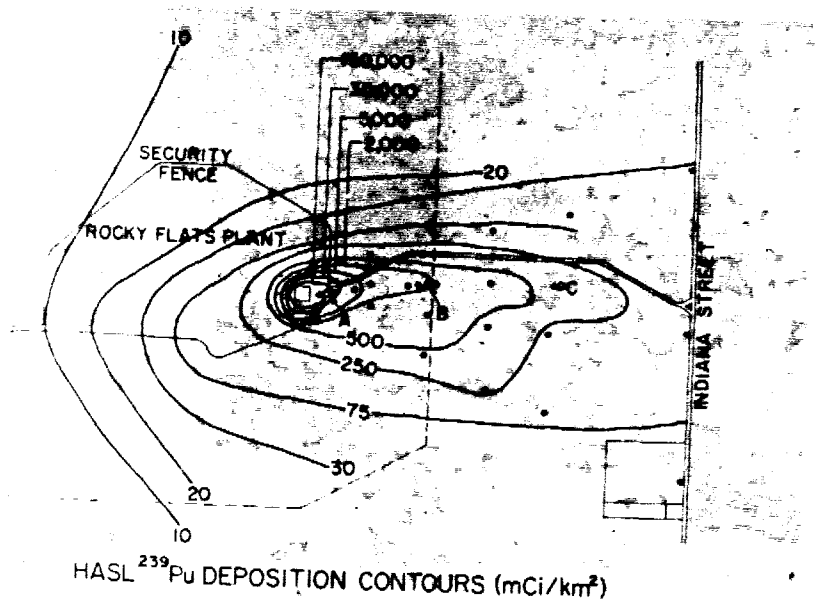
Map Showing Location of the Rocky Flats Plant



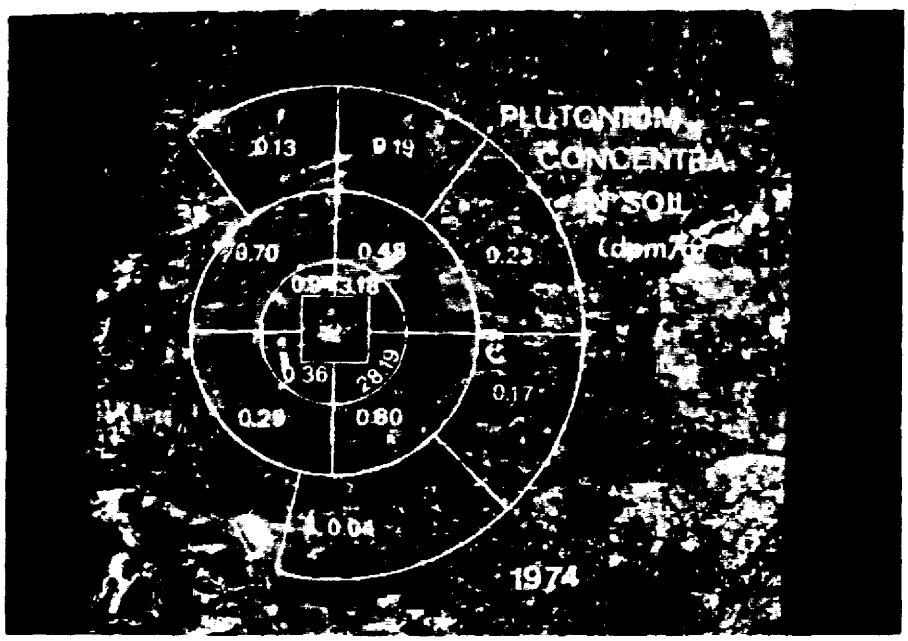
Aerial Photo Showing Major Facilities at Rocky Flats

Drum Storage Area at Rocky Flats in 1967

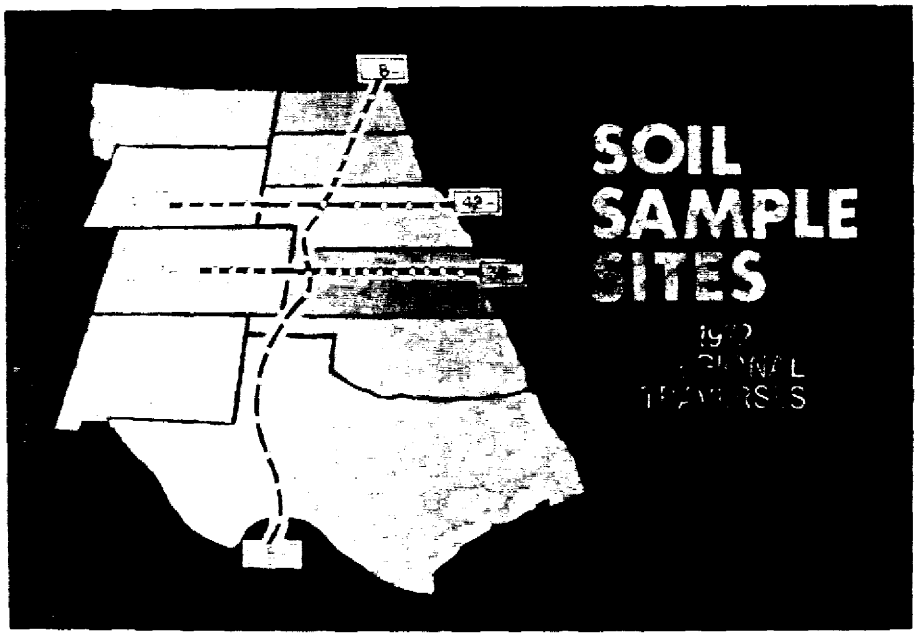
Asphalt Pad Over Abandoned Storage Area in 1970



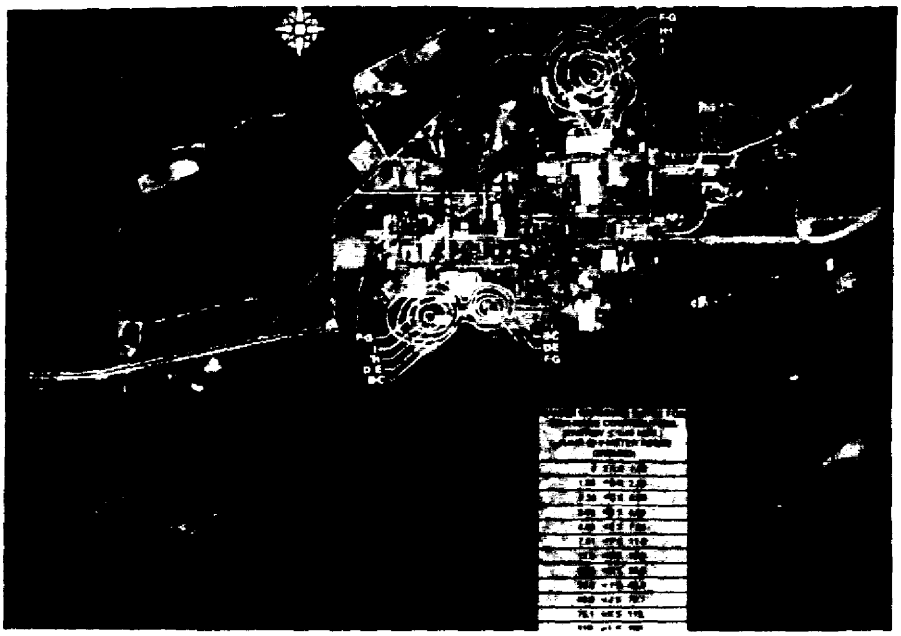
HASL Map Showing Plutonium Deposition Contours



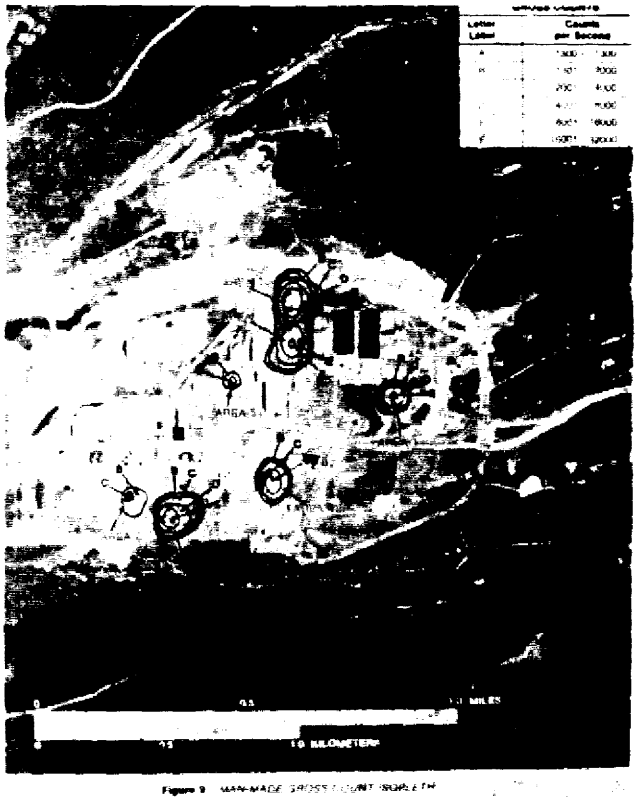
Colorado Department of Health Plutonium Sectors Map



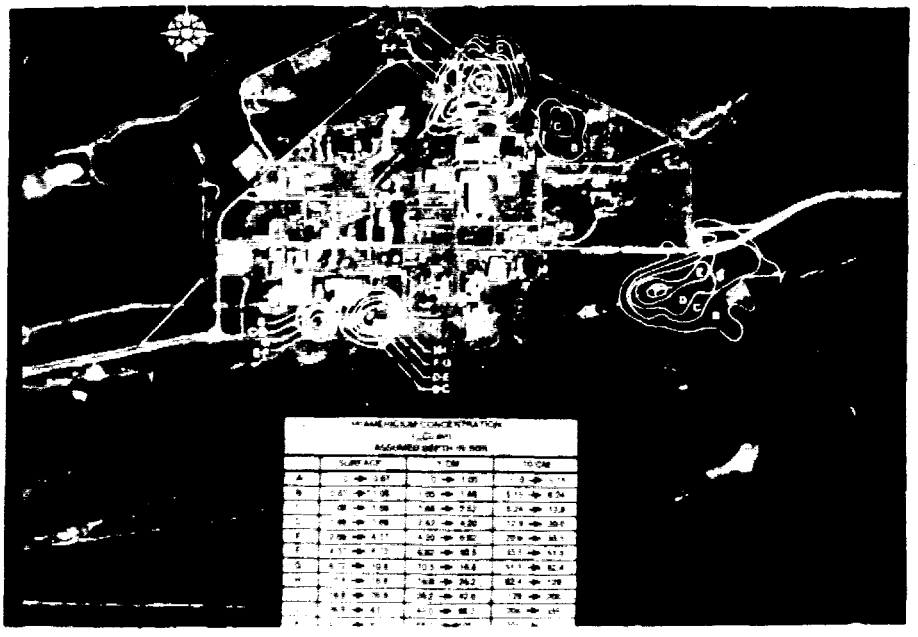
Soil Sample Sites of Regional Traverses



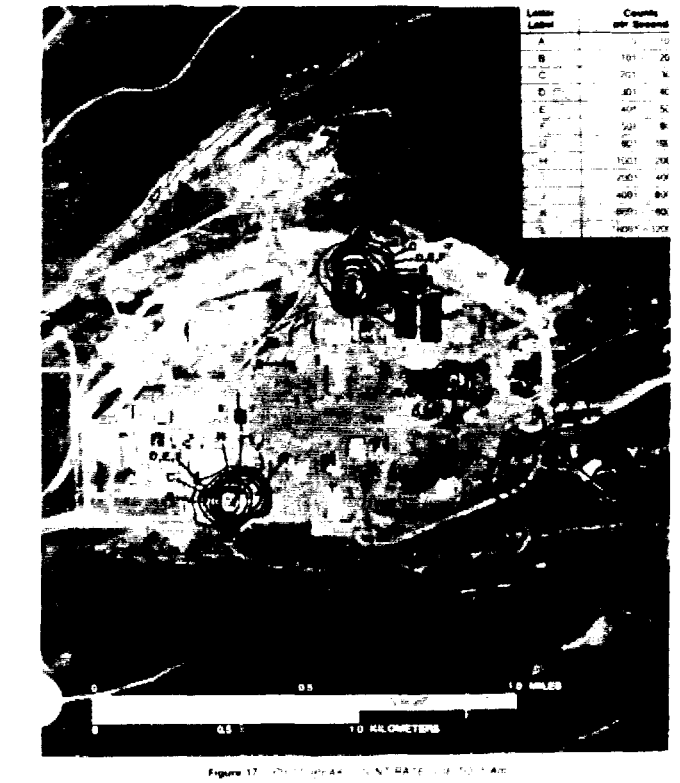
EG&G Aerial Radiometric Survey of Total Gamma in 1973



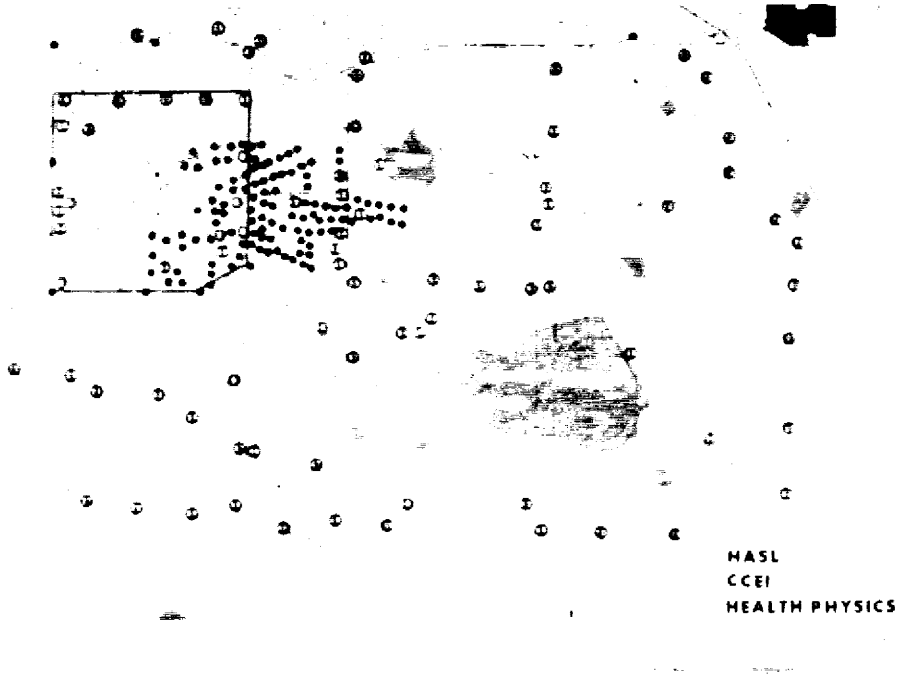
EG&G Aerial Radiometric Survey of Total Gamma in 1981



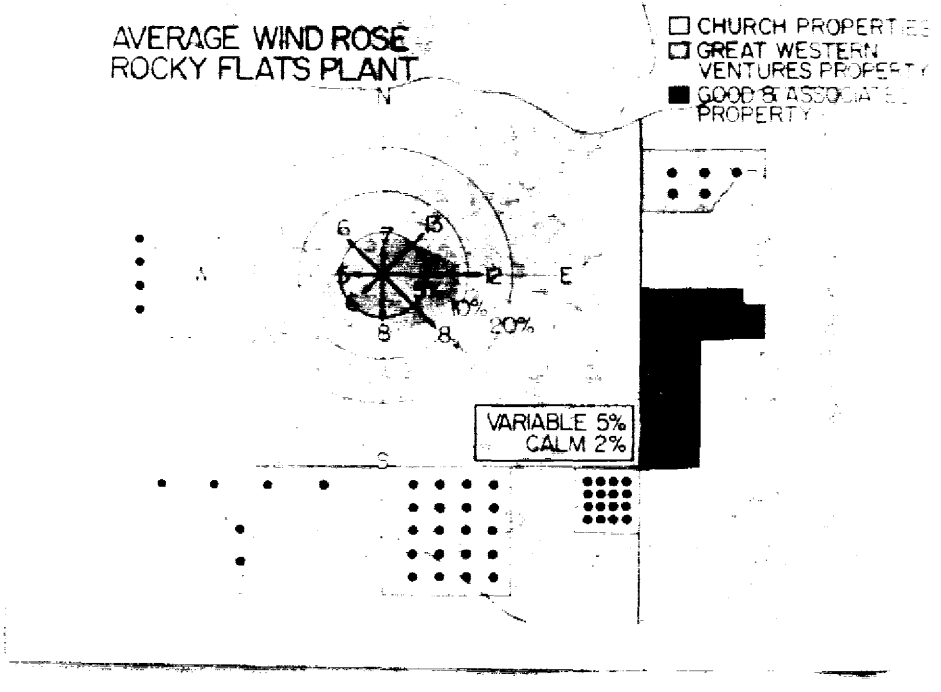
EG&G Aerial Radiometric Survey of ^{24}/Am Activity in 1973



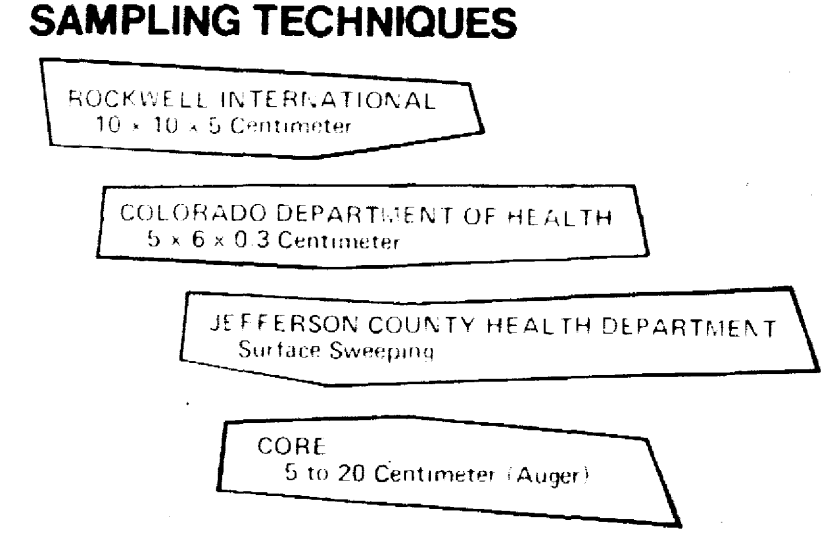
EG&G Aerial Radiometric Survey of ^{24}/Am Activity in 1981



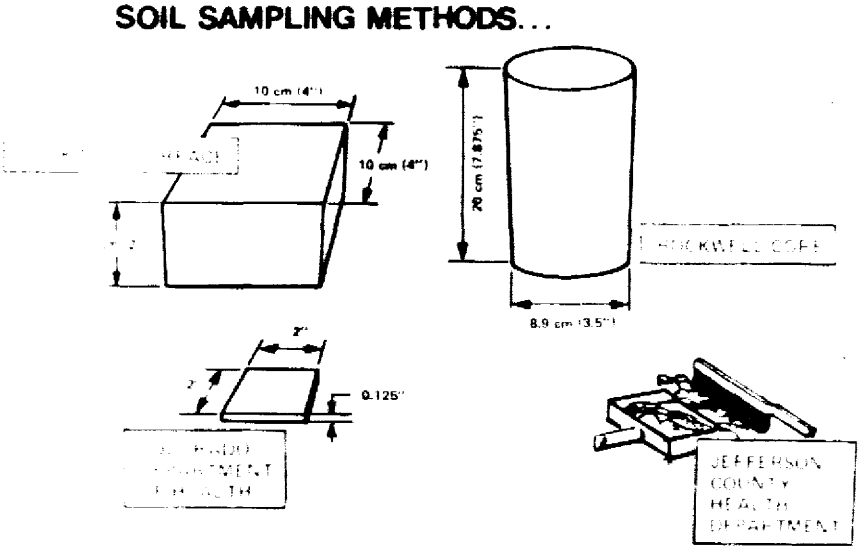
Composite Map Showing Locations of Several Soil Sample Surveys



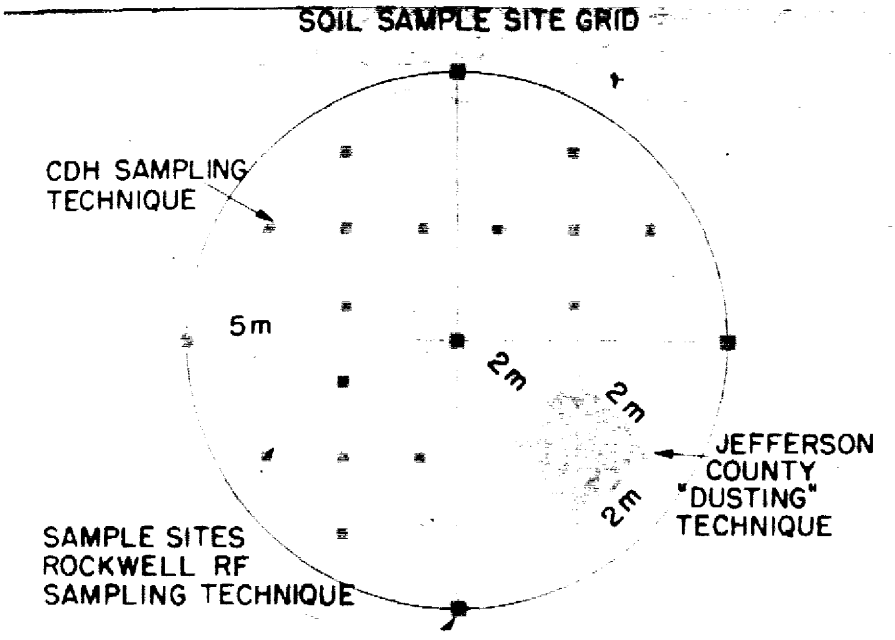
Average Wind Rose at the Rocky Flats Plant Site



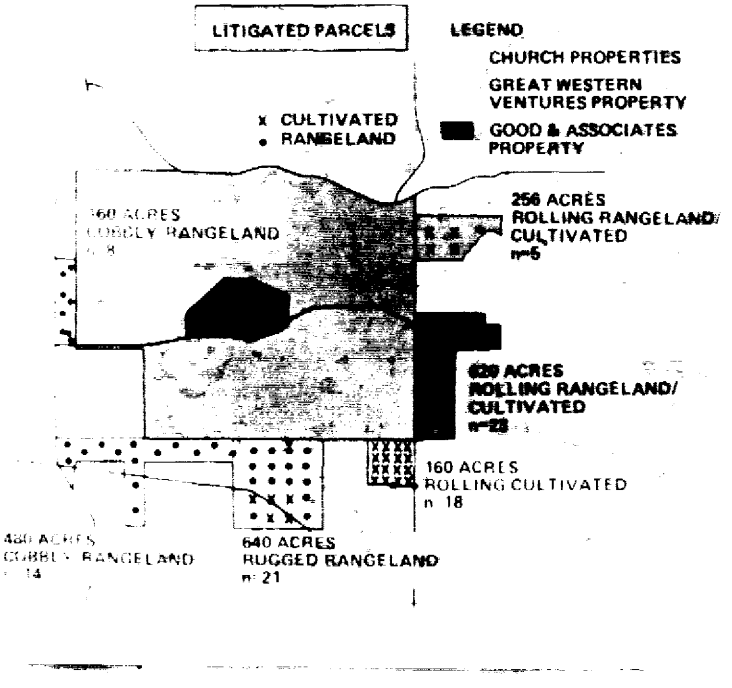
Soil Sampling Techniques Used for Litigation Samples



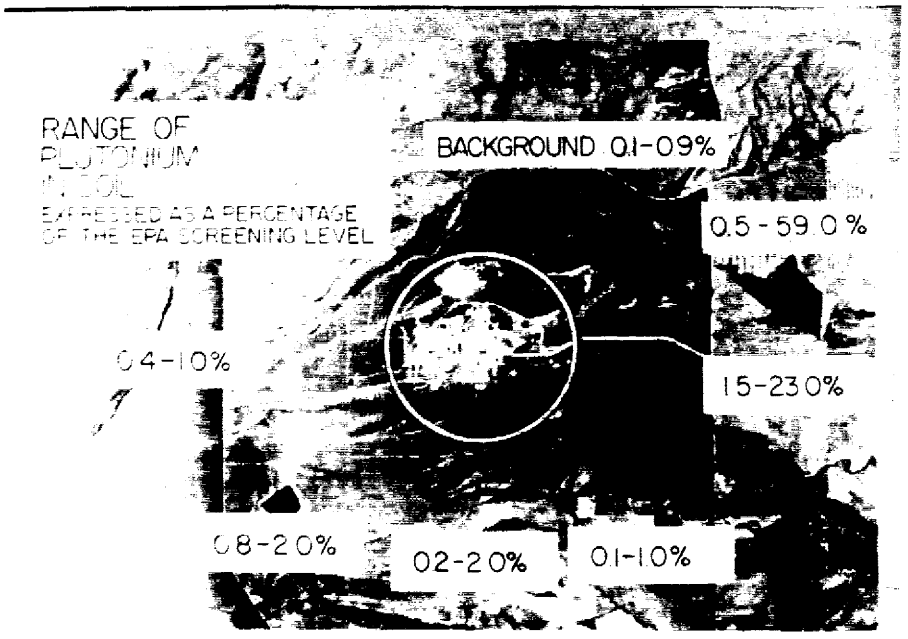
Soil Sampling Methods Used for Litigation Samples



Soil Sample Site Grid Used at Each Litigation Location



Map Showing Types of Land Involved in Litigation



Map Summary of Plutonium Concentrations Around Rocky Flats

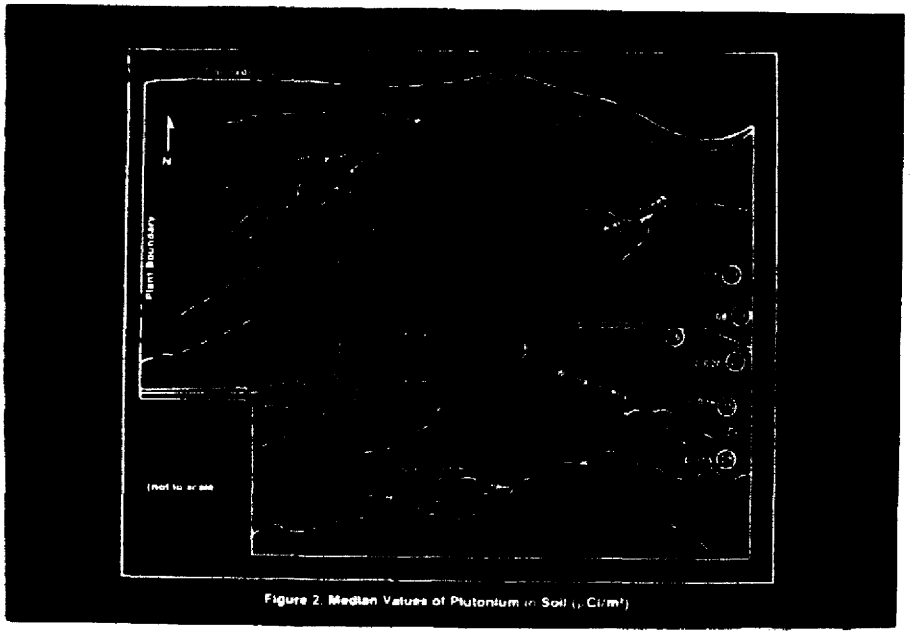
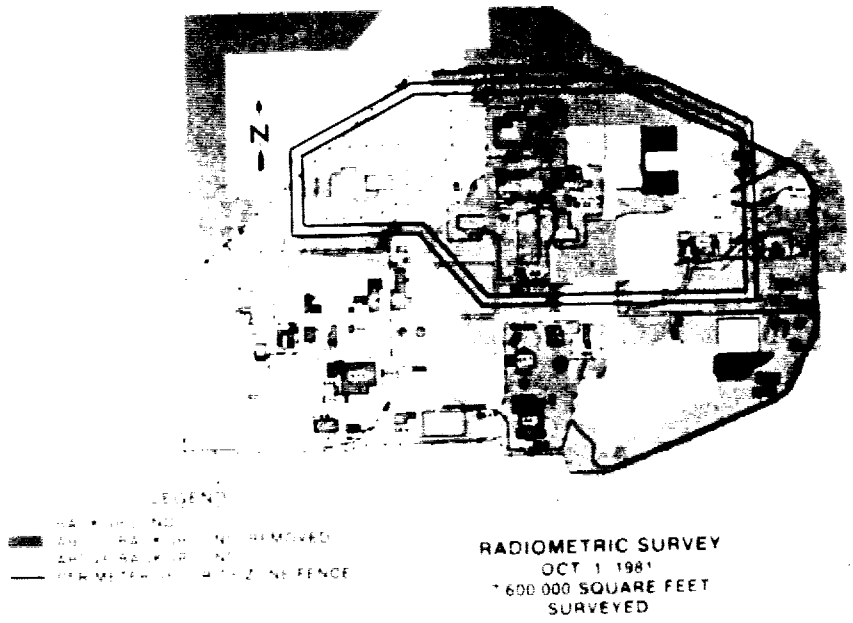
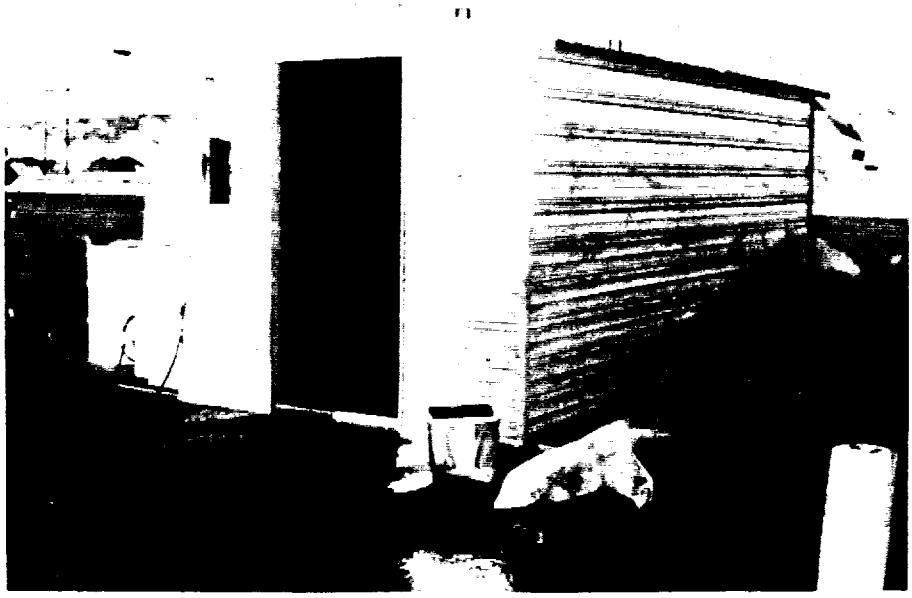


Figure 2. Median Values of Plutonium in Soil (pCi/m²)

Map Showing Plutonium Concentrations Inside Eastern Boundary

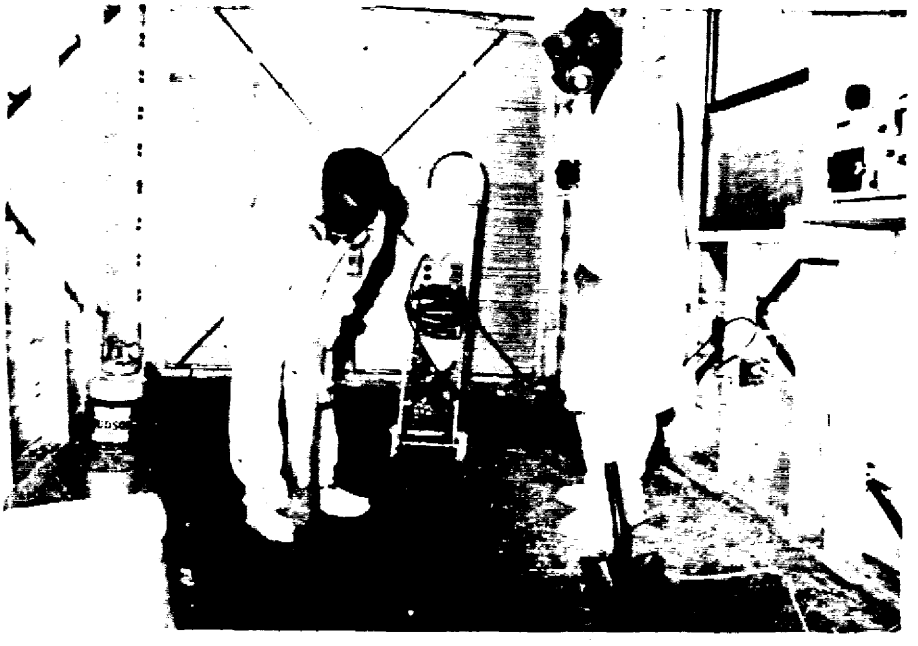


Radiometric Survey of Rocky Flats Plant Site



Portable Building Used In Contaminated Soil Removal

Health Physics Technician Monitoring Bag of Contaminated Soil



Decontamination Workers Manually Removing Soil

ROCKY FLATS SOIL CONTAMINATION

HISTORICAL SEQUENCE

JULY 1958

DRUM STORAGE AREA ESTABLISHED, DRUMS CONTAINING PLUTONIUM CONTAMINATED OILS WERE ADDED DURING SUBSEQUENT YEARS

1959

FIRST DRUM LEAKAGE DISCOVERED AND RUST INHIBITOR, ETHANOLAMINE, WAS ADDED TO DRUMS PRIOR TO STORAGE TO MINIMIZE CORROSION

JANUARY 1964

FIRST EVIDENCE OF LAYER SCALE DETERIORATION OF DRUMS WAS REPORTED. SOIL CONTAMINATION WAS REPORTED TO BE INCREASING.

JANUARY 1967

LAST DRUMS WERE ADDED TO STORAGE AREA AND REMOVAL TO PROCESS AREA BEGAN. OLDEST DRUMS WERE SHIPPED FIRST.

JUNE 1968

LAST DRUMS WERE SHIPPED FOR PROCESSING. HIGH WINDS SPREAD SOME CONTAMINATION.

JULY 1968

RADIATION MONITORING AND MAPPING OF AREA WAS COMPLETED. LEVELS FROM 2×10^5 TO 3×10^7 D/M/GM AND PENETRATION FROM 1 TO 8 INCHES WERE REPORTED.

SEPTEMBER 1968

PRELIMINARY PROPOSAL FOR CONTAINMENT COVER WAS PREPARED BY ROCKY FLATS ENGINEERING.

JULY 1969

FIRST COAT OF FILL MATERIAL WAS APPLIED.

AUGUST 1969

FILL WORK WAS COMPLETED, PAVING CONTRACT WAS LET.

SEPTEMBER 1969

OVERLAY MATERIAL, SOIL STERILANT AND ASPHALT PRIME COAT WERE COMPLETED.

NOVEMBER 1969

ASPHALT CONTAINMENT COVER WAS COMPLETED. FOUR SAMPLING WELLS WERE INSTALLED.

ACCIDENT SUMMARY

DRUM STORAGE AREA

TOTAL DRUMS IN STORAGE		5240
DRUMS CONTAINING URANIUM		1670
DRUMS CONTAINING PLUTONIUM		3570
ESTIMATED MATERIAL		7000-9000 GRAMS
RECOVERED	600 GRAMS	
PROCESSED WITH OIL	2500 GRAMS	
RESIDUE IN DRUMS	5200 GRAMS	
SUBTOTAL		8300 GRAMS
ESTIMATED OIL LEAKAGE		5000 GALLONS

ESTIMATED PLUTONIUM LOSS

1.	DOW CHEMICAL	.01-.02 G/GALLON	86 GRAMS
2.	HASL		176 GRAMS
			(11 CURIES)
		UNDER PAD	1.7 CURIES
		IN SOIL	6.9 CURIES
		ONSITE	8.6 CURIES
		OFFSITE	2.4 CURIES

SOIL CONTAMINATION-EARLY STUDIES

JANUARY 1970

REPORT BY DR. MARTELL (COLO. COMM. FOR ENVIRONMENTAL INFORMATION) ON PLUTONIUM IN SOIL AROUND ROCKY FLATS

AUGUST 1970

REPORT BY HASL ON PLUTONIUM IN SOIL AROUND THE ROCKY FLATS PLANT

JULY 1971

REPORT BY DOW CHEMICAL ON PLUTONIUM LEVELS IN SOIL WITHIN AND SURROUNDING ROCKY FLATS

LATER STUDIES OF OFFSITE SOIL CONTAMINATION

MAY 1977

DEFENDENT'S EXHIBIT "A" ON SOIL
SAMPLING AND TESTING PROGRAM DATA

MARCH 1979

PLUTONIUM CONCENTRATIONS IN SOIL ON
LANDS ADJACENT TO THE ROCKY FLATS PLANT

JUNE 1983

PLUTONIUM IN SOIL FROM A RANCH
SOUTHEAST OF ROCKY FLATS

OCTOBER 1983

PLUTONIUM IN SOIL FROM THE EASTERN
BORDERS OF BROOMFIELD'S GREAT WESTERN
RESERVOIR

STUDIES OF ONSITE SOIL CONTAMINATION

JULY 1971

DOW CHEMICAL REPORT (PREVIOUSLY NOTED)

MAY 1978

SOIL STUDIES FOR DAM CONSTRUCTION PROJECT

1979-1982

ANNUAL ENVIRONMENTAL MONITORING REPORTS

CRITERIA FOR CLEANUP(ONSITE)

SOIL DECONTAMINATION CRITERIA >5000 D/M/G

>30000 MCI/KM^2

>30 $\mu CI/M^2$

RATIONALE

1) LIMITED ACCESS AREA 40000 MCI/KM^2 *

* PROPOSED BY KATHREN (BNWL-SA-1510-1968)

2) RESEARCH SITE FOR ECOLOGICAL STUDIES

3) COST OF REMOVAL <$500,000

4) FIELD MEASUREMENT METHODS 500 D/M/G

5. ENVIRONMENTAL ASSESSMENT DOCUMENT

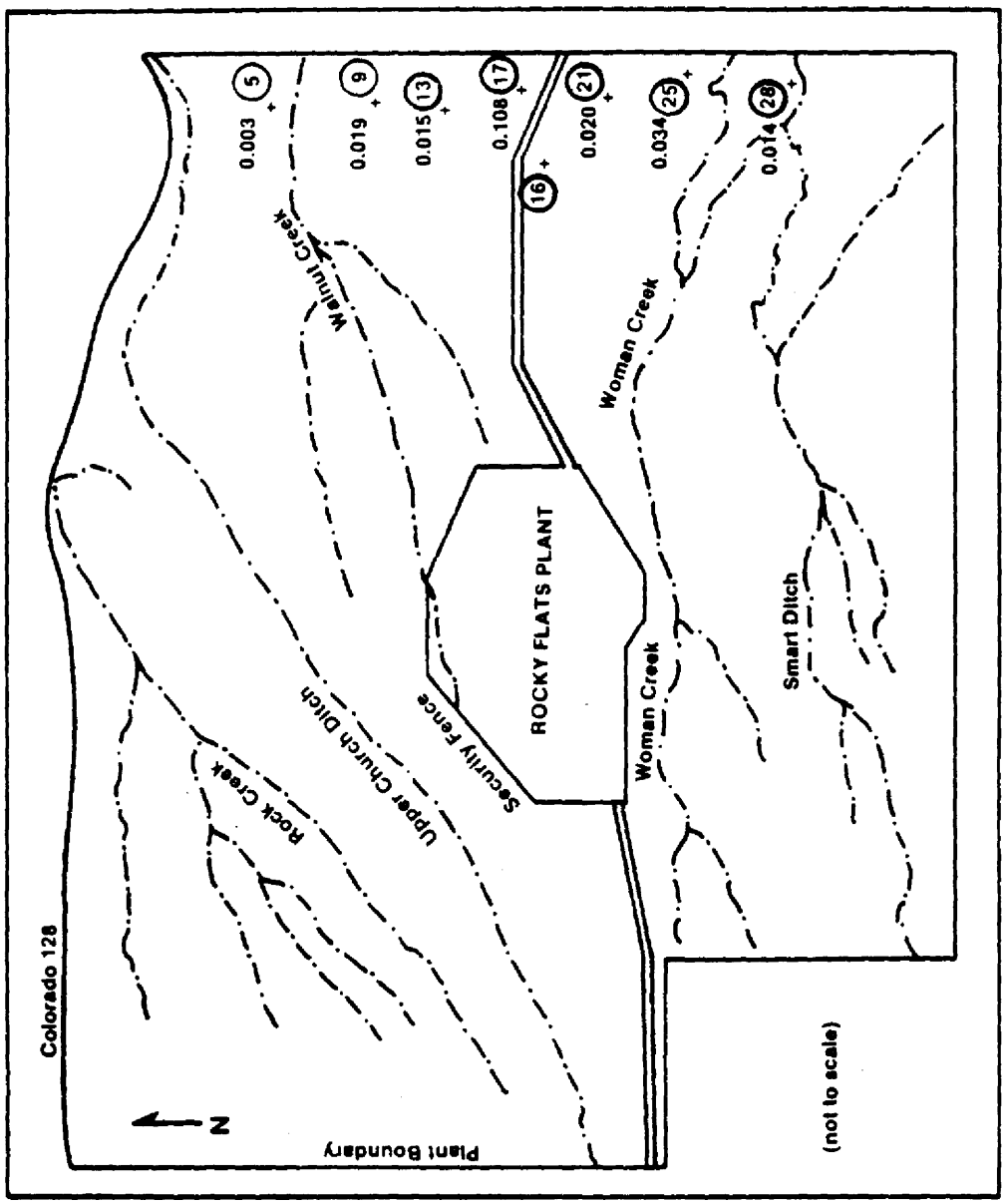


Figure 2. Median Values of Plutonium in Soil ($\mu Ci/m^2$)

COST AND CLEANUP METHODOLOGY

YEAR	LOCATION	AREA(FT^2)	METHOD	COST
1968	903 Area	266,000	Removed Top Three Inches Into Central Area	$ 30,00
1969	Pad (903 Area)	170,000	Area Covered With 10 Inches Fill Material and 3 Inches Asphalt	$100,000
1976	Lip (903 Area)	7,750	Manual Excavation in Floorless Bldg.	$ 43,500
1977	Pond-Area (207 Solar Ponds)	38,950	Front-End Loader Excavation of Moistened Material	$327,000
1978	Oil Burning Pit	2,000 (5 Foot Deep)	Front End Loader Excavation of Moistened Soil	$101,000
1978	Lip (903 Area)	45,500	Front End Loader Excavation of Moistened Soil	$410,000

SOIL REMOVAL UNIT COSTS

YEAR	LOCATION	COST PER FT^2	COST PER BOX	COST PER CWT
1976	903 Area	$ 5.61	$1243	$34.86
1977	Solar Ponds	$ 8.40	$ 623	$14.92
1978	Oil Pit	$50.50	$ 289	$10.10
1978	903 Area	$ 6.79	$ 281	$ 8.35

IMPACT OF PROPOSED GUIDELINES

AREA REQUIRING CLEANUP

OFF SITE	NONE
ON SITE	300 ACRES

ESTIMATED COSTS

ASPHALT PAD	$20 MILLION
ADJACENT LAND	11 MILLION
HOLDING PONDS	40 MILLION
BUFFER ZONE	1 MILLION
TOTAL	72 MILLION