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POLICY ISSUE
(Information)

August 9, 1984

SECY-84-320

For: The Commissioners

From: William J. Dircks
Executive Director for Operations

Subject: NRC STAFF COMMENTS TO ENVIRONMENTAL PROTECTION AGENCY (EPA) ON THE SCIENCE ADVISORY BOARD REPORT ON PROPOSED EPA STANDARD FOR MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR FUEL, HIGH-LEVEL AND TRANSURANIC WASTE (40 CFR PART 191)

Purpose: To inform the Commission of comments of the NRC staff on the EPA Science Advisory Board's Report.

Discussion: In January 1983, the Environmental Protection Agency (EPA) formed a subcommittee of its Science Advisory Board to review the technical basis for the proposed 40 CFR Part 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes. The Subcommittee prepared a report that contains a number of findings and recommendations which the EPA is considering incorporating into the final version of 40 CFR Part 191. On May 8, 1984, the EPA published in the Federal Register a notice of availability of the report, and encouraged the public to comment on it (49 FR 19604, Enclosure 1). Since the report contains recommendations affecting the Commission's ability to implement the standard, and other matters on which the Commission and staff had previously commented, the staff commented to EPA on these matters. A copy of the staff comments is contained in Enclosure 2.

Contact:
D. Fehringer/J. Linehan, WMRP
427-4177

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103 pp.

On July 19, 1984, Acting Chairman Roberts wrote to Administrator Ruckelshaus, suggesting a possible resolution of the jurisdictional issue regarding the procedural and assurance requirements contained in EPA's proposed HLW standard. If the recommendations of Acting Chairman Roberts' memorandum and of the staff's comments on the Science Advisory Board report are adopted by EPA, the staff considers that all of its concerns with the EPA HLW standard would be resolved.

William J. Dircks
Executive Director for Operations

Enclosures:
1. 49 FR 19604 - Commissioners, SECY, OGC and OPE only.
2. Staff Comments

ENCLOSURE 1*

*Commissioners, SECY, OGC and OPE only.

ENCLOSURE 2

WM S/F 3406.3.3
WMRP r/f
NMSS r/f
CF
REBrowning
MJBell
JBunting
PAltomare
MRKnapp
LBarrett
LBHigginbotham
HJMiller
RRBoyle
SCoplan
JKennedy
JWolf
PComella
KGoeller
DFehringer & r
JLinehan
EConti
PComella
PDR

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406.3.3/DJF/84/06/15/0

Central Docket Section (LE-130)
U. S. Environmental Protection Agency
ATTN: Docket No. R-82-3
Washington, DC 20460

The Nuclear Regulatory Commission (NRC) staff is pleased to respond to the request by the Environmental Protection Agency (EPA) for comments on its Science Advisory Board's review of the proposed EPA standards for management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes (40 CFR Part 191). The NRC staff shares the concerns of the Science Advisory Board (SAB) regarding the implementability of the proposed standards, and several of our comments address this concern. Our specific comments are listed below. In each case the SAB's recommendation is first presented, followed by the NRC staff's comment.

EXECUTIVE SUMMARY RECOMMENDATIONS

A. The Standard

1. The Subcommittee recommends that the release limits specified in Table 2 of the proposed standards be increased by a factor of ten, thereby causing a related ten fold relaxation of the proposed societal objective (population risk of cancer).

The NRC staff considers that the proposed release limits can be achieved provided that the implementation concerns expressed in the NRC's formal comments on the proposed standards (comment letters dated May 10 and 11, 1983) are resolved. (Specific issues of concern are discussed below.) Thus, from the point of view of implementation of the standards, the NRC staff would not consider it necessary to increase the proposed release limits.

B. Uncertainty and the Standard

1. We recommend that the probabilistic release criteria in the draft standard be modified to read "analysis of repository performance shall demonstrate that there is less than a 50% chance of exceeding the Table 2 limits, modified as is appropriate. Events whose median frequency is less than one in one-thousand in 10,000 years need not be considered."

2. We recommend that use of a quantitative probabilistic condition on the modified Table 2 release limits be made dependent on EPA's ability to provide evidence that such a condition is practical to meet and will not lead to serious impediments, legal or otherwise, to the licensing of high-level waste

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geologic repositories. If such evidence cannot be provided, we recommend that EPA adopt qualitative criteria, such as those suggested by the NRC.

The NRC staff believes it is important to recognize a distinction between a standard of performance and the quality of evidence that the standard has been met. A quantitative probabilistic standard of performance can be applied in administrative proceedings. However, when it comes to determining the evidence that should be admitted, or in evaluating the probative force of that evidence, different considerations come into play. These matters involve judgments which are qualitative. We would regard it as arbitrary and inappropriate to rule, as an absolute principle, that a certain median frequency of occurrence should always be the basis for considering particular events. And while we could apply a preponderance-of-evidence standard of proof (in place of the suggested 50%), we regard the reasonable assurance standard as being more restrictive and better suited to protection of public health and safety. Accordingly, the NRC staff would take exception to the above recommendations. Moreover, it is noted that the recommendations are more matters of implementation than environmental standards as such. It may nevertheless be possible to meet the intent of the SAB recommendation in an appropriate manner that would be implementable in a license review. The NRC staff considers that the revised wording of the containment requirements set out on page three of this letter would achieve this goal.

C. The Time Frame - 10,000 Years and Beyond

1. We recommend that EPA retain the 10,000-year time period as the basis for determining the adequacy of repository performance. We believe that use of formal numerical criteria limited to this approximate time period is a scientifically acceptable regulatory approach.

2. We recommend that the process of selection of sites for disposal systems also take into account potential releases of radioactivity somewhat beyond 10,000 years. Particular attention should be focused on potential releases of long-lived alpha-emitting radionuclides and their decay products.

The NRC staff agrees, in principle, with these recommendations. We note, however, that the process of site selection is assigned by the Nuclear Waste Policy Act (NWPA) to the Department of Energy (DOE), and that DOE's siting guidelines include a criterion requiring comparative evaluations of the performance of alternative sites for 100,000 years, fully satisfying the SAB recommendation. Since criteria for site selection are not "environmental standards" as envisioned by the NWPA or by Reorganization Plan No. 3, EPA should not add such a requirement to its standards.

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MAIN REPORT RECOMMENDATIONS

A. Uncertainty and the Standard

2. We believe that repository designers will find it quite difficult and perhaps excessively expensive to demonstrate with reasonable or high assurance that the levels of protection sought by EPA in the draft standard have been met.

The following wording has been suggested, in recent discussions with the EPA staff, for the containment requirements:

191.13 Containment Requirements

(a) Disposal systems for spent nuclear fuel or high-level or transuranic wastes shall be designed to provide a reasonable expectation, based upon performance assessments, that the cumulative releases of waste to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall: (1) have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A), and (2) have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).

(b) Performance assessments need not provide complete assurance that the requirements of 191.13(a) will be met. Because of the long time period involved and the nature of the events and processes of interest, there will inevitably be substantial uncertainties in projecting disposal system performance. Proof of the future performance of a disposal system is not to be had in the ordinary, more short term, sense of the word. Instead, what is required is a reasonable expectation, on the basis of the record before the implementing agency, that compliance with 191.13(a) will be achieved.

The NRC staff considers that this revised wording of the containment requirements will alleviate the concerns of the SAB, and will be implementable in a licensing review.

7. We find that an approach to the EPA standard employing "individual dose limits" (considering some "maximally exposed individual," or alternatively some "average exposed individual") would in practice make the standard difficult to meet with high assurance for very long times for any repository concept currently under active consideration. However, we recommend that for the first 500 years, the EPA standard embody an extremely low likelihood that increases in radioactivity approaching the limits allowed by the EPA drinking water standards will occur in potable well water drawn from any

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well adjacent to the site of the repository. For longer time periods, we recommend that EPA rely on the assumption that standards similar to the present drinking water standards will exist to protect groups of individuals.

The NRC staff agrees with this recommendation. We particularly note the SAB's use of the phrase "adjacent to the site of the repository". We think it is clear that the SAB intends that groundwater protection requirements be applied only to groundwaters beyond the geologic barrier which serves as part of an overall repository system (e.g., groundwaters beyond the "controlled area" as defined in 10 CFR Part 60). We believe that any groundwater protection requirement adopted by EPA should be applied as intended by the SAB.

E. Assurance Requirements

1. We recommend that the assurance requirements, as amended by this report, be submitted as a Federal Radiation Guidance document in support of the EPA rule package.

The NRC staff agrees with this recommendation, and notes that the NRC's formal comments on the proposed standards identified the assurance requirements as being inappropriate for an environmental standard and recommended that they be deleted. The NRC staff also agrees with the recommended specific changes (Recommendations E.2-E.7, not listed here) if these provisions are to be published as Federal Radiation Protection Guidance.

Recognition of the similarity between several of the proposed assurance requirements and the corresponding provisions of the NRC's regulation, 10 CFR Part 60, suggests a possible alternative solution. This would take the form of modification of Part 60 if and as appropriate so as to incorporate the principles of EPA's proposed assurance requirements. In view of these changes, EPA would delete the assurance requirements from the standard. Thus, problems of overlapping jurisdiction between the two agencies (and potentially conflicting requirements) could be avoided. The NRC staff will continue discussions with the EPA staff to explore the feasibility of this approach.

L. Limit Standard to Mined Geologic Repositories

1. We recommend that the applicability of Subpart B of the proposed standards be explicitly restricted by EPA to disposal in mined geologic repositories.

The NRC agrees with this recommendation for the reasons cited by the SAB and because of the direction in NWPA to develop standards for disposal in mined geologic repositories.

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N. High-Level Radioactive and Transuranic Wastes Definitions

1. We recommend that EPA's definition of high-level radioactive wastes be consistent with that set forth in the Nuclear Waste Policy Act (NWPA) and coordinated with the definition used by the Nuclear Regulatory Commission (NRC).

The NRC staff agrees with this recommendation and notes that recent working drafts of the EPA standards have contained an appropriate definition.

We appreciate the opportunity to comment on the SAB report and will be pleased to consult with the EPA staff on these comments or other matters that will assist in publication of the final standards.

Sincerely,

Original Signed by
MICHAEL J. BELL

Robert E. Browning, Director
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards

*See previous concurrence page.

	WMRP:ejc	WMRP	WMRP	RES	DWM	RES	DWM
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High-Level Radioactive Waste Disposal, EPA Proposed Rule, 40 CFR Part 191

Comparison of Changes and Recommendations

FEDERAL REGISTER NOTICE, 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT, JAN.1984 [NUCLEAR WASTE POLICY ACT OF 1982]
SUBPART A - ENVIRONMENTAL STANDARDS FOR MANAGEMENT AND STORAGE		
§ 191.01 APPLICABILITY		
COVERS WASTE MGT. & STORAGE OPERATIONS NOT SUBJECT TO 40 CFR PART 190.	COVERS BOTH NRC AND AGREEMENT STATE LICENSED FACILITIES NOT SUBJECT TO 40 CFR PART 190, AND DOE FACILITIES NOT REGULATED BY NRC OR BY AGREEMENT STATES.	
§ 191.02 DEFINITIONS		
EXCEPT AS DEFINED, TERMS HAVE SAME MEANING AS IN SUBPART A OF 40 CFR PART 190.	EXCEPT AS DEFINED, TERMS HAVE SAME MEANING AS IN SUBPART A OF 40 CFR PART 190.	RECOMMENDED CONSISTENCY WITH NWPA AND COORDINATION WITH NRC (HLW) AND OTHER AGENCIES (TRU).
"SPENT NUCLEAR FUEL"- IRRADIATED FUEL REMOVED FROM A NUCLEAR REACTOR.	SAME DEFINITION WITH ADDED SPECIFICATION "CONSTITUENT ELEMENTS OF WHICH HAVE NOT BEEN SEPARATED BY REPROCESSING."	[CONFORMED TO NWPA]
"HIGH-LEVEL RADIOACTIVE WASTE" DEFINED IN TERMS OF > TABLE 1 CONCENTRATIONS FOR: - FIRST CYCLE LIQUID WASTE FROM REPRO. - CONC. WASTES FROM SUBSEQUENT EXTRACTION. - SOLIDS FORMED FROM SUCH LIQ. WASTES. - SPENT NUCLEAR FUEL IF DISPOSED OF WITHOUT REPROCESSING.	DEFINED AS: - LIQUID WASTE PRODUCED DIRECTLY IN REPROCESSING AND ANY SOLID MATERIAL DERIVED FROM SUCH LIQ. WASTE THAT CONTAINS FISSION PRODUCTS IN SUFFICIENT CONCENTRATIONS. - OTHER HIGHLY RADIOACTIVE MATERIAL DETERMINED BY NRC BY RULE TO REQUIRE PERMANENT ISOLATION.	RECOMMENDED CONSISTENCY AND COORDINATION WITH NRC DEFINITION. [CONFORMED TO NWPA]
"TRANSURANIC WASTES" DEFINED IN TERMS OF α-EMITTING TRANSURANICS WITH > 100 nCi/g, $T_{1/2}$ > 1 YR	DEFINED AS α WASTES > 100 nCi/g, $T_{1/2}$ > 20 YR, EXCEPT FOR HIGH-LEVEL RADIOACTIVE WASTE; WASTES DETERMINED BY DOE NOT TO REQUIRE DEGREE OF ISOLATION REQUIRED BY 40 CFR PART 191, EPA CONCURRING, OR WASTES APPROVED FOR DISPOSAL BY NRC ON CASE-BY-CASE BASIS UNDER 10 CFR PART 61.	RECOMMENDED EQUIVALENCY IN LIEU OF MTHM CONCEPT FOR DOE WASTES AND FOR SOME KINDS OF COMMERCIAL RADIOACTIVE WASTES.

FEDERAL REGISTER NOTICE, 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT,JAN.1984 [NUCLEAR WASTE POLICY ACT OF 1982]
	"RADIOACTIVE WASTE" IS DEFINED AS THE HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTE COVERED BY 40 CFR PART 191.	
"MANAGEMENT AND STORAGE" DEFINED TO INCLUDE PREPARATION FOR STORAGE OR DISPOSAL, OR ACTIVITIES ASSOCIATED WITH DISPOSAL	"STORAGE" MEANS RETENTION OF SPENT NUCLEAR FUEL OR RADIOACTIVE WASTES WITH INTENT AND CAPABILITY TO READILY RETRIEVE SUCH FUEL OR WASTE FOR SUBSEQUENT USE, PROCESSING, OR DISPOSAL. "MANAGEMENT" MEANS ANY ACTION (EXCEPT FOR TRANSPORTATION) CONDUCTED TO PREPARE SUCH FUEL OR RADIOACTIVE WASTE FOR STORAGE OR DISPOSAL, OR THE ACTIVITIES ASSOCIATED WITH THE DISPOSAL OF SUCH WASTE.	
§ 191.03 STANDARDS EXCEPT FOR VARIANCES GRANTED UNDER SUBPART 191.04, THE COMBINED ANNUAL DOSE EQUIVALENT TO ANY MEMBER OF THE PUBLIC DUE TO OPERATIONS COVERED BY PART 190, PLANNED DISCHARGES UNDER THIS PART, AND DIRECT RADIATION FROM THESE OPERATIONS SHALL NOT EXCEED: - 25 MREM WHOLE BODY, - 75 MREM THYROID, OR - 25 MREM TO ANY OTHER ORGAN.	MANAGEMENT AND STORAGE ACTIVITIES AT ALL FACILITIES REGULATED BY NRC OR AGREEMENT STATES SHALL NOT RESULT IN COMBINED ANNUAL DOSE EQUIVALENT TO ANY MEMBER OF THE PUBLIC DUE TO OPERATIONS COVER- BY PART 190, DISCHARGES OF RADIOACTIVE MATERIALS, AND DIRECT RADIATION IN EXCESS OF: - 25 MREM WHOLE BODY, - 75 MREM THYROID, OR - 25 MREM TO ANY OTHER CRITICAL ORGAN. MANAGEMENT AND STORAGE ACTIVTIES AT DOE FACILITIES SHALL NOT RESULT IN COMBINED ANNUAL DOSE EQUIVALENT TO ANY MEMBER OF THE PUBLIC FROM DISCHARGES OF RADIOACTIVE MATERIAL AND DIRECT RADIATION IN EXCESS OF 25 MREM WHOLE BODY OR 75 MREM TO ANY OTHER CRITICAL ORGAN.	

FEDERAL REGISTER NOTICE, 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT, JAN. 1984 [NUCLEAR WASTE POLICY ACT OF 1982]
§ 191.04 VARIANCES FOR UNUSUAL OPERATIONS		
IMPLEMENTING AGENCY MAY GRANT VARIANCES, SUBJECT TO NOTICE TO STATE GOVERNORS AND TO PUBLIC.	EPA ADMINISTRATOR MAY GRANT A VARIANCE FROM THE EXPOSURE STANDARDS FOR DOE FACILITIES NOT REGULATED BY NRC OR AGREEMENT STATES, SUBJECT TO VARIOUS CONDITIONS, INCLUDING THAT THE VARIANCE WILL PREVENT A MEMBER OF THE PUBLIC FROM RECEIVING A CONTINUOUS EXPOSURE > 100 MREM/YR DOSE EQUIVALENT AND AN INFREQUENT EXPOSURE OF > 500 MREM/YR DOSE EQUIVALENT FROM ALL SOURCES.	
§ 191.05 EFFECTIVE DATE		
EFFECTIVE 12 MONTHS AFTER PROMULGATION OF RULE.	EFFECTIVE 30 DAYS AFTER PUBLICATION IN FEDERAL REGISTER.	
SUBPART B - ENVIRONMENTAL STANDARDS FOR DISPOSAL		
§ 191.11 APPLICABILITY		
APPLIES TO RADIOACTIVE MATERIALS RELEASED INTO THE ACCESSIBLE ENVIRONMENT. DOES NOT APPLY TO DISPOSAL DIRECTLY INTO OCEANS OR OCEAN SEDIMENTS.	APPLIES TO RADIOACTIVE MATERIALS RELEASED INTO: - THE ACCESSIBLE ENVIRONMENT, AND - CERTAIN SOURCES OF GROUND WATER IN THE VICINITY OF DISPOSAL SYSTEMS. DOES NOT APPLY TO DISPOSAL DIRECTLY INTO OCEANS OR OCEAN SEDIMENTS, OR TO WASTES DISPOSED OF BEFORE PROMULGATION OF THIS RULE.	
§ 191.12 DEFINITIONS		
"DISPOSAL" MEANS ISOLATION OF RADIOACTIVE WASTES WITH NO INTENT TO RECOVER THEM.	(DELETED ?)	["DISPOSAL" MEANS EMPLACEMENT IN A REPOSITORY WITH NO FORESEEABLE INTENT OF RECOVERY.]

FEDERAL REGISTER NOTICE, 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT, JAN. 1984 [NUCLEAR WASTE POLICY ACT OF 1982]
"DISPOSAL SYSTEM" MEANS ANY COMBINATION OF ENGINEERED AND NATURAL BARRIERS THAT CONTAINS RADIOACTIVE WASTES AFTER DISPOSAL.	"DISPOSAL SYSTEM" MEANS ANY COMBINATION OF ENGINEERED AND NATURAL BARRIERS THAT ISOLATE SPENT NUCLEAR FUEL OR RADIOACTIVE WASTE AFTER DISPOSAL.	
	"WASTE" MEANS ANY SPENT NUCLEAR FUEL OR RADIOACTIVE WASTE ISOLATED IN A DISPOSAL SYSTEM.	
	"WASTE FORM" MEANS THE MATERIALS COMPRISING THE RADIOACTIVE COMPONENTS OF SPENT NUCLEAR FUEL OR RADIOACTIVE WASTE AND ANY ENCAPSULATING OR STABILIZING MATRIX.	
"ACCESSIBLE ENVIRONMENT" INCLUDES:(1) THE ATMOSPHERE,...(ETC.) THAT ARE MORE THAN 10 KM. IN ANY DIRECTION FROM THE ORIGINAL LOCATION OF ANY OF THE RADIOACTIVE WASTES IN A DISPOSAL SYSTEM.	"ACCESSIBLE ENVIRONMENT" MEANS:(1) THE ATMOSPHERE,...(ETC.) THAT ARE BEYOND THE CONTROLLED AREA.	RECOMMENDED EPA EXTEND THE DEFINITION TO INCLUDE MAJOR SOURCES OF POTABLE GROUNDWATER THAT ARE BEYOND THE CONTROLLED AREA (AS DEFINED IN 10 CFR PART 60) <u>AND</u> ARE MORE THAN 2 KM. IN A HORIZONTAL DIRECTION FROM THE ORIGINAL LOCATION, ETC.
	"CONTROLLED AREA" MEANS A SURFACE LOCATION, IDENTIFIED BY PASSIVE INSTITUTIONAL CONTROLS, EXTENDING HORIZONTALLY NO MORE THAN 2 KM. FROM THE OUTER BOUNDARY OF THE WASTES' ORIGINAL LOCATION, AND THE SUBSURFACE UNDERLYING SUCH A SURFACE LOCATION.	

FEDERAL REGISTER NOTICE. 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT,JAN. 1984 [NUCLEAR WASTE POLICY ACT OF 1982]
"BARRIERS" MEANS ANY MATERIALS OR STRUCTURES THAT PREVENT OR SUBSTANTIALLY DELAY MOVEMENT OF RADIOACTIVE WASTES TOWARD THE ACCESSIBLE ENVIRONMENT.	"BARRIER" MEANS ANY MATERIAL OR STRUCTURE THAT PREVENTS OR SUBSTANTIALLY DELAYS MOVEMENT OF WATER OR RADIONUCLIDES TOWARD THE ACCESSIBLE ENVIRONMENT.	["ENGINEERED BARRIERS" MEANS MAN-MADE COMPONENTS OF A DISPOSAL SYSTEM DESIGNED TO PREVENT THE RELEASE OF RADIONUCLIDES INTO THE GEOLOGIC MEDIUM INVOLVED.
"PASSIVE INSTITUTIONAL CONTROLS" MEANS: (1) PERMANENT MARKERS PLACED AT A DISPOSAL SITE; (2) PUBLIC RECORDS OR ARCHIVES; (3) FEDERAL GOVERNMENT OWNERSHIP OR CONTROL OF LAND USE; OR (4) OTHER METHODS OF PRESERVING KNOWLEDGE ABOUT A DISPOSAL SYSTEM.	"PASSIVE INSTITUTIONAL CONTROL" MEANS: (1) PERMANENT MARKERS PLACED AT A SITE; (2) PUBLIC RECORDS AND ARCHIVES; (3) GOVERNMENT OWNERSHIP AND REGULATIONS REGARDING LAND OR RESOURCE USE; AND (4) OTHER METHODS OF PRESERVING KNOWLEDGE ABOUT A GEOLOGIC REPOSITORY.	
"ACTIVE INSTITUTIONAL CONTROLS" MEANS: (1) GUARDING A DISPOSAL SITE, OR (2) PERFORMING MAINTENANCE OPERATIONS OR REMEDIAL ACTIONS AT A DISPOSAL SITE, OR (3) CONTROLLING OR CLEANING UP RELEASES FROM A DISPOSAL SITE.	"ACTIVE INSTITUTIONAL CONTROL" MEANS ANY MEASURE OTHER THAN A PASSIVE INSTITUTIONAL CONTROL PERFORMED TO: (1) CONTROL ACCESS TO A SITE, (2) PERFORM MAINTENANCE OPERATIONS OR REMEDIAL ACTIONS AT A SITE, (3) CONTROL OR CLEAN UP RELEASES AT A SITE, OR (4) MONITOR PARAMETERS RELATED TO GEOLOGIC REPOSITORY PERFORMANCE.	
	"AQUIFER" MEANS AN UNDERGROUND GEOLOGICAL FORMATION, ETC., CAPABLE OF YIELDING A SIGNIFICANT AMOUNT OF WATER TO A WELL OR SPRING.	
	"TRANSMISSIVITY" MEANS THE HYDRAULIC CONDUCTIVITY INTEGRATED OVER THE STRURATED THICKNESS OF AN UNDERGROUND FORMATION. THE TRANSMISSIVITY OF A SERIES OF FORMATIONS IS THE SUM OF THE INDIVIDUAL TRANSMISSIVITIES OF EACH FORMATION.	

FEDERAL REGISTER NOTICE, 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT, JAN. 1984 [NUCLEAR WASTE POLICY ACT OF 1982.]
	"COMMUNITY WATER SYSTEM' MEANS A SYSTEM FOR PROVIDING PIPED WATER FOR PUBLIC CONSUMPTION, WITH AT LEAST 15 SERVICE CONNECTIONS USED BY YEAR-ROUND RESIDENTS, OR REGULARLY SERVES 25 YEAR-ROUND RESIDENTS	
	"SIGNIFICANT SOURCES OF GROUND WATER" MEANS: (1) AN AQUIFER THAT: - IS SATURATED WITH WATER WITH < 10^4 MG/L TOTAL DISSOLVED SOLIDS; - IS WITHIN 2,500 FT. OF LAND SURFACE; - HAS TRANSMIISSIVITY >200 GAL/DAY/FT., PROVIDED EACH FORMATION OR PART THEREOF HAS INDIVIDUAL HYDRAULIC CONDUCTIVITY >2 GAL/DAY/FT^2; - CAPABLE OF CONTINUOUS YIELD ≥ 10^4 GAL/DAY TO A PUMPED OR FLOWING WELL FOR A PERIOD OF AT LEAST A YEAR; OR (2) PROVIDES THE PRIMARY SOURCE OF WATER FOR A COMMUNITY WATER SYSTEM AS OF THE EFFECTIVE DATE OF THIS RULE.	
	"SPECIAL SOURCES OF GROUND WATER" MEANS THOSE CLASS I GROUND WATERS IDENTIFIED BY EPA AS IRREPLACEABLE, IN THAT NO REASONABLE ALTERNATIVE SOURCE OF DRINKING WATER IS AVAILABLE TO SUBSTANTIAL POPULATIONS.	

FEDERAL REGISTER NOTICE, 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT,JAN. 1984 [NUCLEAR WASTE POLICY ACT OF 1982]
	"UNDISTURBED PERFORMANCE" MEANS THE PREDICTED BEHAVIOR OF A DISPOSAL SYSTEM, INCLUDING CONSIDERATIONS OF UNCERTAINTIES IN EXPECTED BEHAVIOR, IF UNDISTRUBED BY HUMAN INTRUSION OR THE OCCURENCE OF UNLIKELY NATURAL EVENTS.	
"REASONABLY FORESEEABLE RELEASES" MEANS THE CUMULATIVE RELEASES OF RADIOACTIVE WASTES.... THAT ARE ESTIMATED TO HAVE MORE THAN 1 CHANCE IN 100 OF OCCURRING WITHIN 10^4 YRS.	(SEE § 191.13)	RECOMMENDATION THAT ANALYSIS OF REPOSITORY PERFORMANCE SHALL DEMONSTRATE LESS THAN 50% CHANCE OF EXCEEDING TABLE 2 LIMITS, MODIFIED AS APPROPRIATE, ON CURIES RELEASED TO ENVIRONMENT IN 10^4 YEARS; EVENTS WHOSE MEDIAN FREQUENCY IS LESS THAN 1 IN 1000 IN 10^4 YEARS NEED NOT BE CONSIDERED; ALSO THAT USE OF QUANTITATIVE PROBABILISTIC CONDITION BE DEPENDENT ON EPA SHOWING IT IS PRACTICAL TO MEET - OTHERWISE, QUALITATIVE CRITERIA RECOMMENDED.
"VERY UNLIKELY RELEASES" MEANS THE CUMULATIVE RELEASES BE ESTIMATED TO HAVE BETWEEN 1 CHANCE IN 100 AND ABOUT 1 CHANCE IN 10,000 OF OCCURRING IN 10^4 YRS.	(SEE § 191.13)	
"PERFORMANCE ASSESSMENT" MEANS AN ANALYSIS THAT IDENTIFIES EVENTS AND PROCESSES WHICH MIGHT AFFECT THE DISPOSAL SYSTEM, THEIR EFFECTS ON BARRIERS, AND THE PROBABILITIES AND CONSEQUENCES OF THE EVENTS.	ALSO REQUIRES ESTIMATES OF THE CUMULATIVE RELEASES OF RADIONUCLIDES, CONSIDERING THE ASSOCIATED UNCERTAINTIES, CAUSED BY ALL SIGNIFICANT PROCESSES AND EVENTS, AND REQUIRES THE ASSEMBLY OF THESE ESTIMATES INTO AN OVERALL PROBABILITY DISTRIBUTION OF CUMULATIVE RELEASE TO THE EXTENT PRACTICABLE. (SEE APPENDIX B, FOLLOWING).	

FEDERAL REGISTER NOTICE, 29 DEC. 1982	EPA WORKING DRAFT NO. 5, 21 MARCH 1985	EPA SAB SUBCOMM.REPORT, JAN. 1984 [NUCLEAR WASTE POLICY ACT OF 1982]
	"IMPLEMENTING AGENCY" MEANS THE NRC FOR SPENT NUCLEAR FUEL OR HIGH-LEVEL OR TRANSURANIC WASTES TO BE DISPOSED OF IN NRC-LICENSED FACILITIES, AND DOE FOR ALL OTHER RADIOACTIVE WASTES.	
§ 191.13 CONTAINMENT REQUIREMENTS DISPOSAL SYSTEMS SHALL BE DESIGNED TO PROVIDE REASONABLE EXPECTATION THAT FOR 10^4 YEARS AFTER DISPOSAL: - REASONABLY FORESEEABLE RELEASES BE LESS THAN TABLE 2 QUANTITIES, AND - VERY UNLIKELY RELEASES BE LESS THAN 10 TIMES TABLE 2 QUANTITIES.	DISPOSAL SYSTEMS SHALL BE DESIGNED TO PROVIDE A REASONABLE EXPECTATION, BASED ON PERFORMANCE ASSESSMENTS, THAT THE CUMULATIVE RELEASES OF RADIONUCLIDES TO THE ACCESSIBLE ENVIRONMENT FOR 10^4 YEARS AFTER DISPOSAL: - HAVE A LIKELIHOOD OF LESS THAN 1 CHANCE IN 10 OF EXCEEDING TABLE 1 QUANTITIES; AND - HAVE A LIKELIHOOD OF LESS THAN 1 CHANCE IN 1,000 OF EXCEEDING 10 TIMES TABLE 1 QUANTITIES. PERFORMANCE ASSESSMENTS NEED NOT PROVIDE COMPLETE ASSURANCE THAT ABOVE REQUIREMENTS BE MET DUE TO SUBSTANTIAL UNCERTAINTIES IN PROJECTING DISPOSAL SYSTEM PERFORMANCE; WHAT IS REQUIRED IS A REASONABLE EXPECTATION, BASED ON RECORD BEFORE THE IMPLEMENTING AGENCY. (SEE APPENDIX B, FOLLOWING).	(SEE DEFINITIONS, PREVIOUS PAGE). RECOMMENDATION THAT ANALYSIS OF REPOSITORY PERFORMANCE SHALL DEMONSTRATE LESS THAN 50% CHANCE OF EXCEEDING TABLE 2 LIMITS, MODIFIED AS APPROPRIATE, ON CURIES RELEASED TO ENVIRONMENT IN 10^4 YEARS; EVENTS WHOSE MEDIAN FREQUENCY IS LESS THAN 1 IN 1000 IN 10^4 YEARS NEED NOT BE CONSIDERED; ALSO THAT USE OF QUANTITATIVE PROBABILISTIC CONDITION BE DEPENDENT ON EPA SHOWING IT IS PRACTICAL TO MEET - OTHERWISE, QUALITATIVE CRITERIA RECOMMENDED.
§ 191.14 ASSURANCE REQUIREMENTS DISPOSAL SHALL BE CONDUCTED IN ACCORDANCE WITH THE FOLLOWING PROVISIONS:	SAME REQUIREMENT, EXCEPT THESE PROVISIONS DO NOT APPLY TO FACILITIES REGULATED BY NRC (SEE INSTEAD 10 CFR PART 60).	
- WASTES SHALL BE DISPOSED OF PROMPTLY	(DELETED)	DELETION RECOMMENDED.

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- DISPOSAL SYSTEMS SHALL BE SELECTED AND DESIGNED TO KEEP RELEASES TO THE ACCESSIBLE ENVIRONMENT AS SMALL AS REASONABLY ACHIEVABLE:	(DELETED)	USE OF ALARA CONCEPT RECOMMENDED SOLELY FOR CONSIDERATION OF THE GEOLOGIC CHARACTERISTICS OF SITES.
- DISPOSAL SYSTEMS SHALL USE SEVERAL DIFFERENT TYPES OF BARRIERS TO ISOLATE THE WASTES FROM THE ACCESSIBLE ENVIRONMENT. BOTH ENGINEERED AND NATURAL BARRIERS SHALL BE INCLUDED. EACH SUCH BARRIER SHALL BE DESIGNED SEPARATELY TO PROVIDE SUBSTANTIAL ISOLATION.	SAME, EXCEPT LAST REQUIREMENT ON DESIGN OF EACH SEPARATE BARRIER HAS BEEN DELETED. (SEE APPENDIX B, FOLLOWING).	RECOMMENDED USE OF MULTIPLE BARRIERS BE REVISED TO GIVE MORE EMPHASIS TO THE SYSTEM AS A WHOLE; BARRIERS SHOULD BE DESIGNED SO THAT THEY COMPLEMENT EACH OTHER AND HELP TO COMPENSATE FOR UNEXPECTED FAILURES.
- DISPOSAL SYSTEMS SHALL NOT RELY ON ACTIVE INSTITUTIONAL CONTROLS BEYOND A REASONABLE PERIOD OF TIME, E.G., A FEW HUNDRED YEARS.	ACTIVE INSTITUTIONAL CONTROLS SHOULD BE MAINTAINED FOR AS LONG A PERIOD OF TIME AS IS REASONABLE AFTER DISPOSAL; CREDIT FOR SUCH CONTROLS FOR ISOLATION OF WASTES SHALL NOT BE TAKEN FOR MORE THAN 100 YEARS AFTER DISPOSAL. (SEE APPENDIX B, FOLLOWING). DISPOSAL SYSTEMS SHALL BE MONITORED AFTER DISPOSAL TO DETECT ANY SUBSTANTIAL AND DETRIMENTAL DEVIATIONS FROM EXPECTED PERFORMANCE. THIS MONITORING SHALL BE DONE WITH TECHNIQUES THAT DO NOT JEOPARDIZE THE ISOLATION OF THE WASTES AND SHALL BE CONDUCTED UNTIL THE IMPLEMENTING AGENCY DETERMINES THAT THERE ARE NO SIGNIFICANT CONCERNS TO BE ADDRESSED BY FURTHER MONITORING.	RECOMMENDED A TIME LIMIT OF 100 YEARS AND THAT SUITABLE SURVEILLANCE BE REQUIRED DURING THAT PERIOD.

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- DISPOSAL SYSTEMS SHALL BE IDENTIFIED BY THE MOST PERMANENT MARKERS AND RECORDS PRACTICABLE TO INDICATE THE DANGERS OF THE WASTES AND THEIR LOCATION.	SAME, EXCEPT OTHER PASSIVE INSTITUTIONAL CONTROLS ARE ADDED.	BROADENING OF THE DEFINITION OF PASSIVE INSTITUTIONAL CONTROLS RECOMMENDED BY THE ASSURANCE REQUIREMENTS SUBGROUP.
- DISPOSAL SYSTEMS SHALL NOT BE LOCATED WHERE THERE HAS BEEN MINING FOR RESOURCES OR THERE IS A REASONABLE EXPECTATION OF OF EXPLORATION FOR RESOURCES, ETC.	PLACES WHERE THERE HAS BEEN MINING FOR RESOURCES, OR WHERE THERE IS A REASONABLE EXPECTATION OF EXPLORATION FOR RESOURCES..... SHOULD BE AVOIDED. RESOURCES TO BE CONSIDERED INCLUDE (AMONG OTHERS) GROUND WATERS THAT ARE EITHER IRREPLACEABLE....OR ARE VITAL TO THE PRESERVATION OF UNIQUE AND SENSITIVE ECOSYSTEMS.	CONSIDERATION OF A POTENTIAL REPOSITORY SITE SHOULD NOT BE PRECLUDED BECAUSE NATURAL RESOURCES ARE AT OR NEAR A SITE, BUT RATHER, THEIR PRESENCE SHOULD BE TAKEN AS A HIGHLY UNFAVORABLE FACTOR...
- DISPOSAL SYSTEMS SHALL BE SELECTED SO THAT REMOVAL OF MOST OF THE WASTES IS NOT PRECLUDED FOR A REASONABLE PERIOD OF TIME AFTER DISPOSAL.	SAME REQUIREMENT.	ASSURANCE REQUIREMENT ON RETRIEVABILITY OF WASTE SHOULD BE DELETED.
<u>§ 191.15 PROCEDURAL REQUIREMENTS</u> (PROCEDURAL REQUIREMENTS ARE SPECIFIED, APPLICABLE TO PERFORMANCE ASSESSMENTS TO DETERMINE COMPLIANCE WITH THE CONTAINMENT REQUIREMENTS OF § 191.13, ABOVE.)	<u>APPENDIX B - GUIDANCE FOR IMPLEMENTATION OF SUBPART B</u> (PROCEDURAL REQUIREMENTS ARE SPECIFIED AS GUIDANCE NOT AS AN INTEGRAL PART OF 40 CFR PART 191. IMPLEMENTING AGENCIES ARE NOT BOUND BY THIS GUIDANCE.) THIS GUIDANCE INDICATES EPA INTENT REGARDING CERTAIN ISSUES THAT MAY ARISE WHEN IMPLEMENTING §§ 191.13 AND 191.15 (NEW). SOME APPLIES ONLY TO DISPOSAL IN MINED GEOLOGIC REPOSITORIES AND WOULD BE INAPPROPRIATE FOR OTHER TYPES OF SYSTEMS.	

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- ASSESSMENTS SHALL CONSIDER REALISTIC PROJECTIONS OF THE PROTECTION PROVIDED BY ALL OF THE ENGINEERED AND NATURAL BARRIERS OF A DISPOSAL SYSTEM.	GUIDANCE SAME, PLUS EXCEPTION FOR PORTIONS OF SYSTEM THAT MAKE NEGLIGIBLE CONTRIBUTIONS TO OVERALL ISOLATION PROVIDED BY THE DISPOSAL SYSTEM.	
- ASSESSMENTS SHALL NOT ASSUME THAT ACTIVE INSTITUTIONAL CONTROLS CAN PREVENT OR REDUCE RELEASES TO THE ACCESSIBLE ENVIRONMENT BEYOND A REASONABLE PERIOD, E.G., A FEW HUNDRED YEARS. IT SHOULD BE ASSUMED THE FEDERAL GOVERNMENT WILL RETAIN PASSIVE INSTITUTIONAL CONTROL OF DISPOSAL SITES IN PERPETUITY. SUCH PASSIVE INSTITUTIONAL CONTROLS SHOULD BE ASSUMED TO KEEP THE CHANCE OF INADVERTENT HUMAN INTRUSION VERY SMALL AS LONG AS THE FEDERAL GOVERNMENT RETAINS SUCH PASSIVE CONTROL OVER DISPOSAL SITES. (SEE § 191.14, ABOVE).	IMPLEMENTING AGENCY WILL ASSUME THAT NONE OF THE ACTIVE INSTITUTIONAL CONTROLS CAN PREVENT OR REDUCE RADIONUCLIDE RELEASES FOR MORE THAN 100 YEARS AFTER DISPOSAL. THE FEDERAL GOVERNMENT IS COMMITTED TO RETAINING OWNERSHIP OF ALL DISPOSAL SITES AMD WILL ESTABLISH APPROPRIATE MARKERS AND RECORDS. EPA BELIEVES SUCH MARKERS, RECORDS AND OTHER PASSIVE INSTITUTIONAL CONTROLS SHOULD BE EFFECTIVE IN DETERING EXPLOITATION OF THESE DISPOSAL SITES, AND THAT THEY CAN SUBSTANTIALLY REDUCE THE CHANCE OF INADVERTENT HUMAN INTRUSION; EPA BELIEVES THAT PASSIVE INSTITUTIONAL CONTROLS CANNOT BE ASSUMED TO COMPLETELY ELIMINATE THE CHANCE OF HUMAN INTRUSION INTO THESE DISPOSAL SITES.	RECOMMENDED A TIME LIMIT OF 100 YEARS FOR ACTIVE INSTITUTIONAL CONTROLS.
- ASSESSMENTS SHALL USE INFORMATION ABOUT LIKELIHOOD OF HUMAN INTRUSION AND ALL OTHER UNPLANNED EVENTS THAT MAY CAUSE RELEASES TO THE ACCESSIBLE ENVIRONMENT AS DETERMINED BY THE IMPLEMENTING AGENCY FOR EACH DISPOSAL SITE.	INADVERTENT INTRUSION BY EXPLORATORY DRILLING FOR RESOURCES (OTHER THAN THOSE IN THE DISPOSAL SYSTEM) SHOULD BE THE MOST SEVERE INTRUSION SENARIO TO BE CONSIDERED BY IMPLEMENTING AGENCIES. IMPLEMENTING AGENCIES SHOULD ASSUME PASSIVE INSTITUTIONAL CONTROLS OR THE INTRUDERS' OWN EXPLORATORY PROCEDURES SUFFICE TO INFORM INTRUDERS OF THE INCOMPATIBILITY OF THE AREA WITH THEIR ACTIVITIES.	

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	IMPLEMENTING AGENCIES SHOULD CONSIDER THE LIKELIHOOD AND CONSEQUENCES OF INADVERTENT EXPLORATORY DRILLING. THE LIKELIHOOD OF SUCH INADVERTENT DRILLING SHOULD NOT BE ASSUMED TO BE > 30 BOREHOLES/KM^2 OF REPOSITORY AREA PER 10^4 YEARS FOR REPOSITORIES IN PROXIMITY TO SEDIMENTARY ROCK FORMATIONS; OR > 3 BOREHOLES/KM^2, FOR REPOSITORIES IN OTHER GEOLOGIC FORMATIONS. THE CONSEQUENCES OF SUCH INADVERTENT DRILLING SHOULD NOT BE ASSUMED TO BE MORE SEVERE THAN: - DIRECT RELEASE TO THE LAND SURFACE OF ALL THE GROUND WATER IN THE REPOSITORY HORIZON THAT COULD PROMPTLY FLOW INTO THE NEWLY CREATED BOREHOLE, OR 200 M^3 OF GROUND WATER, WHICHEVER IS GREATER; AND - CREATION OF A GROUND WATER FLOW PATH WITH A PERMEABILITY TYPICAL OF A BORHOLE FILLED BY SOIL OR GRAVEL THAT WOULD NORMALLY SETTLE INTO AN OPEN HOLE OVER TIME, NOT THE PERMEABILITY OF A CAREFULLY SEALED BOREHOLE. IMPLEMENTING AGENCIES ARE FREE TO DEVELOP LESS SEVERE ASSUMPTIONS THAN THE ABOVE, AS APPROPRIATE TO THE PARTICULAR DISPOSAL SYSTEM. (SCOPE OF PERFORMANCE ASSESSMENTS AS REQUIRED BY § 191.13 AND DEFINED IN § 191.12.) SUCH PERFORMANCE ASSESSMENTS NEED NOT CONSIDER CATEGORIES OF EVENTS OR PROCESSES THAT ARE ESTIMATED TO HAVE < 1 CHANCE IN 10,000 OF OCCURRING OVER 10^4 YEARS. ALSO, EVENTS AND PROCESSES MAY	

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BE OMITTED FROM THE PERFORMANCE ASSESSMENTS IF THE REMAINING PROBABILITY DISTRIBUTION OF CUMULATIVE RELEASES WOULD NOT BE SIGNIFICANTLY CHANGED.

(COMPLIANCE WITH § 191.13.)

WHENEVER PRACTICABLE, IMPLEMENTING AGENCY SHOULD ASSEMBLE AS RESULTS OF PERFORMANCE ASSESSMENTS INTO A "COMPLEMENTARY CUMULATIVE DISTRIBUTION FUNCTION" THAT INDICATES THE PROBABILITY OF EXCEEDING VARIOUS LEVELS OF CUMULATIVE RELEASE. WHEN UNCERTAINTIES IN PARAMETERS ARE CONSIDERED IN A PERFORMANCE ASSESSMENT, THE EFFECTS OF THE UNCERTAINTIES CAN BE INCORPORATED INTO A SINGLE SUCH DISTRIBUTION FUNCTION FOR EACH DISPOSAL SYSTEM CONSIDERED. EPA CONSIDERS A DISPOSAL SYSTEM MAY BE CONSIDERED TO BE IN COMPLIANCE IF THIS SINGLE DISTRIBUTION FUNCTION MEETS THE REQUIREMENTS OF § 191.13.

(COMPLIANCE WITH § 191.15 (NEW)).

WHEN THE UNCERTAINTIES IN UNDISTURBED PERFORMANCE OF A DISPOSAL SYSTEM ARE CONSIDERED, IMPLEMENTING AGENCIES NEED NOT REQUIRE A VERY LARGE PERCENTAGE OF THE RANGE OF ESTIMATED RADIONUCLIDES FALL BELOW THE LIMITS ESTABLISHED IN § 191.15. EPA BELIEVES COMPLIANCE MAY BE BASED UPON THE "BEST ESTIMATE" PREDICTIONS (E.G., THE MEAN OR THE MEDIAN OF THE APPROPRIATE DISTRIBUTION, WHICHEVER IS HIGHER).

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(NOT IN ORIGINAL NOTICE)	§ 191.15 GROUND WATER PROTECTION REQUIREMENTS - DISPOSAL SYSTEMS SHALL BE DESIGNED TO PROVIDE THAT, FOR FIRST 1000 YEARS AFTER DISPOSAL, UNDISTURBED PERFORMANCE OF THE DISPOSAL SYSTEM SHALL NOT CAUSE AVERAGE ANNUAL RADIONUCLIDE CONCENTRATIONS WITHIN ANY SIGNIFICANT SOURCE OF GROUND WATER OUTSIDE THE CONTROLLED AREA TO EXCEED: - 5 pCi/L OF RA-226 AND RA-228; - 15 pCi/L OF α-EMITTERS (INCLUDING RA-226 AND RA-228); OR - COMBINED βγ-EMITTERS THAT WOULD PRODUCE ANNUAL DOSE EQUIVALENT TO WB OR ANY INTERNAL ORGAN > 4 MREM/YR IF AN INDIVIDUAL CONTINUOUSLY CONSUMED 2 L/DAY OF DRINKING WATER FROM SUCH A SOURCE OF GROUND WATER. - DISPOSAL SYSTEMS SHALL ALSO BE DESIGNED SO THAT, FOR 1000 YEARS AFTER DISPOSAL, UNDISTURBED PERFORMANCE OF THE DISPOSAL SYSTEM SHALL NOT CAUSE THE AVERAGE ANNUAL RADIONUCLIDE CONCENTRATIONS IN WATER WITHDRAWN FROM ANY PORTION OF A SPECIAL SOURCE OF GROUND WATER TO EXCEED THE CONCENTRATIONS IN § 191.15 (AS GIVEN ABOVE). - IF ANY OF THE AVERAGE ANNUAL RADIONUCLIDE CONCENTRATIONS IN WATERS CONSIDERED ABOVE ALREADY EXCEED THE ABOVE LIMITS BEFORE CONSTRUCTION OF THE DISPOSAL SYSTEM, THE DISPOSAL SYSTEM SHALL BE DESIGNED TO PROVIDE A REASONABLE EXPECTATION THAT, FOR 1000 YEARS AFTER DISPOSAL, UNDISTURBED	[NUCLEAR WASTE POLICY ACT OF 1982] RECOMMENDATION THAT FOR FIRST 500 THE STANDARD EMBODY AN EXTREMELY LOW LIKELIHOOD THAT INCREASES IN RADIOACTIVE CONTENT IN POTABLE WELL WATER APPROACH PRESENT EPA DRINKING WATER LIMITS.

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-	PERFORMANCE OF THE DISPOSAL SYSTEM SHALL NOT INCREASE THOSE AVERAGE ANNUAL RADIONUCLIDE CONCENTRATIONS BY MORE THAN 10% OF THE CONCENTRATIONS EXISTING BEFORE DISPOSAL SYSTEM CONSTRUCTION. HOWEVER, IF THE 10% POTENTIAL INCREASE WILL EXCEED THE ABOVE NUMERICAL LIMITS, THE INCREASE SHALL BE LIMITED TO THE VALUE OF THE NUMERICAL LIMITS.	

§ 191.16 ALTERNATIVE PROVISIONS FOR DISPOSAL OF EXISTING HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES

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(NOT IN ORIGINAL NOTICE)	- THE ADMINISTRATOR MAY BY RULE SUBSTITUTE ALTERNATIVE PROVISIONS FOR DISPOSAL OF SPECIFIC WASTES THAT: - EXIST ON THE EFFECTIVE DATE OF THIS SUBPART; - HAVE BEEN STORED IN SUCH A MANNER THAT RETRIEVAL AND RELOCATION OF THE WASTES WOULD BE UNUSUALLY DIFFICULT OR WOULD PRESENT SUBSTANTIAL RISKS TO HUMAN HEALTH AND THE ENVIRONMENT; AND - CAN BE ISOLATED FROM THE ENVIRONMENT SO THAT THE RISKS WOULD BE NO MORE THAN RISKS FROM RETRIEVAL AND RELOACTION TO A DISPOSAL SYSTEM MEETING SUBPART B REQUIREMENTS. - THE ADMINISTRATOR SHALL PROMULGATE SUCH ALTERNATIVE PROVISIONS ONLY AFTER: - DOE HAS PROVIDED EPA WITH INFORMATION ON COSTS, RISKS, BENEFITS OF DISPOSAL UNDER THE ALTERNATIVE PROVISIONS AND REASONS WHY SUBPART B PROVISIONS WOULD BE IMPRACTICAL; - ALTERNATIVE PROVISIONS HAVE BEEN PROPOSED FOR PUBLIC COMMENT IN THE FEDERAL REGISTER;	

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-	- A PUBLIC COMMENT PERIOD OF AT LEAST 90 DAYS HAS BEEN COMPLETED, INCLUDING OPPORTUNITY FOR PUBLIC HEARINGS; AND - PUBLIC COMMENTS RECEIVED HAVE BEEN FULLY CONSIDERED IN DEVELOPING THE FINAL VERSION OF THE ALTERNATIVE PROVISIONS.	
<u>§191.16 EFFECTIVE DATE</u> EFFECTIVE IMMEDIATELY UPON PROMULGATION OF RULE.	<u>§ 191.17 EFFECTIVE DATE</u> EFFECTIVE WITHIN 30 DAYS AFTER PUBLICATION IN FEDERAL REGISTER.	
<u>APPENDIX, TABLE 1</u> CONCENTRATIONS IDENTIFYING HIGH-LEVEL RADIOACTIVE WASTES	<u>APPENDIX</u> (DELETED)	
<u>APPENDIX, TABLE 2, RELEASE LIMITS FOR CONTAINMENT REQUIREMENTS (Ci/1000 MTHM)</u>	<u>APPENDIX A, TABLE 1, RELEASE LIMITS FOR CONTAINMENT REQUIREMENTS (Ci/1000 MTHM)</u>	
AMERICIUM-241 — 10 AMERICIUM-243 — 4	AMERICIUM-241 OR -243 — 100	RECOMMENDED FACTOR OF 10 INCREASE IN TABLE VALUES.
CARBON-14 — 200	CARBON-14 — 100	
CESIUM-135 — 2000 CESIUM-137 — 500	CESIUM-135 OR -137 — 1000	
	IODINE-129 — 100	
NEPTUNIUM-237 — 20	NEPTUNIUM-237 — 100	
PLUTONIUM-238 — 400 PLUTONIUM-239 — 100 PLUTONIUM-240 — 100 PLUTONIU,-242 — 100	PLUTONIUM-238, -239, -240, OR -242 — 100	
RADIUM-226 — 3	RADIUM-226 — 100	
STRONTIUM-90 — 30	STRONTIUM-90 — 100	
TECHNETIUM-99 — 10000	TECHNETIUM-99 — 10000	

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APPENDIX, TABLE 2 (CONT'D)

	(Ci/1000 MTHM)
TIN-126	80
ANY OTHER α-EMITTER	10
ANY OTHER NON-α-EMITTER	500

APPENDIX, NOTE 1

RELEASE LIMITS IN TABLE 2 APPLY TO:

- AMOUNT OF HIGH-LEVEL WASTES GENERATED FROM 1,000 MTHM, OR
- AMOUNT OF TRU WASTES CONTAINING 10^6 Ci OF α-EMITTING TRANSURANICS.

QUANTITIES IN TABLE 2 SHALL BE ADJUSTED TO DEVELOP RELEASE LIMITS FOR A SPECIFIC DISPOSAL SYSTEM (EXAMPLES GIVEN).

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APPENDIX A, TABLE 1 (CONT'D)

	(Ci/1000 MTHM)
THORIUM-230 OR -232	10
TIN-126	1000
URANIUM-233, -234, -235, -236 OR -238	100
ANY OTHER α-EMITTER, $T_{1/2}$ > 20 YRS.	100
ANY OTHER NON-α-EMITTER, $T_{1/2}$ > 20 YRS.	1000

APPENDIX A, NOTE 1

RELEASE LIMITS IN TABLE 1 APPLY TO:

- AMOUNT OF SPENT NUCLEAR FUEL CONTAINING 1,000 MTHM, BURNUP BETWEEN 25,000 AND 40,000 MWD/MTHM;
- AMOUNT OF HIGH-LEVEL WASTES GENERATED FROM 1,000 MTHM, BURNUP BETWEEN 25,000 AND 40,000 MWD/MTHM;
- EACH 10^9 Ci OF γ OR β-EMITTERS, 20 YRS. < $T_{1/2}$ < 100 YRS., IDENTIFIED BY NRC AS HIGH-LEVEL RADIOACTIVE WASTE;
- EACH 10^6 Ci OF OTHER RADIONUCLIDES (γ- OR β-EMITTERS, $T_{1/2}$ > 100 YRS.; OR α-EMITTERS, $T_{1/2}$ > 20 YRS.) IDENTIFIED BY NRC AS HIGH-LEVEL RADIOACTIVE WASTE; OR
- AMOUNT OF TRU WASTES CONTAINING 10^6 Ci OF α-EMITTING TRANSURANICS, $T_{1/2}$ > 20 YRS.

APPENDIX A, NOTE 2

SAME REQUIREMENT.

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RECOMMEND A SUITABLE EQUIVALENCY TO THE MTHM CONCEPT (SUCH AS ONE BASED ON NUMBER OF FISSIONS) BE ESTABLISHED FOR DEFENSE WASTES, AND FOR SOME KINDS OF COMMERCIAL WASTES.

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APPENDIX, NOTE 1 (CONT'D)

APPENDIX, NOTE 2

IF A MIXTURE OF RADIONUCLIDES IS PROJECTED TO BE RELEASED, THE LIMITING VALUE WILL BE DETERMINED AS FOLLOWS: FOR EACH RADIONUCLIDE IN THE MIXTURE, DETERMINE THE RATIO BETWEEN THE CUMULATIVE RELEASE QUANTITY OVER 10^4 YEARS AND THE TABLE 2 AND NOTE 1 LIMIT. THE SUM OF ALL SUCH RATIOS MAY NOT EXCEED 1.

APPENDIX A, NOTE 3

FOR REACTOR FUELS EXPOSED TO BURNUPS OF < 25,000 MWD/MTHM, OR > 40,000 MWD/MTHM, UNITS OF WASTE DEFINED IN NOTE 1 (FIRST TWO UNITS) SHALL BE ADJUSTED:

- IF BURNUP KNOWN, THEN:

$$\text{ADJUSTED UNIT} = \frac{(\text{NOTE 1 UNIT})(30{,}000\ \text{MWD/MTHM})}{(\text{FUEL'S ACTUAL BURNUP, MWD/MTHM})}$$

- IF BURNUP NOT KNOWN, THEN:

$$\text{ADJUSTED UNIT} = \frac{(\text{NOTE 1 UNIT})(1.5 \times 10^8\ \text{Ci})}{(\text{TOTAL SR-90 AND CS-137 IN WASTE OR SPENT FUEL} \sim 10\ \text{YRS. AFTER DISCHARGE FROM REACTOR})}$$

APPENDIX A, NOTE 4

FOR HIGH-LEVEL WASTE STREAMS THAT HAVE BEEN SEPARATED INTO COMPONENTS DESTINED FOR DIFFERENT DISPOSAL SYSTEMS, OR NO LONGER ASSOCIATED WITH THE QUANTITY AND EXPOSURE OF THE ORIGINAL REACTOR FUEL, FIRST TWO UNITS OF NOTE 1 ARE NOT RELEVANT, AND LAST TWO UNITS OF NOTE 1 SHALL BE USED.

APPENDIX A, NOTE 5

SAME REQUIREMENT, ENCOMPASSING TABLE 1 AND NOTES 1 THROUGH 4.

Objectives in High-Level Wastes/Spent Fuel Disposal

by

F. E. Culler

R. J. Catlin

R. F. Williams

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3412 Hillview Avenue

Palo Alto, California 94303

Objectives of High-Level Wastes/Spent Fuel Disposal

F. L. Culler, R. J. Catlin, R. F. Williams

Introduction

My purpose today is to review the objectives of the disposal of high-level radioactive wastes and spent reactor fuel elements, and, in the light of recent experience, suggest some potential areas where we can improve the process of implementation.

To a considerable extent, the challenge we face is much like that of the highway engineer who must devise a way to keep traffic moving on an expressway while performing major construction on the road. For the highway engineer it is sometimes possible to set up a detour, so that traffic can be routed around the area of construction. Detours generally produce delay. In the case of the high-level waste disposal program, a detour into more studies, legislative review, or a search for new concepts is not needed or appropriate. We have, through a painful but deliberate process over the past thirty years, developed the technology, a regulatory structure, and a lengthy process for public and agency participation to build repositories for high-level waste. There is much that we can do to improve the structure as we proceed down the path of program implementation.

Objectives

In defining the objectives of high-level waste disposal, four functional areas of interest must be addressed:

- Safety - the establishment of goals, standards and criteria for the protection of health and safety.

- Technology - the identification, development, and selection of a technology from a spectrum of choices.

- Regulation - the acquisition of scientific and experimental evidence to specify the level and to demonstrate the effectiveness of the technology to meet the criteria for safe permanent disposal.

- Process - the implementation of the selected technology within an agreed-upon framework that defines the responsibilities of the involved parties within the society, the process by which they interact, and the time frame for such action.

The objectives of high-level waste/spent fuel disposal are now stated with varying emphasis and level of complexity, depending on how explicitly the underlying requirements are stated.

For example, such objectives may be presented in the form of primary and secondary functional goals. Table 1 presents one such summary in a form which highlights some of the present issues in implementation.

An alternate approach would be to define the objectives in terms of progressive activities and operations, such as:

> "Site, design, license, construct, operate, and close a repository for the safe permanent disposal of radioactive waste."

A more complex statement making visible more of the implicit budgetary and institutional requirements would be:

> "Site, design, license, construct, operate, and close a repository for the safe permanent disposal of radioactive waste, at a reasonable or acceptable cost, and within a process affording reasonable opportunity for participation and comment by interested or involved individuals, organizations and governmental entities."

An even more complex approach escapes presentation in a single paragraph or paragraphs. The objectives are expressed in terms of "34 sources of goals" which specify a mixture of activity requirements in three time frames of interest, as shown in Table

2. This table, taken from NUREG-0300[1], is an example of a very complete and explicit spectrum of actions. In this formulation, the conflicts between certain factors and the need for tradeoffs is evident.

From the previous discussion of objectives several observations can be made. If the overall objectives are stated only in a complete and theoretical sense, it will be difficult to appreciate the degree to which the objectives in the real world have been modified over the past 30 years, particularly by choices and decisions in the technical, regulatory, and political arenas.

The major area of progress in the past several years has been to resolve some of the conflicts in goals by reduction in the number of technology options, by further embellishment of the regulatory process and by establishment of a complex procedural approach to institutional interaction. Given the confusion and overlap between objectives, goals, parameters, functions and responsibilities, it is not surprising that the primary objective of establishing an adequate and appropriate level of safety may be seemingly ignored.

Resolution of Goals

Let us briefly highlight some of the tradeoffs in goals which

have been made during the past several years. The technological base has changed little since the late 1960's when most technical options and failure modes were understood and reasonably evaluated. The analytic capabilities have undergone extensive expansion and improvements, however. Some new experimental data have been added. Changes and additions have occurred, hopefully to satisfy the greater public concern about nuclear wastes by the regulatory process. For example:

- The selection of mined geologic repositories over other options, such as deep space disposal, or burial under the polar ice caps, accomplished by the GEIS for Commercial High Level Waste Disposal[2], was a major programmatic technical decision. However, this selection should not foreclose research on other options of excellence.

- The issuance by EPA of its environmental standards for the management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes is a key element in the definition of regulatory requirements. It is now in draft form for public comment[3]. The definition by NRC of the procedural requirements for repository licensing and the technical criteria for HLW disposal[4] are also part of the procedures and published in final.

- o The Nuclear Waste Policy Act[5] established the major procedural elements for the institutional process by which the repositories are to be licensed, built and monitored. Tasks and schedules have been established that are heavily weighted for additional development and multiple levels of proof.

Thus, I would propose the following concise statement of waste disposal objectives, in light of the mixture of safety goals, technology, political process and the licensing and regulatory processes:

> "Try to build and operate a geologic repository by 1998 under the schedule, cost, and procedural requirements of the NWPA, meeting the safety, procedural, regulatory, and technical requirements of the EPA, the NRC, the DOE, the DOT (and 20 or so other federal, state, and local agencies)."

Because of the series of tradeoffs and compromises, a real question of feasibility remains. To use the phrase coined by Fred Singer in an informal talk at EPRI,

> Can the schedule and mandate of the NWPA be met, or do the process, procedures, and milestones constitute "pre-programmed grid-lock"?

Singer's question is certainly justified, because the approval mechanism enacted in Sections 114 and 115 of the Nuclear Waste Policy Act provides a Catch 22 for the actual location of a repository site some 5-10 years from now. Some of the elements that set the catch are:

- The approval structure for site selection, with two major feedback loops, as shown in Figure 1[6], that provides the potential for successive delays.

- Overlapping review and approval authorities of the President, the Congress, Federal and State agencies, Governors, local governments and Indian tribes.

Further, there is an increasing overlap among the several responsible Federal agencies involved in high-level waste disposal. It should be noted that the regulatory agencies operate almost as a fourth branch of the Government, one not contemplated by or subject to the Constitution, each with its own rules, compliance (trial) processes, decision-making, and enforcement actions and penalties.

Also, the courts have to a degree become extensions of the regulatory arm by ruling more frequently on issues of substantive technical judgment rather than of legal merit. The extent to which such actions may constitute a legal grid-lock in high-level waste disposal is yet conjectural.

A very real potential exists for grid-lock. However, a number of specific steps can be taken that might help to avoid paralysis, and some which might improve the present process. A few specific suggestions related to the topic of regulatory criteria and radiation protection are offered.

Improving the Regulatory Process during the Preparation Period Prior to 1998.

A major fraction of the expenditures in a $25 to $35 billion dollar waste management program[7] is directed to collecting sufficient data for repository performance assessment, and to demonstrate compliance with regulatory criteria. Perhaps 20 to 30% of the program expenditures relate directly, and another 30 to 40% of the program expenditures indirectly to the process of demonstrating regulatory compliance with adequate or reasonable assurance.

In order to simplify the selection, nomination and licensing of the initial repositories, we should ask: does the process, the design, or the criteria need modification? If so, can the change be made without major detrimental side effects? There are topics or areas in the regulatory process and the implementation of radiation protection criteria which offer the possibility for simplification, cost containment and other improvements, and deserve review. The topic is too broad to be treated

comprehensively in this paper, but let us consider a few examples:

- Societal goals and radiological health protection criteria.
- Numerical standards and redundancy requirements for engineered barriers.
- Treatment of uncertainty in performance evaluation.
- Use of the collective dose concept.

Societal Goals and Radiological Health Protection Criteria

Societal goals must be established for waste disposal in order to keep potential health detriments to present populations and future generations unlikely to exceed low, acceptable levels of risk. From these goals, secondary standards must be established to define performance criteria and design parameters. Such criteria may be evaluated against analyses of expected behavior of the repository in the geochemical environment, from which analyses of future risk may be projected.

EPA, in its proposed rule[3], enumerated such a societal goal in terms of not more than 1,000 possible additional cancer cases

during the first 10,000 years following closure of a repository in mined geological media, for each 100,000 metric tons of heavy metal (MTHM). As shown in Table 3 taken from the January 1984 report of the High-level Radioactive Waste Disposal Subcommittee of the EPA Science Advisory Board[8], the proposed standards lead to levels of protection that were considered by the Subcommittee to be much more stringent than levels of protection generally required or adopted in today's society and, moreover, far more stringent than the levels imposed on the disposal of chemical wastes. Even so, EPA now proposes to make its release limits more stringent by reducing the diffusion zone from the wastes to the accessible environment from 10 to 2 kilometers horizontal radius[9].

In developing this societal goal, EPA staff gave considered weight to the projected performance of model repositories in various geologic media, as well as to possibly analagous risks to health from unmined uranium ore bodies. In so doing, EPA staff chose not to extrapolate risks to individuals from population health impact projections, contrary to the current practice used by NCRP, ICRP, and proposed in the report of the Waste Isolation Systems Panel of the NAS/NRC[10] to specify goals and standards at an individual risk level.

Nevertheless, it is illuminating to compare safety goals and standards with experience and expectations of the individual cancer risks, as shown in Figure 2[11,12]. In terms of annual

cancer risk to an average individual, the EPA high-level radioactive waste disposal limit is shown to be three orders of magnitude below the nuclear power plant limits of 10 CFR Part 50, Appendix I[13], and almost five orders of magnitude below the cancer risk associated with exposure of the U.S. population from natural background radiation.

Moreover, the cancer risk from probable performance of waste repositories established in accordance with the draft EPA rule is projected to be several orders of magnitude lower than that derived from the rule, due to conservatisms inherent in regulatory risk assessment and design practices. Such perspectives contributed in large measure to recommendations by the EPA Subcommittee that the societal objective and the release limits in the EPA draft rule each be relaxed by a factor of 10.

In examining the possible outcomes of regulatory criteria, as set forth in Table 3[8], the preceding discussion shows that although the levels of the EPA draft rule may be taken at face value to assure public health and safety, the proposed standards do not appear to have a direct relationship to real levels of potential harm. Nor are the relationships to other hazards or tradeoffs in cost-benefit or cost-effectiveness readily apparent. Considering the billions of dollars cost projections for the high-level radioactive waste disposal programs in the United States, together with other multi-billion dollar waste management programs, such as Superfund, placing demands on the public

monies, the societal goals and release criteria would appear candidates for review in terms of risk/cost tradeoffs and perspective on acceptable levels of risk.

Numerical Standards for Engineered Barriers

In the reference models derived by EPA in its draft population risk report[14], expected health effects over the first 10,000 years were compared for salt, granite and basalt for a series of comparable parameters (geochemistry, ground water flow, waste form, canister performance, etc.). For levels of 100 and 1,000 health effects (cancers) over 10,000 years, certain minimum engineering controls were specified in EPA's Draft Regulatory Risk Analysis[15] in terms of leach rate and canister life, for the purposes of estimating performance, as shown in Table 4. Similarly, NRC has specified in 10 CFR Part 60[4] its minimum performance standards for the engineered barriers (as a whole) and for canister life, also given in Table 4. As the comparison shows, application of the more conservative NRC requirements would lead to the expectation of a ten-fold reduction in societal effects, i.e., from 1,000 down to 100 cancer in 10,000 years. The difference appears as a good example of one regulatory agency exercising conservatism on the technical specifications of another agency without due consideration of either the necessity or trade-offs of its actions. The example also represents one of the inputs to regulatory conservatism exercised on the EPA draft standard, as indicated in Figure 2.

Approach to Treatment of Uncertainty

High-level radioactive waste disposal is a probabilistic process, as noted previously. It is a process which the scientific and public communities can characterize in absolute certitude as an uncertain endeavor. Yet, the licensing and operation of a nuclear waste repository will require a detailed analysis built upon treatment of uncertainties to provide reasonable assurance of safety, i.e., that Federal performance requirements will be met. Such analysis of expected performance will involve the construction of probability density functions for all important parameters in the waste disposal system.[3,16].

Both risk assessment and risk management actions require an intelligent treatment of uncertainty. Uncertainties are real in many parameter of waste disposal systems, involving:

- Dose/effect models for predicting health effects;
- Stochastic and non-stochastic diffusion and dispersion properties;
- Lack of perfect data; and
- Extrapolation from short-term phenomena to extended-term behavior of man and his environment.

In the past, distribution functions for determining probability density function (or pdf's) in waste management have, in large measure, been constructed on the basis of expert opinion or mathematical convenience. Popular choices have included normal, log-normal and uniform distributions. Faced with the desire for statistically valid rationales in selecting pdf types, various limiting theorems in probability theory, such as the Central Limit Theorem, have been invoked to justify the choice. But this theorem must be applied with caution because of the great difficulty, generally, in proving that physical situations being modeled satisfy the mathematical prerequisites.

When data are sparse, proof of the correctness of a particular type of distribution is difficult, as shown in Figure 3[16]. In this histogram showing the distribution of 1000 samples of the sum of 10 log-normally distributed travel times, the normal distribution (solid line) best fits the histogram, but the log-normal best-fitting distribution would be equally reasonable. In this case, the sum of log-normally distributed travel times approaches a normal distribution, as predicted by the Central Limit Theorem, chiefly because the geologic units were assumed to have identically distributed travel times. If the travel times differed or the travel time in one layer were to affect the travel time in another, the theorem might not hold.

Although the Central Limit Theorem does not apply directly to give normal distributions when variables are combined in ways

other than by addition, it can be used to show that products do tend to become log-normal, as shown in Figure 4[16]. This histogram shows the result of multiplying four normally distributed variables, each with the same mean and standard distribution. The resultant distribution is not normal but very close to log-normal.

Thus, under certain circumstances, the Central Limit Theorem predicts that the sum of a large number of random variables will approach a normal distribution, and the product of a large number of random variables will become log-normally distributed. While in many cases these premises will be true, the results will be sensitive to some key parameters and insensitive to others. The identification of pertinent parameters and their distributions is underway, as shown, for example, in Table 5[17]. However, one cannot assume a priori that the distribution of combined parameters may automatically be deduced from the individual pdf's. First, the individual parameters must be assigned pdf's and the results computed. Then, key parameters must be identified and their pdf's determined with greater precision. Such an approach is needed to ensure that the probability distribution of cumulative releases from repositories comprising the "complementary cumulative distribution function" of the draft EPA standards is meaningful.

Use of the Collective Dose Concept

Now if safety is the paramount determinant for disposal of high-level radioactive waste, taking the form of a societal limit for detrimental health effects over future generations, the scientific community must assure that these health effects are projected in a meaningful way, particularly at the extremely low levels of risk envisaged. I refer to that aspect of collective dose determination commonly characterized as the "minidose/mega-population" issue. The open literature gives many projections of expected fatal cancers per year of normal operations in populations near facilities that stretch scientific credulity: for example, rates of projected fatal cancers per year of operation on the order of 10^{-4} for one facility to 10^{-13} for another, from airborne emissions of radio-nuclides[18]. Similar projections have been integrated in the assessment of performance of high-level radioactive waste repositories. Yet, in a recent publication by the Nuclear Energy Agency[19], Professor Bo Lindell, referring to high-level waste repositories in geological formations where no radioactive material is postulated to reach the biosphere for the first 100,000 years, states:

> "For such long time periods, estimates of collective doses are by necessity uncertain and the result can hardly be used as the basis for differential cost-benefit analysis. Such analysis is therefore just not an available method for

optimization of protection in thoses cases; the collective dose commitment has ceased to be meaningful."

Clearly, this is an area where the NCRP can make an important contribution, bearing as it does not only on waste disposal activites but on "de minimis" and ALARA issues as well.

Conclusions

Considering, then, the objectives and current status of the high-level radioactive waste disposal program in the United States, I should like to offer some observations and conclusions that may prove pertinent to the furtherance of that program. I also suggest that in many of the more important issues an independent body with broad scientific and technical base, such as the National Council on Radiation Protection and Measurements (NCRP), can provide substantial leadership and guidance.

Successful disposal of the Nation's high-level radioactive wastes is an absolute necessity, not an achievement to be temporized or foisted off on future generations. The technology, knowledge and skills are at hand. However, a very real danger exists that such disposal may be significantly delayed or may approach a grid-lock unless the system for approval is clarified, and the coordination of the responsible agencies is improved. We should re-examine

whether the present overlapping, yet independent structures can be simplified and unified.

The goal of safety must not be lost in developing competing programmatic, regulatory and technological pursuits.

It is equally important that this emphasis on safety is not overdone. The pursuit of safety should address an overall goal that is balanced, attainable and demonstrable. Our mechanisms for assuring safety must avoid illogical, cascading requirements, whether in engineering, regulation or public participation.

Radioactive waste management and disposal should not create self-perpetuating organizations who never finish their R&D[1]. It is important that we recognize this goal to apply not only to the disposers of waste but equally to all participants. Progressive regulatory closure should go hand-in-hand following progressive repository implementation and closure.

It is important that the private sector broaden its overview of the high-level radioactive waste disposal program to examine performance in the preparation period, and to constantly look at the issues of risk assessment and risk management. In so doing, attention should be given to several key areas:

- Defining the acceptable level of risk from geologic disposal.

- Simplifying and accelerating the waste disposal program.

- Reviewing how waste management criteria are being developed and applied.

- Ensuring the documentation, validation and usefulness of the standards and methodologies applicable to disposal in geoglogic repositories.

Perhaps the greatest attention should be given first to the determination of the levels of acceptability of risk from geologic disposal. Such determination cannot be made on the basis of first principles, involvng as it does subtle balancing of data, judgments and perceptions. Clearly, a more realistic and attainable solution is needed, one to which the NCRP can contribute in an important way.

Finally, some balance must be found between investment in debate and protocols, and investment in facilities and operations that accomplish real waste disposal and provide real levels of protection.

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Table 1

Waste Disposal Objectives

Primary objective

The primary objective is to achieve the disposal of high-level radioactive waste so that:

- Potential detriments to present populations and future generations are unlikely to exceed low, acceptable levels of risk;

- Disposal methods are efficient, cost-effective, and contain an adequate degree of redundancy in protective measures; and

- Active regulatory overview is provided in the first generation (i.e., up to 100 years) following disposal to ensure overall efficacy and safety of the disposal process.

Secondary Objectives

The secondary objectives required to assure achievement of the primary objective include:

- The establishment of societal objectives and related standards and guides to define health protection goals and performance objectives for meeting those goals;

- The development of risk assessment methodologies for relating projected technological performance to potential effects on the environment and on health;

Table 1 (Continued)

- The development of appropriate disposal technologies for the preparation and packaging of wastes, the selection and construction of repositories, the emplacement of wastes, and repository closure in a safe, efficient and acceptable manner; and

- The establishment of institutional, regulatory, and administrative relationships and processes to assure establishment of disposal facilities and operations in an expeditious manner to achieve the requisite requirements for safety, technological excellence and management of costs.

TABLE 2: PRIMARY SOURCES OF GOALS[1]

GOAL # - TITLE		LAW OR REGULATION	FEDERAL PROGRAM ASSUMPTIONS	CONCERNS OF PUBLIC/CRITICS/ INDUSTRY	CONVENTION WISDOM*
A.1	The Necessity of Basing Decisions and Actions on Impact Assessments	X	X	X	
A.2	The Necessity of Including All Aspects	X	X	X	
A.3	Consideration of Nonquantifiable Values			(X)	X
A.4	The Importance of Making Uncertainties Explicit	(X)		X	
A.5	Making the System Attainable		(X)	X	
A.6	Involving Society in the Decision Planning Process	X	X	X	
A.7	Involving State, Local and Regional Governments		X	X	(X)
A.8	Public Participation in the Decision Process	X	X	X	
A[illegible]	Assigning Costs of the System		(X)	(X)	X
B.1	Providing Organizational Flexibility				X
B.2	Organizational Response to Changes		(X)	(X)	X
B.3	Independence of the System from the Fuel Cycle		(X)	X	X
B.4	Ability of Organizations and Institutions to Detect and Rectify Errors			X	X
B.5	Assuring Managerial Competence	(X)	(X)	X	
B.6	Protecting Public Health and Safety During System Operation	X	X	X	X
B.7	Minimizing Effluents	X	X	X	
B.8	Minimizing the Probability of Untoward Events		X	X	
B.9	Reacting to Untoward Events	(X)	X	X	
B.10	Minimizing the Interval Between Waste Creation and Disposal	X	X	(X)	

Table 2 (Continued)

GOAL # - TITLE		LAW OR REGULATION	FEDERAL PROGRAM ASSUMPTIONS	CONCERNS OF PUBLIC/CRITICS/ INDUSTRY	CONVENTION WISDOM*
C.1	Immediate Establishment of Complete Waste Management Program		X	X	
C.2	Effects of Present Needs on Future Systems	(X)	X	X	
D 1	Budgetary Considerations			(X)	X
E.1	Organizations and Institutions to Detect and Rectify Errors		(X)	(X)	X
E.2	Specifying the Normal State of the System				X
E.3	Documentation for the Future			(X)	X
E.4	Implementing Organizations Must Not Be Self-Perpetuating		(X)		X
E.5	Independence from the Political System			X	X
E.[illegible]	International Considerations		X	X	
F.1	Intermediate Handling and Storage Not Limiting	(X)	(X)	X	
F.2	Retrievability of Wastes After Disposal			X	
G.1	Location and Operation of Disposal Facilities		(X)	X	(X)
G.2	Decommissioning of Facilities			X	X
G.3	Stability of Social and Governmental Institutions		(X)	X	X
G.4	Compliance with Radiation Standards	X	X	X	X

X = Primary Source
(X) = By implication
* Ideas which the Task Group found compelling but which had no identifiable source in the usual radioactive waste management.

Table 3[8]

NUMBER OF POSSIBLE CANCER CASES DUE TO IONIZING RADIATION[1]

ORIGIN	NO. OF CASES PER YR.[2]	NO. OF CASES PER 10,000 YR.[2]
High-level Rad. Waste Disposal[3]	up to 0.1	up to 1,000
Uranium Mill Tailings[4]		
- Unprotected†	3	30,000*
- Protected (covered, etc.)	0.03	300*
Indoor Air Pollution		
- Residential Exposure[5]	1,000 to 20,000	10,000,000 to 200,000,000*
- Residential Weatherization (added cases)[5] (Nero Estimate)	250 to 5,000	2,500,000 to 50,000,000*
- Residential Weatherization (added cases)[6]	10,000 to 20,000	100,000,000 to 200,000,000*
Background Radiation[7]	3,000 to 4,000	30,000,000 to 40,000,000
[Cancer Deaths (U.S.)[8] (all causes)	430,000]	

Notes:

[1] These numbers are all calculated on the same basis using a linear non-threshold dose response model. The linear non-threshold model involves a high degree of speculation, and the resulting values have little merit as absolute indicators of the numbers of biological effects that may occur. It has been used here to provide a framework within which relative risks from various radiation exposure situations can be compared.

[2] Assuming constant U.S. population and culture - numbers with (*) are extrapolated from annual values.

[3] EPA proposed rule 40 CFR Part 191 (December 1982) number per 100,000 MTHM high-level radioactive waste repository.

[4] NRC (October 1980). "Uranium Mill Licensing Requirements: Final Rules," Federal Register, 45, No. 194, 65521-65538. Radon inhalation exposures.

Table 3 (Continued)

[5] Nero, A. V. "Indoor Radiation Exposures from ^{222}Rn and Its Daughters: A View of the Issue, "Health Physics, 45, No. 2, (August 1983), 277-288.

[6] EPA Report EPA 520/4-78-013 (revised printing, July 1979).

[7] NAS/NRC, The Effects on Populations of Exposure to Low Level of Ionizing Radiation (November 1972) - (1972 BEIR Report).

[8] American Cancer Society, Cancer Facts and Figures - 1982, 1981.

† Does not include health effects from water pathways.

Table 4[4,14,15]

MINIMUM PERFORMANCE SPECIFICATIONS - EPA AND NRC

MEDIA	LEVEL OF HEALTH EFFECTS OVER 10,000 YEARS		
	EPA		NRC
	100	1,000	1,000
SALT	10^{-6} - 10^{-5} PPY LEACH RATE & 10s TO 100s YRS. CANISTER	~ 10^{-2} PPY LEACH RATE & 10s TO 100s YRS. CANISTER	≤ 10^{-5} PPY LEACH RATE & 300 TO 1,000 YRS. CANISTER
GRANITE	(ditto)	~ 10^{-4} PPY LEACH RATE & 10s TO 100s YRS. CANISTER	(ditto)
BASALT	10^{-6} - 10^{-5} PPY LEACH RATE & > 2,000 YRS. CANISTER	10^{-6} - 10^{-5} PPY LEACH RATE & > 200 YRS. CANISTER	(ditto)

Table 5[17]

UNCERTAINTY IN RADIONUCLIDE
INDEPENDENT MODEL PARAMETERS

PARAMETER	TYPES OF DISTRIBUTION	LOWER BOUND	MEDIAN	UPPER BOUND
λ EN (VEGETATION WEATHERING COEFFICIENT)	LOGNORMAL	6.0	15.8	42.0
RESUSPENSION FACTOR	LOGNORMAL	1.0E-10	1.0E-9	1.0E-8
WATER TREATMENT FACTOR	UNIFORM	0.2	0.55	0.9
IRRIGATION FRACTION	LOGUNIFORM	0.02	0.1	0.5
DOSE-RESPONSE COEFFICIENT (EFFECTS/10^6 PERSON-REM)				
o LOW LET	SUBJECTIVE	0.0	100.0	1000.0
o HIGH LET	LOGNORMAL	13.7	100.0	761.6

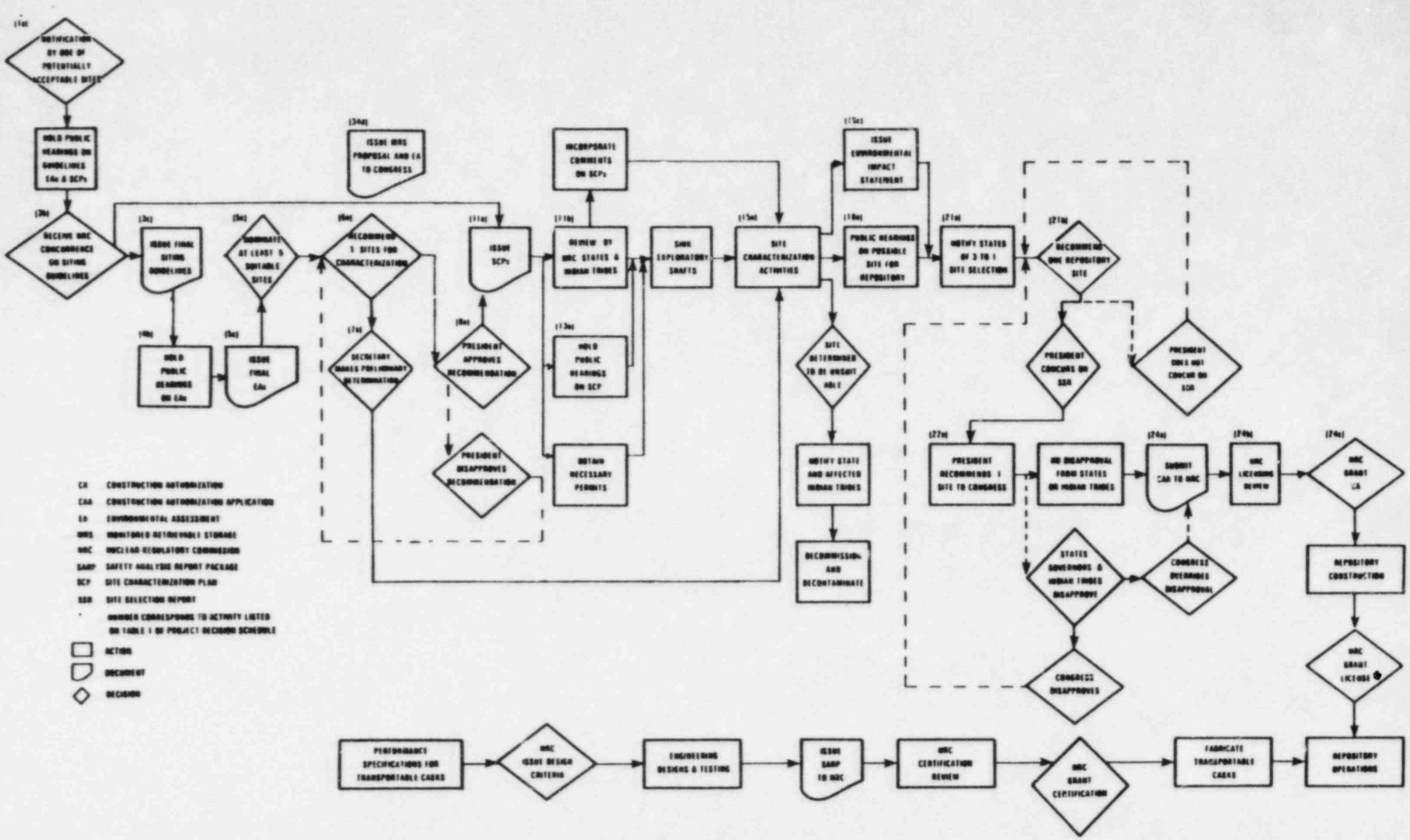
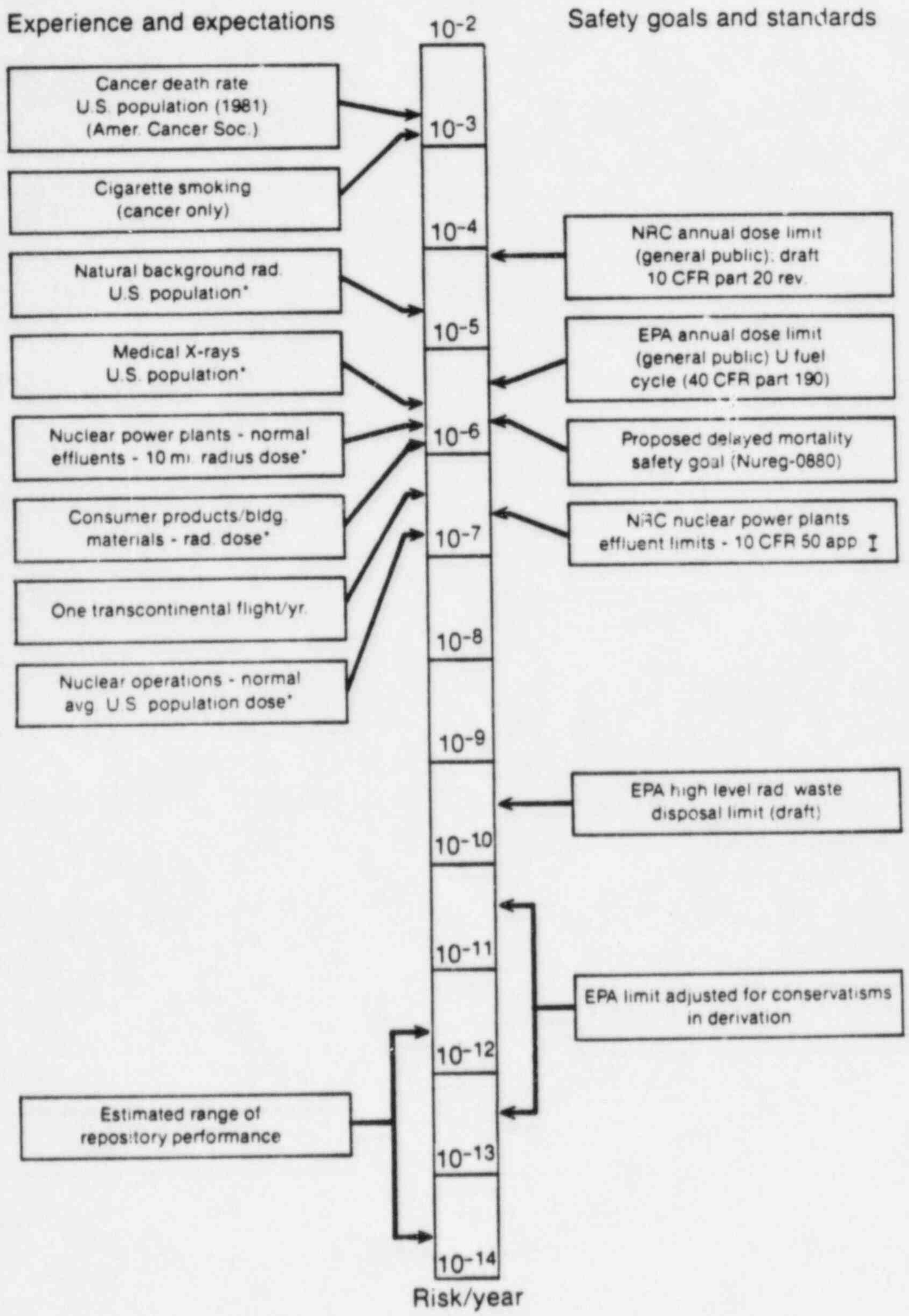


Figure 1. Radioactive waste management system — key activities and decisions points.[16]



Sources: (1) EPRI presentation EPA-SAB San Francisco March 24, 1983
(2) Wilson, Richard. Testimony for OSHA hearings on toxic substances. February 1978
* BEIR III

Figure 2. Individual annual risk of cancer. [11,12]

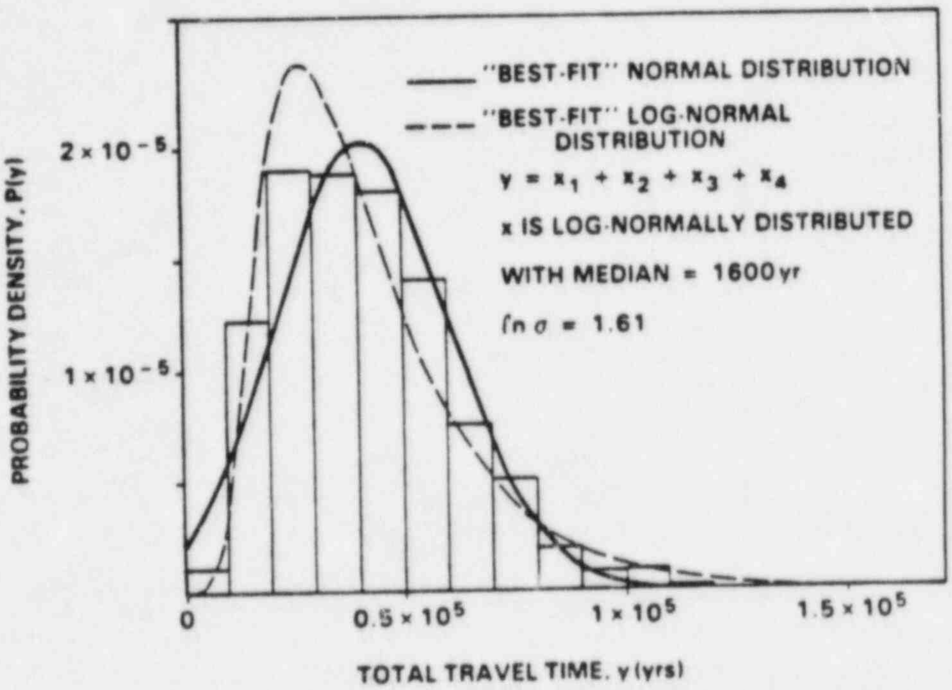


Figure 3. Histogram showing the distribution of 1000 samples of the sum of 10 log-normally distributed travel times. [16]

From: Scott, J. I. and Oston, S. G. *Effects of Parameter Probability Distributions in Performance Assessment Models.* Technical information memorandum no. 3336-9, The Analytical Sciences Corporation, Reading, MA (July 2, 1984).

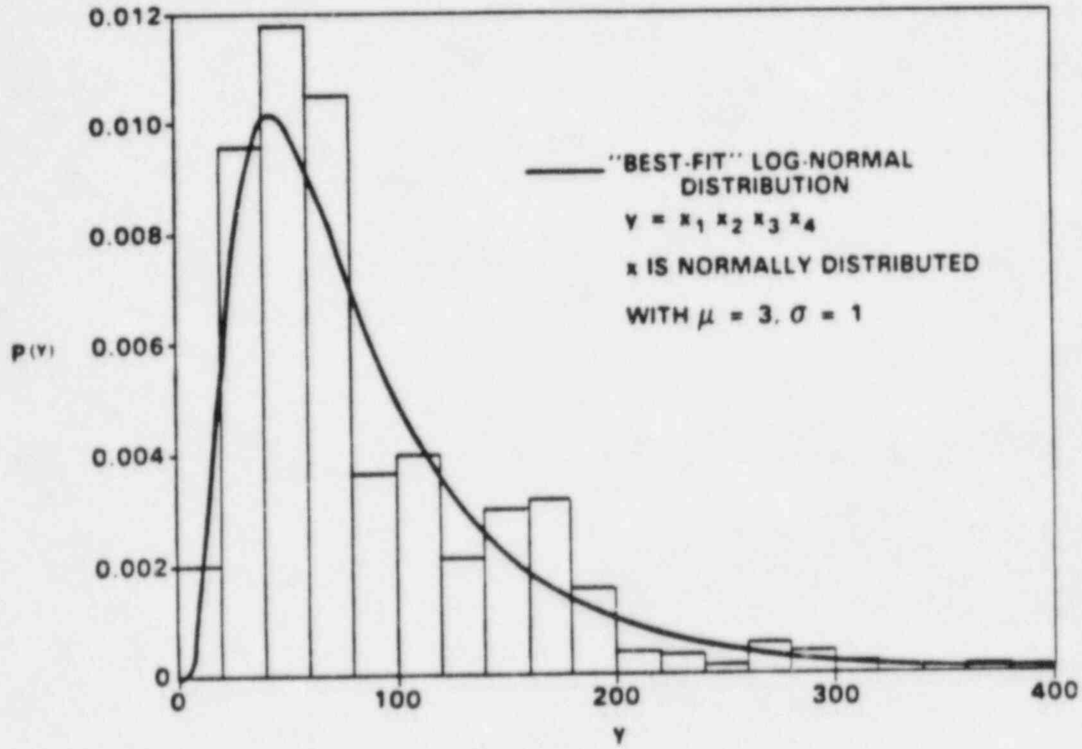


Figure 4. Histogram showing the distribution of 1000 samples of the product of four normally distributed variables.[16]

From: Scott, J. I. and Oston, S. G. *Effects of Parameter Probability Distributions in Performance Assessment Models.* Technical information memorandum no. 3336-9, The Analytical Sciences Corporation, Reading, MA (July 2, 1984).

11 April 1985
R.J.Catlin

SUMMARY ANALYSIS

EPA WORKING DRAFT # 5, 40 CFR PART 191
"Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes"

TECHNICAL FACTORS

Significant Changes

1. Reduction of the horizontal distance from the original location of wastes in a disposal system to the boundary of the accessible environment from 10 km. to 2 km.

2. Extension of applicability of the standards to two types of ground water in the vicinity of disposal system, in terms of limits on average annual radionuclide concentrations for the first 1,000 years after disposal:

   - In ground water outside the controlled area, i.e., in a horizontal direction from the original location of wastes beyond the surface location designated by passive institutional controls (markers, records, etc.) but no more than 2 km. from that original location; such ground water to be characterized as a significant source in terms of quality, depth from surface, transmissivity, capacity and usage; and

   - In Class I ground waters identified in accordance with EPA's Ground-Water Protection Strategy that are irreplaceable.

3. Assurance requirement to avoid locations where resources have been mined or are likely to be mined has been extended to include locations of ground waters that are irreplaceable or are vital to the preservation of unique and sensitive ecosystems.

4. The likelihood of exceeding specified release limits relative to containment requirements has been relaxed by a factor of 10.

Other Major Changes

5. The definition of high-level radioactive waste has been conformed to that in the Nuclear Waste Policy Act of 1982 (NWPA).

6. The definition of barrier has been expanded to include materials or structures that prevent or substantially delay the movement of <u>water</u> toward the accessible environment (as well as the movement of radionuclides).

7. The requirement for disposal system performance assessment has been expanded to include the assembly of cumulative release estimates into overall cumulative probability distributions for "compliance" determinations.

8. Detailed guidance on procedural requirements is given in a new appendix (B) which includes assumptions on inadvertent exploratory drilling to be used by implementing agencies, among other considerations.

9. Alternative definitions of units of waste other than spent fuel and high-level radioactive waste are specified in detail.

PROCEDURAL FACTORS

Significant Changes

10. NRC authority to define high-level radioactive waste is recognized.

11. DOE authority to define transuranic wastes, and NRC authority to define transuranic wastes under 10 CFR Part 61 are recognized.

12. EPA standards are specifically made applicable to DOE disposal facilities not regulated by NRC or Agreement States.

13. Authority to grant variances for unusual operations is moved from the implementing agencies to the EPA Administrator.

14 The definition of passive institutional control is expanded to include government ownership and regulations regarding <u>resource</u> use, as well as land use.

15. Applicability of EPA assurance requirements is lifted from facilities regulated by NRC in favor of their inclusion in 10 CFR Part 60.

16. Monitoring requirements after disposal have been added, with termination of monitoring effort to be made by implementing agency when need has passed.

17. Provision is made for EPA Administrator to issue alternative provisions for disposal of existing specific wastes conditional on DOE studies and proposals, subject to full public review.

Table 3[8]

NUMBER OF POSSIBLE CANCER CASES DUE TO IONIZING RADIATION[1]

ORIGIN	NO. OF CASES PER YR.[2]	NO. OF CASES PER 10,000 YR.[2]
High-level Rad. Waste Disposal[3]	up to 0.1	up to 1,000
Uranium Mill Tailings[4]		
- Unprotected†	3	30,000*
- Protected (covered, etc.)	0.03	300*
Indoor Air Pollution		
- Residential Exposure[5]	1,000 to 20,000	10,000,000 to 200,000,000*
- Residential Weatherization (added cases)[5] (Nero Estimate)	250 to 5,000	2,500,000 to 50,000,000*
- Residential Weatherization (added cases)[6]	10,000 to 20,000	100,000,000 to 200,000,000*
Background Radiation[7]	3,000 to 4,000	30,000,000 to 40,000,000
[Cancer Deaths (U.S.)[8] (all causes)	430,000]	

Notes:

[1] These numbers are all calculated on the same basis using a linear non-threshold dose response model. The linear non-threshold model involves a high degree of speculation, and the resulting values have little merit as absolute indicators of the numbers of biological effects that may occur. It has been used here to provide a framework within which relative risks from various radiation exposure situations can be compared.

[2] Assuming constant U.S. population and culture - numbers with (*) are extrapolated from annual values.

[3] EPA proposed rule 40 CFR Part 191 (December 1982) number per 100,000 MTHM high-level radioactive waste repository.

[4] NRC (October 1980). "Uranium Mill Licensing Requirements: Final Rules," Federal Register, 45, No. 194, 65521-65538. Radon inhalation exposures.

Table 3 (Continued)

[5] Nero, A. V. "Indoor Radiation Exposures from ^{222}Rn and Its Daughters: A View of the Issue, "Health Physics, 45, No. 2, (August 1983), 277-288.

[6] EPA Report EPA 520/4-78-013 (revised printing, July 1979).

[7] NAS/NRC, The Effects on Populations of Exposure to Low Level of Ionizing Radiation (November 1972) - (1972 BEIR Report).

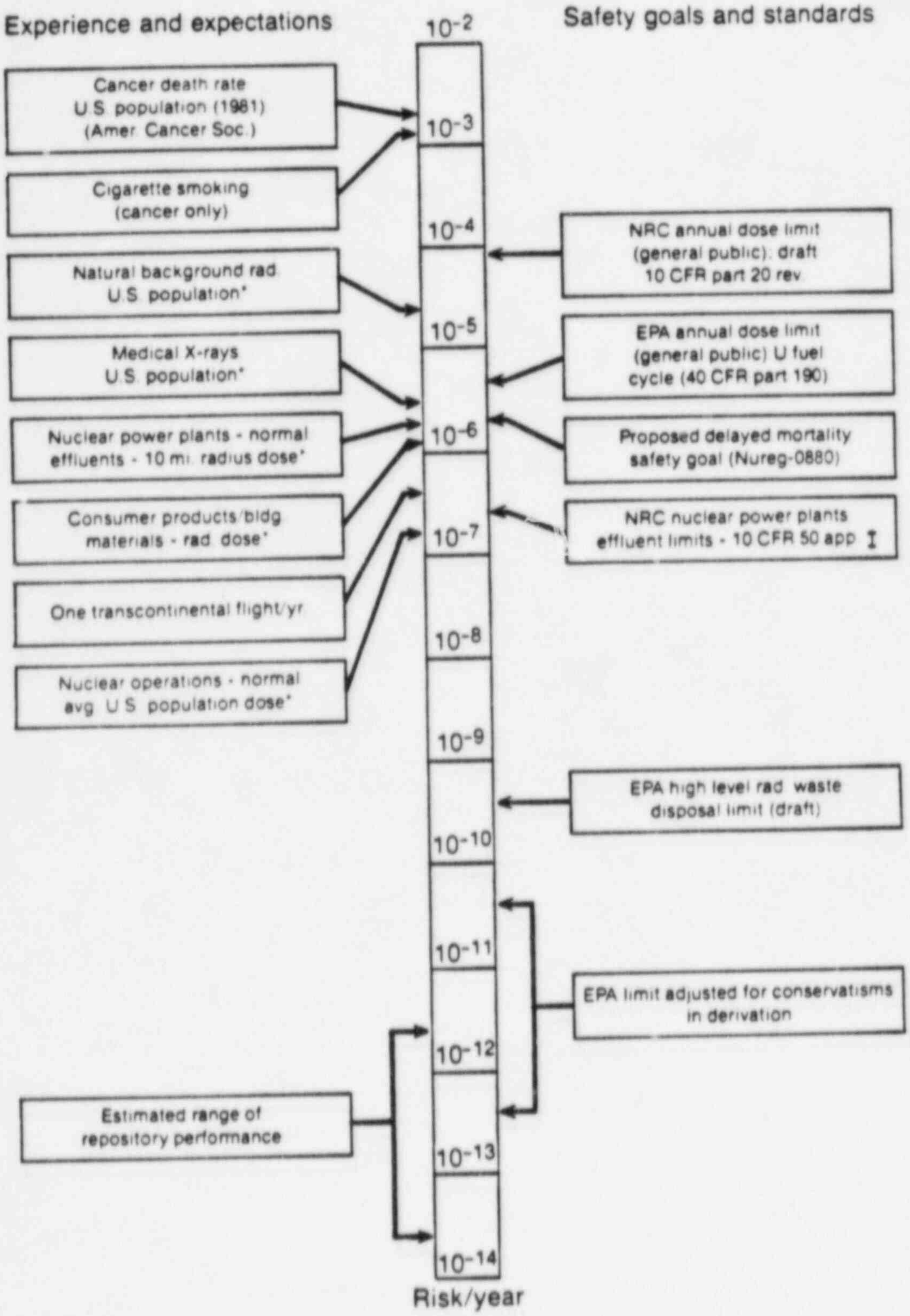
[8] American Cancer Society, Cancer Facts and Figures - 1982, 1981.

† Does not include health effects from water pathways.

Table 4[4,14,15]

MINIMUM PERFORMANCE SPECIFICATIONS - EPA AND NRC

MEDIA	LEVEL OF HEALTH EFFECTS OVER 10,000 YEARS		
	EPA		NRC
	100	1,000	1,000
SALT	10^{-6} - 10^{-5} PPY LEACH RATE & 10s TO 100s YRS. CANISTER	~ 10^{-2} PPY LEACH RATE & 10s TO 100s YRS. CANISTER	≤ 10^{-5} PPY LEACH RATE & 300 TO 1,000 YRS. CANISTER
GRANITE	(ditto)	~ 10^{-4} PPY LEACH RATE & 10s TO 100s YRS. CANISTER	(ditto)
BASALT	10^{-6} - 10^{-5} PPY LEACH RATE & > 2,000 YRS. CANISTER	10^{-6} - 10^{-5} PPY LEACH RATE & > 200 YRS. CANISTER	(ditto)



Sources (1) EPRI presentation EPA-SAB San Francisco March 24, 1983
(2) Wilson, Richard. Testimony for OSHA hearings on toxic substances, February, 1978
* BEIR III

Figure 2. Individual annual risk of cancer. [11,12]

Table 5[17]

UNCERTAINTY IN RADIONUCLIDE INDEPENDENT MODEL PARAMETERS

PARAMETER	TYPES OF DISTRIBUTION	LOWER BOUND	MEDIAN	UPPER BOUND
λ EN (VEGETATION WEATHERING COEFFICIENT)	LOGNORMAL	6.0	15.8	42.0
RESUSPENSION FACTOR	LOGNORMAL	1.0E-10	1.0E-9	1.0E-8
WATER TREATMENT FACTOR	UNIFORM	0.2	0.55	0.9
IRRIGATION FRACTION	LOGUNIFORM	0.02	0.1	0.5
DOSE-RESPONSE COEFFICIENT (EFFECTS/10^6 PERSON-REM)				
o LOW LET	SUBJECTIVE	0.0	100.0	1000.0
o HIGH LET	LOGNORMAL	13.7	100.0	761.6

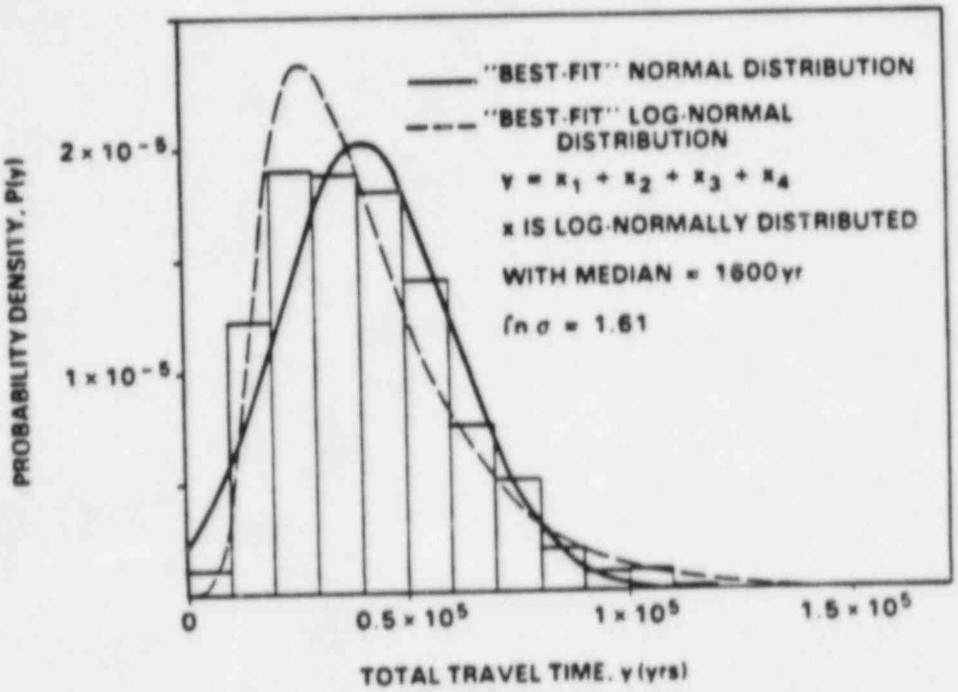


Figure 3. Histogram showing the distribution of 1000 samples of the sum of 10 log-normally distributed travel times. [16]

From: Scott, J. I. and Oston, S. G. *Effects of Parameter Probability Distributions in Performance Assessment Models*. Technical information memorandum no. 3336-9, The Analytical Sciences Corporation, Reading, MA (July 2, 1984).

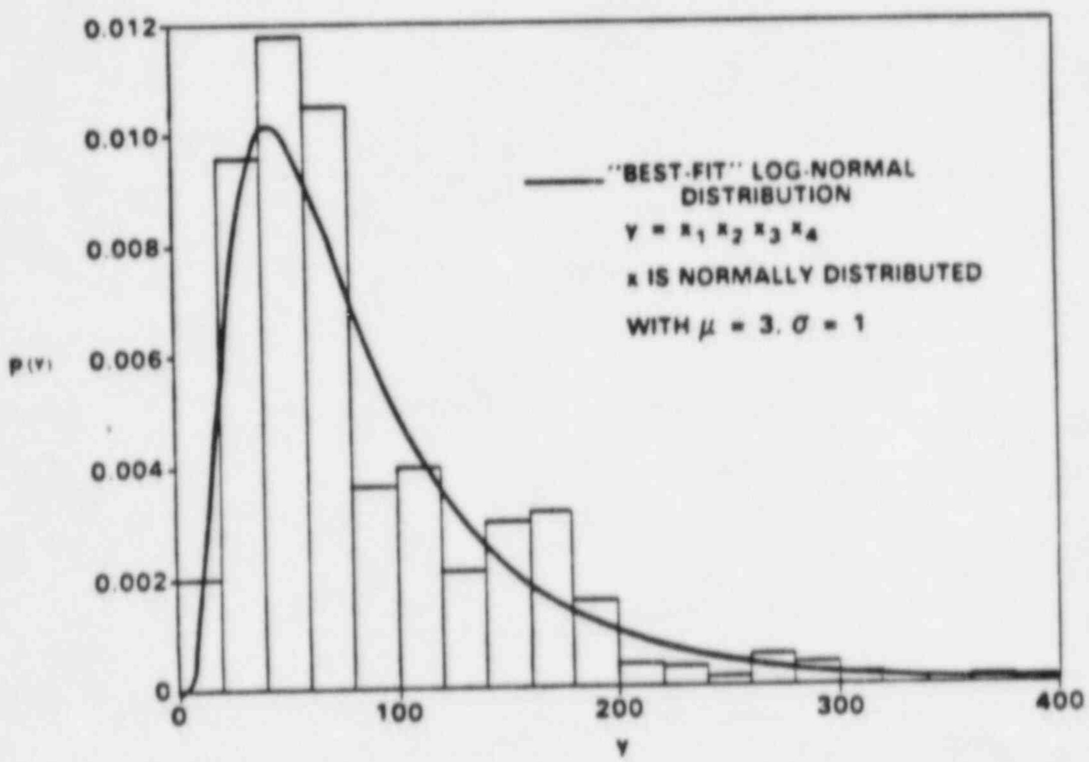
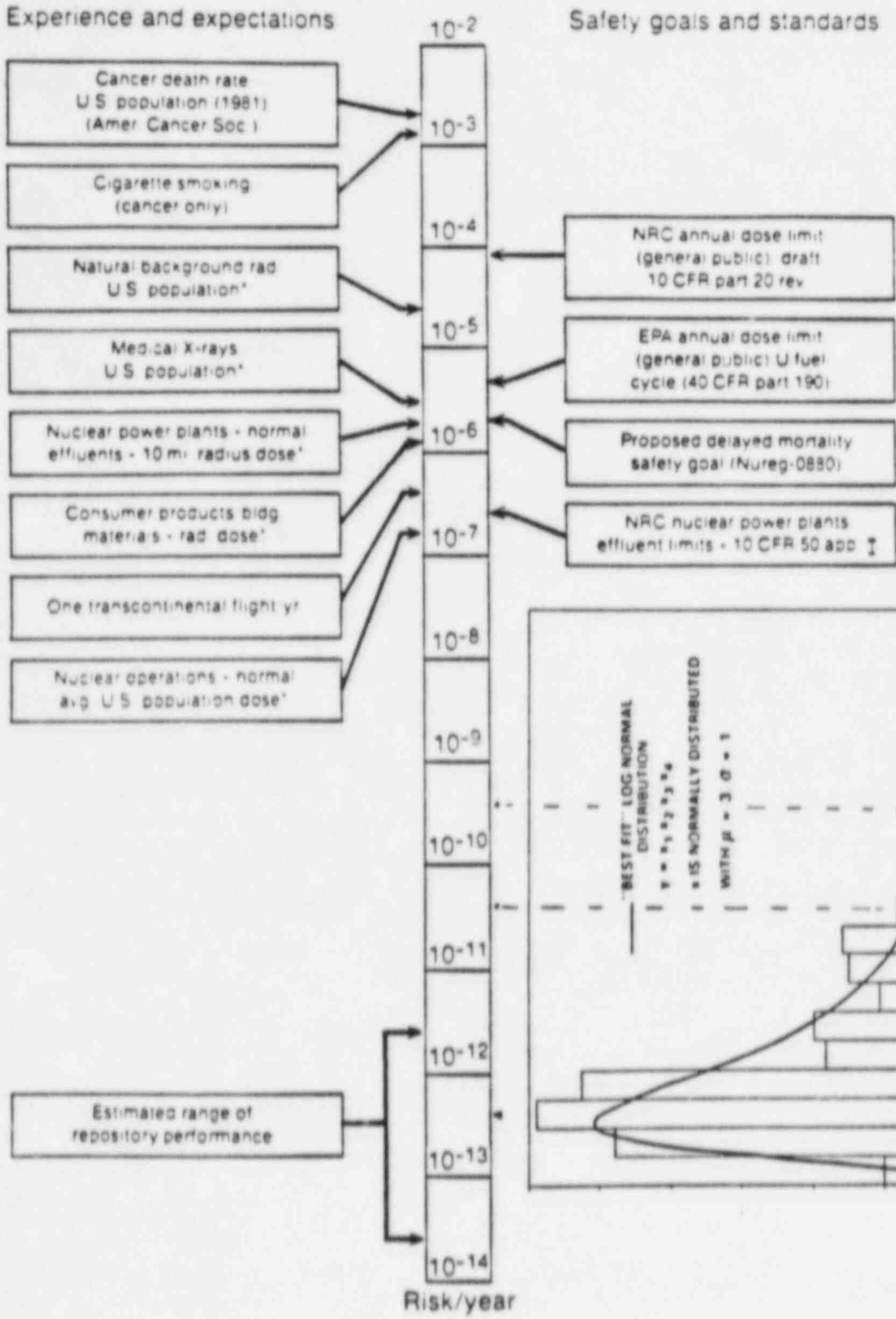


Figure 4. Histogram showing the distribution of 1000 samples of the product of four normally distributed variables. [16]

From: Scott, J. I. and Oston, S. G. *Effects of Parameter Probability Distributions in Performance Assessment Models*. Technical information memorandum no. 3336-9, The Analytical Sciences Corporation, Reading, MA (July 2, 1984).



- ARE STANDARDS UNNECESSARILY STRINGENT?
- WILL LACK OF APPARENT MARGIN COMPLICATE AND DELAY LICENSING?
  - EXTEND SITE CHARACTERIZATION?

FIG.1 **COMPARISON OF DEVELOPMENTAL BASES - GENERAL**

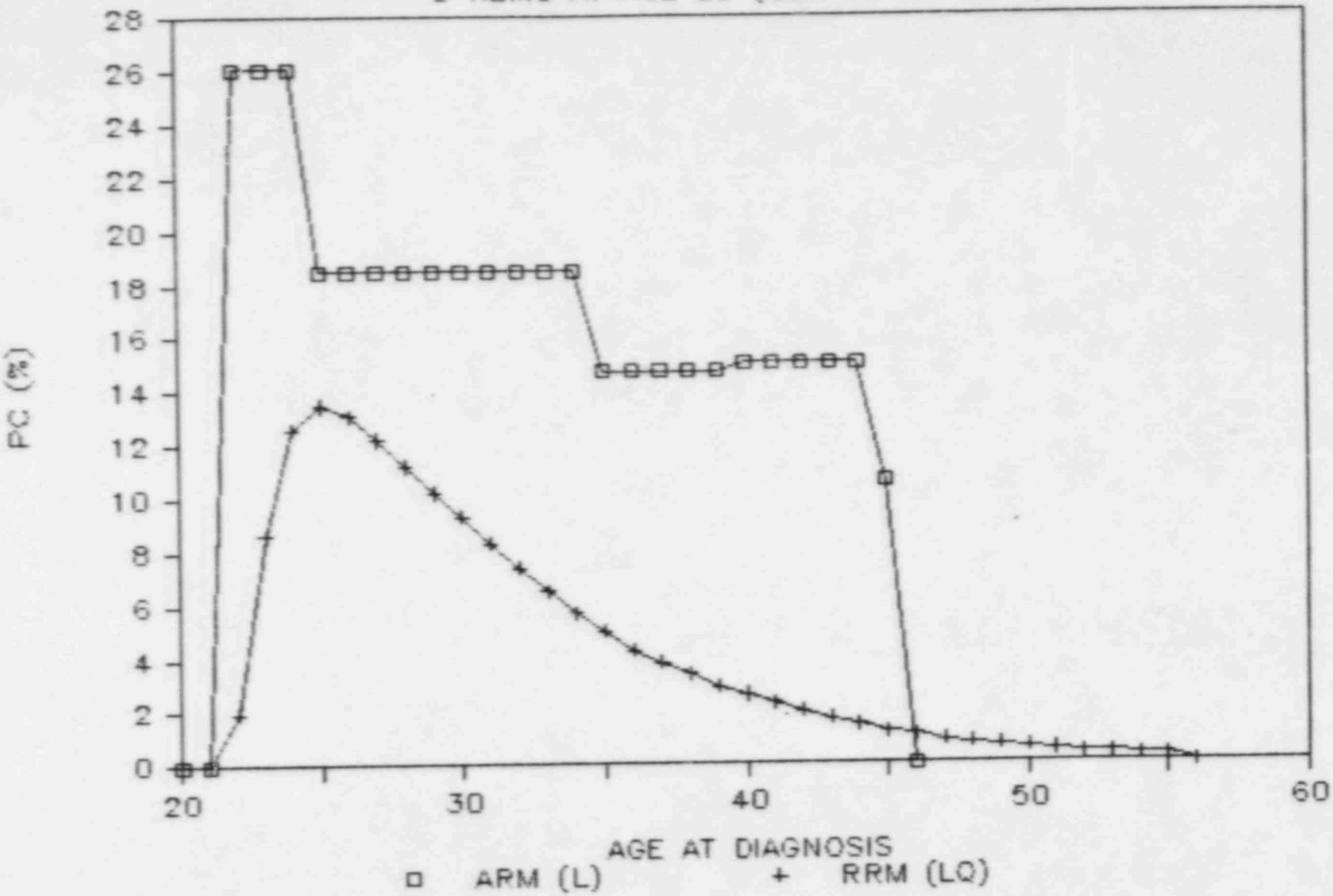
CONSIDERATION	RADIATION PROTECTION STANDARDS	PROBABILITY OF CAUSATION
o RADIATION RISKS	SOMATIC AND GENETIC STOCHASTIC AND NON-STOCHASTIC	SOMATIC STOCHASTIC
o OTHER RISKS	NONE	CHEMICAL CARCINOGENS AND SMOKING (WITH KNOWN DOSE-EFFECT RELATIONSHIPS)
o RISK RELATIONSHIPS	ADDITIVE	ADDITIVE AND MULTIPLICATIVE
o RADIATION SOURCES	INDUSTRY AND DEFENSE - OCCUPATIONAL AND PUBLIC EXPOSURES	INDUSTRY, DEFENSE AND MEDICAL PROCEDURES EXPOSURES
o PRIMARY CANCER SITES	ALL SITES (EXCEPT CHRONIC LYMPHOCYTIC LEUKEMIA)	12 SPECIFIED SITES - 14 SITES EXCLUDED
o AGE GROUPS	ALL AGE GROUPS	AGE GROUPS LIMITED FOR 7 OF THE 12 SPECIFIED SITES
o END POINT(S) OF INTEREST	MORBIDITY AND MORTALITY	MORBIDITY

FIG.2 COMPARISON OF DEVELOPMENTAL BASES - MODELING

CONSIDERATION	RADIATION PROTECTION STANDARDS	PROBABILITY OF CAUSATION
o RISK PROJECTION MODEL (OVER TIME)	ABSOLUTE RISK PROJECTION MODEL: ALL SITES	ABS. RISK PROJ. MODEL (WAVE FUNCTION): LEUKEMIA AND BONE CANCER RELATIVE RISK PROJ. MODEL: SOLID TUMORS EXCEPT BONE
o DOSE-RESPONSE MODEL	LINEAR: LOW- OR HIGH-LET: ALL SITES	LINEAR-QUADRATIC: LOW-LET: ALL SITES EXCEPT BREAST AND THYROID. LINEAR: LOW-LET: BREAST AND THYROID; HIGH-LET: ALL SITES
o RISK COEFFICIENTS	LINEAR (BEIR REPORT, 1980)	LINEAR ADAPTED TO LINEAR-QUADRATIC: SOLID TUMORS EXCEPT BREAST AND THYROID. LINEAR: BREAST AND THYROID
o LATENT PERIOD	BEIR REPORT (1980) VALUES	2 YEAR MINIMUM FOR LEUKEMIA AND BONE CANCER; SMOOTHED 5-10 YEARS FOR SOLID TUMORS

FIG.3 LEUKEMIA — ALL FORMS EXCEPT CLL

5 REMS AT AGE 20 (50% TO MARROW)



DOE F 1325.8
(5-83)

United States Government — Department of Energy

memorandum

DATE: FEB 14 1985

REPLY TO ATTN OF: NE-24

SUBJECT: Guidelines for Residual Radioactivity at FUSRAP and Remote SFMP Sites

TO: E. L. Keller, Director
Technical Services Division
Oak Ridge Operations Office

Clarence Miller, Director
Surplus Facilities Management
Program Office
Richland Operations Office

The attached guidelines, "U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites" (January 1985) should be implemented in FUSRAP and SFMP to establish authorized limits for remedial actions. The guidelines provide specific authorized limits for residual radium and thorium radioisotopes in soil, for airborne radon decay products, for external gamma radiation, and for residual surface contamination levels on materials to be released for unrestricted use. These guidelines will be supplemented in April 1985 by a document providing the methodology and guidance to establish authorized limits for residual radioisotopes other than radium and thorium in soil at sites to be certified for unrestricted use. The supplement will provide further guidance on the philosophies, scenarios, and pathways to derive appropriate authorized limits for residual radionuclides and mixtures in soil. These guidelines are based on the International Commission on Radiation Protection (ICRP) philosophies and dose limits in ICRP reports 26 and 30 as interpreted in DOE Order 5480.1A. These dose limits are 500 mrem/yr for an individual member of the public over a short period of time and an average of 100 mrem/yr over a lifetime.

The approval of authorized limits differing from the guidelines is described in section D, last sentence of the attached document. If the urgency of field activity makes DRAP concurrence not cost-effective, a copy of the approval and backup analysis should be furnished to DRAP as soon as possible, although not necessarily prior to beginning field activities.

As a result of a recent court decision, the Environmental Protection Agency (EPA) has issued airborne radiation standards applicable to DOE facilities. These final standards, issued as revisions to 40 CFR 61, are:

- o 25 mrem/yr-whole body

- o 75 mrem/yr-organ

- o waiver of these standards will be granted if DOE demonstrates that no individual would receive 100 mrem/yr continuous exposure whole body dose equivalent from all sources within 10 km radius, excluding natural background and medical procedures.

- o radon and radon daughters are excluded (these standards are covered in 40 CFR 192).

The primary airborne radioisotopes of concern in the FUSRAP are radon and its daughters and inasmuch as they are excluded from the EPA airborne standards, there appears to be minimal, if any, effect on the attached DOE/DRAP guidelines or its supplement.

The attached guidelines have been written to be consistent with the revision of the DOE Order 5480.1A now in draft at Headquarters and have the concurrence of the Public Safety Division, Office of Operational Safety. The guidelines have been prepared with the assistance and review by PE, DP, OR, RL, ANL, ORNL, PNL, and LASL. We greatly appreciate the contributions and comments that all involved organizations have made, particularly Tom Gilbert, ANL, who did much of the work.

John E. Baublitz

John E. Baublitz, Director
Division of Remedial Action Projects
Office of Terminal Waste Disposal
and Remedial Action
Office of Nuclear Energy

Attachments

cc:
See attached distribution list

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U.S. DEPARTMENT OF ENERGY GUIDELINES
FOR RESIDUAL RADIOACTIVITY AT
FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM
AND
REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(February 1985)

A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactivity, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Dept. Energy 1984). More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactivity from basic dose limits, is contained in a supplementary document--referred to herein as the "supplement" (U.S. Dept. Energy 1985).

"Residual radioactivity" includes: (1) residual concentrations of radionuclides in soil material,** (2) concentrations of airborne radon decay products, (3) external gamma radiation level, and (4) surface contamination. A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). Basic dose limits are used explicitly for deriving guidelines for residual concentrations of radionuclides in soil material, except for thorium and radium. Guidelines for

*A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

**The term "soil material" refers to all material below grade level after remedial action is completed.

residual concentrations of thorium and radium and for the other three quantities (airborne radon decay products, external gamma radiation level, and surface contamination) are based on existing radiological protection standards (U.S. Environ. Prot. Agency 1983; U.S. Nucl. Reg. Comm. 1982). These standards are assumed to be consistent with basic dose limits within the uncertainty of derivations of levels of residual radioactivity from basic limits.

A "guideline" for residual radioactivity is a level of residual radioactivity that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactivity presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement.

An "authorized limit" is a level of residual radioactivity that must not be exceeded if the remedial action is to be considered completed. Under normal circumstances, expected to occur at most sites, authorized limits are set equal to guideline values for residual radioactivity that are acceptable if use of the site is not be restricted. If the authorized limit is set higher than the guideline, restrictions and controls must be established for use of the site. Exceptional circumstances for which authorized limits might differ from guideline values are specified in Sections D and F. The restrictions and controls that must be placed on the site if authorized limits are set higher than guidelines are described in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). Implementation of ALARA policy is specified as procedures to be applied after authorized limits have been set. For sites to be released for unrestricted use, the intent is to reduce residual radioactivity to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual radioactivity is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to ALARA levels. Procedures for implementing ALARA policy are described in the supplement. ALARA policies, procedures, and actions must be documented and filed as a permanent record upon completion of remedial action at a site.

B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 500 mrem/yr for a period of exposure not to exceed 5 years and an average of 100 mrem/yr over a lifetime. The committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), shall be used for determining the dose.

C. GUIDELINES FOR RESIDUAL RADIOACTIVITY

C.1 Residual Radionuclides in Soil Material

Residual concentrations of radionuclides in soil material shall be specified as above-background concentrations averaged over an area of 100 m^2. If the concentration in any area is found to exceed the average by a factor greater than 3, guidelines for local concentrations shall also be applicable. These "hot spot" guidelines depend on the extent of the elevated local concentrations and are given in the supplement.

The generic guidelines specified below are for concentrations of individual radionuclides occurring alone. If mixtures of radionuclides are present, the concentrations of individual radionuclides shall be reduced so that the dose for the mixture would not exceed the basic dose limit. Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

The generic guidelines for residual concentrations of Th-232, Th-230, Ra-228, and Ra-226 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

The guidelines for residual concentrations in soil material of all other radionuclides shall be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. Procedures for deriving these guidelines are given in the supplement.

C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

C.3 External Gamma Radiation

The level of gamma radiation at any location on a site to be released for unrestricted use, whether inside an occupied building or habitable structure or outdoors, shall not exceed the background level by more than 20 μR/h.

*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

C.4 Surface Contamination

The following generic guidelines, adapted from standards of the U.S. Nuclear Regulatory Commission (1982), are applicable only to existing structures and equipment that will not be demolished and buried. They apply to both interior and exterior surfaces. If a building is demolished and buried, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

	Allowable Total Residual Surface Contamination (dpm/100 cm^2)†[1]		
Radionuclides†[2]	Average†[3],†[4]	Maximum†[4],†[5]	Removable†[6]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000β-γ	15,000β-γ	1,000β-γ

†[1] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

†[2] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

†[3] Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

†[4] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

†[5] The maximum contamination level applies to an area of not more than 100 cm^2.

†[6] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVITY

The remedial action shall not be considered complete unless the residual radioactivity is below authorized limits. Authorized limits shall be set equal to guidelines for residual radioactivity unless: (1) exceptions specified in Section F of this document are applicable, in which case an authorized limit may be set above the guideline value for the specific location or condition to which the exception is applicable; or (2) on the basis of site-specific data not used in establishing the guidelines, it can be clearly established that limits below the guidelines are reasonable and can be achieved without appreciable increase in cost of the remedial action. Authorized limits that differ from guidelines must be justified and established on a site-specific basis, with documentation that must be filed as a permanent record upon completion of remedial action at a site. Authorized limits differing from the guidelines must be approved by the Director, Oak Ridge Technical Services Division, for FUSRAP and by the Director, Richland Surplus Facilities Management Program Office, for remote SFMP--with concurrence by the Director of Remedial Action Projects for both programs.

E. CONTROL OF RESIDUAL RADIOACTIVITY AT FUSRAP AND REMOTE SFMP SITES

Residual radioactivity above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A requires compliance with applicable federal, state, and local environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to both interim storage and long-term management.

a. 5440.1B, Implementation of the National Environmental Policy Act

b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations

c. 5480.2, Hazardous and Radioactive Mixed Waste Management

d. 5480.4, Environmental Protection, Safety, and Health Protection Standards

e. 5482.1A, Environmental, Safety, and Health Appraisal Program

f. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

h. 5484.2, Unusual Occurrence Reporting System

i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing federal, state, or local standards.

d. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The federal government shall have title to the property.

E.2 Long-Term Management

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 $pCi/m^2/s$, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b of this section (E.2) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a of this section (E.2).

d. Groundwater shall be protected in accordance with 40 CFR 192.20(a)(2) and 192.20(a)(3), as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The federal government shall have title to the property.

F. EXCEPTIONS

Exceptions to the requirement that authorized limits be set equal to the guidelines may be made on the basis of an analysis of site-specific aspects of a designated site that were not taken into account in deriving the guidelines. Exceptions require approvals as stated in Section D. Specific situations that warrant exceptions are:

a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

c. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not be necessary where only minor quantities of residual radioactive materials are involved or where residual radioactive materials occur in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. In order to invoke this exception, a site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactivity must be included in the appropriate state and local records.

d. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be effected by remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of remedial actions that would be less costly than removal of the residual radioactive materials. A statement specifying the residual radioactivity must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

G. SOURCES

Limit or Guideline	Source
Basic Dose Limits	
Dosimetry Model and Dose Limits	International Commission on Radiological Protection (1977, 1978)
Guidelines for Residual Radioactivity	
Residual Radionuclides in Soil Material	40 CFR 192
Airborne Radon Decay Products	40 CFR 192
External Gamma Radiation	40 CFR 192
Surface Contamination	U.S. Nuclear Regulatory Commission (1982)
Control of Radioactive Wastes and Residues	
Interim Storage	DOE Order 5480.1A
Long-Term Management	DOE Order 5480.1A; 40 CFR 192

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RISK BALANCING: AN APPROACH TO RISK ASSESSMENT AND MANAGEMENT

Thomas L. Gilbert

Environmental Research Division
Argonne National Laboratory

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BACKGROUND

Based on insights gained during the development of U.S. Department of Energy Guidelines for Residual Radioactivity at FUSRAP* and remote SFMP† sites

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*FUSRAP = Formerly Utilized Sites Remedial Action Program

†SFMP = Surplus Facilities Management Program

GENERAL APPROACH TO ESTABLISHING GUIDELINES

- Establish basic dose limit
- Derive guidelines from basic dose limit
- Establish site-specific authorized limits based on guidelines
- Establish management criteria for sites that cannot comply with limits
- Apply ALARA* concept to reduce residual radioactivity or potential exposure below limits

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*ALARA = As Low As Reasonably Achievable

UNDERLYING ISSUES AND PROBLEMS

- Distinguishing questions of policy from questions of science
- Identifying and quantifying benefits, costs, and risks
- Providing a sound scientific basis for risk estimates
- Taking uncertainties in risk estimates into account
- Trade-offs: balancing benefits, costs, and risks
- Achieving an equitable distribution of benefits, costs, and risks
- Responding to public concerns, perceptions (and misperceptions) in a consistent and rational manner
- How safe is safe enough?
- How much can we afford for risk reduction?
- HOW SHOULD WE ALLOCATE LIMITED AVAILABLE RESOURCES FOR REDUCTION OF DIFFERENT RISKS?

MAJOR CONCERN

- Different government agencies focus on different risks, excluding consideration of other risks

- Leads to inconsistent regulation: some risks receive much more attention than others, with little regard for relative risks or total risk

- Need for balancing of different risks

A RISK BALANCING APPROACH

<u>Guiding Principle</u>: The purpose of government should be to maximize the quality of life and achieve reasonable equity.

QUALITY OF LIFE (Q) = BENEFITS (B) - COSTS (C)

- [RISKS (R) + COST OF LIMITING RISKS (L)]

where:

Q = Quality of life in a society

B = Benefits (monetary and nonmonetary) to all individuals from all societal activities

C = Costs (monetary and nonmonetary) for all societal activities except risk reduction

R = All risks (adverse consequences times probability)

L = Monetary costs for reducing risks to a specified limit

A RISK BALANCING APPROACH (Continued)

- There is a maximum, $L = L_{max}$, that a society is willing to allocate to limiting the total risk.

- The optimum risk management strategy is to minimize the total risk R subject to the constraint that $L = L_{max}$.

A RISK BALANCING APPROACH: MATHEMATICAL FORMULATION

$$R = \sum_{n=1}^{N} W_n R_n \qquad L = \sum_{n=1}^{N} L_n$$

where:

n = Index labeling different categories of regulated risk (e.g., cancer deaths from disposal of radioactive waste, fatalities from airplane crashes or traffic - accidents, etc.)

W_n = Risk weighting factor for public concern

R_n = Total of risks for a given category

$L_n = F_n(R_n)$ = Cost of limiting the nth risk, which will be a function of the level, R_n, to which the risk is reduced

Statement of Problem: $\delta R/\delta R_n = 0 \Big|_{L = L_{max}}$

A RISK BALANCING APPROACH: SIMPLIFIED MODEL

Assume: $L_n = A_n/R_n$

where: A_n = empirical constant

Then the risks and costs of risk reduction for an optimum management strategy are:

$$R_n = B\ A_n^{1/2}/W_n^{1/2}$$

$$L_n = W_n^{1/2}\ A_n^{1/2}/B$$

where:

$$B = (1/L_{max}) \sum_{n=1}^{N} W_n^{1/2}\ A_n^{1/2}$$

A RISK BALANCING APPROACH: GENERAL CONCLUSIONS

- A risk category for which the costs of risk reduction are higher should receive a larger share of the total resources allocated to risk reduction

but

- The allocated share should be limited by allowing the risk for that category to be larger

A RISK BALANCING APPROACH: ESTIMATING A_n

$$L(R_n - 1) - L(R_n) = -\delta L_n / \delta R_n = A_n / R_n^2$$

$$= \text{cost per fatality averted}$$

$$A_n = (\text{number of fatalities for nth risk})^2 \times (\text{cost per fatality averted})$$

A RISK BALANCING APPROACH: SAMPLE CALCULATION

Class of Risk	Cost per Fatality Averted	Fatalities per Year	Relative Risk†[1] Optimum	Relative Risk†[1] Actual
Traffic	$100,000†[2]	50,000	1	1
Commercial aircraft	$1,000,000†[2]	10	6×10^{-4}	2×10^{-4}
General radwaste practice	$10,000,000†[3]	0.1 (est.)	2×10^{-5}	2×10^{-6}

†[1] Relative values of total risk of a given category to all exposed individuals for $W_n = 1$.

†[2] Crouch and Wilson (from Cohen).

†[3] Corresponds to $1,000/rem.

A RISK BALANCING APPROACH: ELABORATIONS

- Equity considerations may be introduced by limiting the risk to a critical group or maximally exposed individual.

- This may be done by redefining R_n as the risk to a critical population group or maximally exposed individual rather than the risk to the entire exposed population.

- Public concerns may be taken into account by using a different weighting factor, W_n, for different risk categories.

CONSEQUENCES OF UNBALANCE IN RISK REDUCTION

Let R_n and L_n be the risk and cost of limiting risk, respectively, for the nth category of risk with optimum management.

$$R = R_1 + R_{N-1} \qquad R_{N-1} = \sum_{n=2}^{N} R_n$$

$$L = L_1 + L_{N-1} \qquad L_{N-1} = \sum_{n=2}^{N} L_n$$

Suppose that R_1 is reduced below optimum by a factor 1/f.

$$R \longrightarrow R' = R_1/f + R'_{N-1} = R + \delta R$$

Because $L = L' = L_{max}$ is fixed and R is minimum, the increment δR must be positive; i.e., the overall risk must increase.

CONSEQUENCES OF UNBALANCE IN RISK REDUCTION (cont.)

Incremental Risk Increase for a simple model: $L_n = A_n/R_n$

Case 1: Cost of reducing R_1 below optimum is distributed among all other risks.

$$\delta R = \frac{(f - 1)(L_1/L_{N-1})}{1 - (f - 1)(L_1/L_{N-1})} - (1 - 1/f)R_1$$

Assume N large and $A_1 \ldots A_n$ are equal

$f = 2$: $\delta R = R_1/2$

$f >> 1$: $\delta R = (f - 2)R_1$

Case 2: Cost of reducing R_1 below optimum taken entirely from cost of limiting R_2

as $f \longrightarrow 1 + L_2/L_1$, $\delta R \longrightarrow \infty$

This result (an artefact of the model) suggests that distributing costs of unbalance may be the better strategy

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