EPA'S LLW STANDARDS PROGRAM: BELOW REGULATORY CONCERN CRITERIA DEVELOPMENT

William F. Holcomb and James M. Gruhlke
U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

ABSTRACT

The Environmental Protection Agency (EPA) is developing generally applicable environmental standards for land disposal of low-level radioactive wastes. These standards will include criteria for determining which wastes have sufficiently low levels of radioactivity to be considered "Below Regulatory Concern" (BRC) in regards to their radiation hazard. To support the concept of potential BRC wastes the Agency has developed technical information, cost data and a methodology for analyzing promising candidate waste streams. The BRC criteria will be based on general population health risks, maximum annual exposures to critical population groups, and the costs now associated with the regulation of these wastes. Risk assessments to support the BRC criteria include an analysis of 18 surrogate radioactive waste streams, generated by nuclear power reactors and other fuel cycle facilities, industrial, medical and educational facilities, and consumers.

Deregulated disposal alternatives, such as sanitary landfills, municipal dumps, incinerators and on-site landfills, situated in diverse demographic settings are used in the analysis. A number of waste streams which contributed only small doses or fractions of a health effect over 10,000 years were identified. Disposal of such wastes without consideration of their very low radioactivity could result in significant cost savings to the commercial fuel cycle and government operations as well as to medical, educational, and industrial facilities, and with minimal risk to the public. The concept of BRC wastes appears both feasible and cost effective.

INTRODUCTION

In August 1983, the U.S. Environmental Protection Agency (EPA) published an Advance Notice of Proposed Rulemaking (1), stating the Agency's intention to develop generally applicable environmental standards for the land disposal of low-level radioactive waste (LLW).

The standard will have criteria defining radiation exposures from radioactive waste disposal that are sufficiently small that they do not need to be regulated regarding their radiation hazard (i.e., a level "below regulatory concern," or BRC). Any waste meeting these criteria could be disposed of as a non-radioactive waste. However, it would have to be disposed of in compliance with other disposal regulations (e.g., RCRA Regulations).

These standards are being developed under the authority of Reorganization Plan Number 3 of 1970 (2) and the Atomic Energy Act of 1954, as amended (3). They will apply to facilities licensed and regulated by the Nuclear Regulatory Commission (NRC) or Agreement States, or owned and operated by the Department of Energy (DOE) and their contractors. To date the technical, risk and cost-effectiveness analyses for determining BRC criteria have been completed.

PHILOSOPHICAL APPROACH

It is not practical to reduce radiation exposure from disposal of all materials to absolute zero, because there is some radioactivity in all matter. This includes all wastes, the buildings we live in, ordinary municipal garbage, and the human body also. Therefore, we believe that when LLW contains sufficiently small concentrations of radioactivity, there is no reason, from a public health point of view, why they cannot be disposed of as we would normal trash. Therefore, at some level of risk, the effort and expense of further regulation overshadows the gain in risk reduction, although such risk is still somewhat quantifiable and is acknowledged.

In developing our BRC criteria, we want people to clearly understand that we have made a careful analysis and thoughtfully deliberated before deciding on a level below which regulation is not warranted. We want to particularly emphasize that, in carrying out this activity, protection of the public and the environment are always our most important considerations. It is important to note that this BRC criteria will apply only to radioactive low-level waste disposal and not to any other radiation control activities.

Non-EPA Activities

The Low-Level Radioactive Waste Policy Amendments Act of 1985 (4) endorsed the BRC concept, and required the NRC to establish procedures for acting expeditiously on petitions to exempt specific radioactive waste streams from the NRC's regulations. An NRC Policy Statement was issued in August, 1985, outlining guidance for filing a petition for Rulemaking to exempt specific waste streams (5). The question no longer remains of whether or not we ought to have a category of material "below regulatory concern," but "how" it should be defined and implemented. There appears to be a definable amount of waste that could be deregulated with minimal risk to the public and at the same time, worthwhile cost savings would accrue to the generators.

Guidance for similar exemptions are being developed by other countries and international organizations. The Canadian Atomic Energy Control Board has issued a document proposing a 5 mrem per year dose criterion to be used for case-by-case analysis of applications for license exemptions for radioactive waste disposal. The United Kingdom National Radiological Protection Board issued formal advice on treatment of small radiation doses to members of the public. The advice states the total dose contribution to an individual from all sources may be disregarded if it does not exceed 5 mrem/year.

The International Atomic Energy Agency has considered a de minimis dose of 1 mrem/year to the average individual in the critical group for ocean dumping and for quantities of solid radioactive waste for uncontrolled disposal by incineration and landfill.

Implementation

The EPA will provide the criteria [and level of standard] for identifying those radioactive wastes which could qualify as BRC. The NRC, the Agreement States and DOE will be responsible for establishing regulations to implement EPA's BRC criteria, and for identifying specific wastes that would be deregulated because of their low radioactivity levels. This is appropriate considering that detailed decisions on which specific types of waste should be deregulated at a specific facility requires an analysis of the specified waste, handling and segregation methods involved. Such matters are beyond EPA's authority.

ANALYSIS METHODOLOGY

The EPA risk assessment analyses for considering BRC disposal were developed using several scenarios, based on possible waste streams, disposal methods, demographic and hydrogeologic/climatic settings.

Wastes

To determine if it was feasible to allow some types of LLW to be BRC wastes, a number of reasonably well characterized waste streams were identified for subsequent analysis. In general, they had very low radioactivity, and potentially large volumes. Sixteen surrogate LLW streams representing wastes generated at nuclear power reactors, uranium fuel fabrication and uranium process facilities, industrial, medical and educational facilities were chosen. For comparison, two consumer products waste streams were also included. These items are manufactured under the NRC licensing process but are used and disposed of by the public virtually without restriction. All of these wastes are described in Table I.

TABLE I

TYPES OF LOW-LEVEL RADIOACTIVE WASTES CONSIDERED AS SURROGATE WASTE STREAMS FOR BRC ANALYSIS

Waste Stream Acronym	Identification
	NUCLEAR FUEL SOURCES
B-COTRASH	BWR Compactible Trash
P-COTRASH	PWR Compactible Trash
P-CONDRSN	PWR Condensate Resins
L-WASTOIL	LWR Waste Oils
F-NCTRASH	Fuel Fabrication Noncompactible Trash
F-COTRASH	Fuel Fabrication Compactible Trash
F-PROCESS	Fuel Fabrication Process Waste
U-PROCESS	Uranium Hexafluoride Process Waste
	INDUSTRIAL SOURCES
N-SSWASTE	Source and Special Nuclear Material Waste
N-SSTRASH	Source and Special Nuclear Material Trash
N-LOWASTE	Low Activity Waste
N-LOTRASH	Low Activity Trash
	MEDICAL AND EDUCATIONAL INSTITUTIONAL SOURCES
I-LQSCNVL	Liquid Scintillation Vial Wastes
I-BIOWAST	Animal Carcasses, Tissues, and Excreta
I-ABSLIQD	Absorbed Liquid Wastes
I-COTRASH	Compactible Trash
	CONSUMER PRODUCTS*
C-SMOKDET	Residential Smoke Detectors (Using Am-241)
C-TIMEPCS	Radioluminous Timepieces (Using Tritium)

NOTE: BWR - Boiling Water Reactor
PWR - Pressurized Water Reactor
LWR - Light Water Reactor (i.e., representative of both BWRs and PWRs)

*These wastes are for comparison since they are presently not regulated

To make our work comparable with that of others, EPA's BRC waste sources and volumes are based on waste characterizations done by NRC, the Atomic Industrial Forum and others. A variation of the liquid scintillation vial waste stream (I-LQSCNVL), modeled after the upper limits of the NRC biomedical rule (6), was also chosen as a separate incineration scenario for further comparison.

Disposal Methods and Demographic Settings

After selecting a group of surrogate BRC waste streams, it was necessary to select reasonable less restrictive disposal methods for such wastes. Consideration of the numerous generators represented by the 16 surrogate BRC waste types indicated the very real possibility that a given waste disposal site might receive such waste from more than one generator. To account for this, fifteen scenarios were devised (Table II). Each scenario combined a generic BRC disposal method with selected groups of surrogate BRC waste types. Generic BRC disposal methods included a variety of alternatives, i.e., municipal sanitary landfills, dumps, on-site landfills, and incineration options. Three demographic settings were used: rural with a surrounding population of 60,000; suburban with a surrounding population of 175,000; and an urban setting with a population of 1,000,000.

TABLE II

BRC DISPOSAL SCENARIOS

Generator Description with Disposal Option
1. 3-Unit pressurized water power reactor complex - municipal dump
2. 2-Unit boiling water power reactor complex - municipal dump
3. University and Medical center complex - urban sanitary landfill
4. Metro area and fuel cycle facility - suburban sanitary landfill
5. Metro area and fuel cycle facility - suburban sanitary landfill with incineration
6. 2-Unit power reactor, institutional, and industrial facilities - municipal dump
7. Uranium hexafluoride facility - municipal dump
8. Uranium foundry - municipal dump
9. Large university and medical center; volatilization of 90% H-3 and 75% C-14; on-site landfill with on-site incineration
10. Large metropolitan area with consumer wastes - suburban sanitary landfill with incineration
11. Large metropolitan area with consumer wastes - urban sanitary landfill with incineration
12.* Consumer product wastes - suburban sanitary landfill
13.* Consumer product wastes - urban sanitary landfill
14.* Large university and medical center; 100% volatilization of H-3 and C-14; on-site landfill with on-site incineration
15.* Large university and medical center; 50% volatilization of H-3 and C-14; on-site landfill with on-site incineration

*Indicates those scenarios where the waste streams are already deregulated

Hydrogeologic/Climatic Settings

Three hydrogeologic/climatic settings were used for the analysis that we believe cover the expected range of values for parameters affecting radionuclide retention and site performance any place in the United States. The settings include: (a) an arid zone site with permeable disposal medium (water infiltrating through the waste trench into the ground and radionuclides moving very slowly to groundwater); (b) a humid zone site with permeable disposal medium (water infiltrating through the waste trench into the ground and radionuclides moving more rapidly to groundwater); and (c) a humid zone site with impermeable disposal medium (water infiltrating into the waste trench and radionuclides overflowing to surface waters rather than moving to the groundwater).

RESULTS OF RISK ASSESSMENTS

Health risks and exposures were estimated for (a) the general population and (b) a critical population group individual (both on- and off-site workers). Population exposures were determined and risks were calculated as fatal cancers and debilitating genetic effects to both local and regional general populations over 10,000 years. Individual risks and exposures were calculated as maximum annual radiation dose (effective whole body dose equivalent), and year of occurrence over 10,000 years for the critical population group (CPG). For those off-site individuals living close to the disposal site the major pathways are via water from a well or stream, and from atmospheric dispersion due to incineration, dust suspension or trench fire. The on-site exposure pathways include the operations worker, dust inhalation, and food grown on-site after site closure. Another pathway is the transportation worker who might collect the waste. In the case of BRC, the on-site worker is included because exposure of these personnel cannot be considered as occupational (i.e., radiation workers). The human exposure pathways considered in the BRC risk analyses are listed in Table III.

General Population Exposures

In analyzing the results of our general population risk assessments, based on our scenarios, we found:

- Risks to the smaller local populations in the first 1,000 years dominated in the arid and humid permeable scenarios, whereas the larger regional populations dominated in the first 1,000 years in the humid impermeable scenarios.
- The majority of health effects were greatest in the humid permeable, and much less in the arid permeable and the humid impermeable.
- As expected, demographics will play a role. Rural settings (60,000 population) will incur least number of health effects and the urban settings (1,000,000 population) will incur the greatest amount of health effects.

TABLE III

PATHWAYS CONSIDERED IN BRC ANALYSIS

On-Site Worker (Pre-closure)

1. Direct gamma exposure from undisturbed waste.

2. Inhalation of radioactive dust stirred up on site.

On-Site Resident (Post-closure)

1. Reclaimer moves onto site, builds house, disturbes waste brought to surface, and food grown on land.

2. Biointrusion by plant roots into the undisturbed waste.

Off-Site Worker (Pre-closure)

1. Direct exposure to transportation workers who collect and transport wastes from generator to disposal facilities.

Off-Site Worker (Post-closure)

1. Groundwater migration with discharge to a river. (For the humid zone site with impermeable disposal medium only.)

2. Groundwater migration with discharge to a well.

3. Surface erosion of the cover material and deposition in nearby river. (For humid zones only.)

4. Spillage of the waste on surface, mixes with surface water and discharges to nearby stream. (For humid zone site with impermeable disposal medium only.)

5. Saturation of the waste and surface water contamination by the bathtub effect. (For the humid zone site with impermeable disposal medium only.)

6. Inhalation of radioactive airborne contaminants from dust resuspension, incinerator, or trench fire.

- The use of incineration reduces the number of health effects by a factor of two.

- The majority of health effects were incurred in the first 1,000 years in all the geohydrologic/climatic settings.

- In terms of total health effects, the dominant radionuclide was carbon-14 and the largest contributor was institutional trash (I-COTRASH).

The predicted health effects for the postulated 15 scenarios ranged from extremely small fractions, 0.0001 health effects, to about 30 health effects over 10,000 years.

Critical Population Group Exposures

In analyzing the results of our critical population group (individual) assessments, based on our scenarios, we found:

- Risk, or maximum annual doses for a given set of waste streams, generally shows little variability between disposal method, demographic, or hydrogeologic/climatic settings.

- The maximum annual dose was less than 1 mrem (2.8×10^{-5} lifetime risk) in roughly half of the scenarios.

- In all regions, the dominant pathways providing the maximum annual doses approaching or exceeding 1 mrem were external gamma radiation, biointrusion, and groundwater.

- The dominant radionuclides were cobalt-60 through direct exposure of workers, cesium-137 through biointrusion, and carbon-14 through well water usage.

- The maximum annual dose occurred within the first year in most scenarios for non-groundwater pathways.

- For the overall time span, the maximum individual in any given year may be one of three persons; on-site worker, on-site resident, and off-site resident.

Transportation Exposures

A special CPG pathway was investigated to evaluate radiation exposures to transportation workers who would collect and haul BRC wastes from the generator to the disposal facility. Additional short-lived radionuclides (half-lives ranging from 2 days to 1 year) were included which might provide additional direct radiation doses. The analysis showed that (a) cobalt-58/60 and cesium-134/137 provided the major external radiation doses to individuals collecting and transporting potential BRC wastes and (b) transportation workers could receive significant (greater than several mrem per year) exposures from some waste types.

EPA APPROACH

The proposed 40 CFR 193 would establish individual radiation exposure limits for defining low-level radioactive wastes (LLW) with sufficiently low levels of radioactivity to be considered "Below Regulatory Concern" (BRC) in regard to their radiation hazard. In examining the population risk and the maximum individual risk, we find that the exclusion of certain waste sources (including specific radionuclides such as Cobalt-60) would reduce the health effects to less than 1 in 10,000 years and the CPG to less than 1 mrem per year.

Cost-effectiveness Analysis

A cost-effectiveness evaluation was done for a range of alternative exposure levels: 0.1 to 15 mrem per year. All of the alternative BRC exposure levels could reduce the volume of regulated LLW substantially. Volumes of regulated waste could be reduced from 25% to 43%, with attendant cost savings ranging from $380 million to over $690 million over a 20-year period, except at the very low levels of exposure where it would require considerable expense to regulate those materials presently not being regulated.

A preliminary cost-effectiveness evaluation of the BRC waste disposal alternative exposure levels is presented in Table IV. To measure the marginal cost-effectiveness of alternative BRC criteria, the costs and health risks of unregulated disposal of those waste streams meeting each of the proposed alternative BRC criterion were compared to the health risks of the conventional shallow land disposal option. This was done to show cost per avoided health effect for regulation of those wastes. The additional health effects reflect the impact of each alternative compared with regulated disposal. The marginal cost-effectiveness compares different, increasing stringent BRC standards with each other.

TABLE IV

EVALUATION OF ALTERNATIVE CRITERIA FOR BRC STANDARDS

BRC Standard CPG Dose (Mrem/yr)	BRC Waste (Percent of Total Vol.)	Net BRC* Savings ($Millions)	Additional** Health Effects	Marginal* Cost-Effectiveness ($ Million Per Avoided HE)
15.0	43%	690	460	
				0.4
4.0	34%	540	85	
				1.3
1.0	30%	470	30	
				3.3
0.1	25%	380	1	

*For a 20-year waste generation total.
**Over a 10,000-year time span.

Advantages

For a 1 mrem per year criterion the following advantages are possible in establishing such a lower limit for defining LLW:

- o Could reduce volume of regulated waste by approximately 30%.
- o Would be applicable to a wide variety of LLW generators.
- o Could save up to $500 million over 20 years.
- o Exposure from many of the disposal scenarios were under the 1 mrem/year thus providing a maximum estimated lifetime risk for the critical individual of 2.8×10^{-5}.
- o Would be comparable with proposed BRC levels and risks currently being considered by Canada, the United Kingdom, the UN's International Atomic Energy Agency, and the International Commission on Radiological Protection.
- o Would be practicable for the licensee to demonstrate compliance with the standard.

CONCLUSION

The Agency considers the concept of BRC wastes to be both feasible and cost effective. Our analyses indicate that many wastes could be disposed of without consideration of their very low radioactivity, while still protecting public health and the environment, and in addition, result in significant cost savings to the commercial fuel cycle and government operations as well as to medical, educational, and industrial institutions. We acknowledge there are obvious and practical difficulties. If we can succeed in establishing BRC criteria, we can be sure of two things: (a) it will have a practical and a very useful impact, and (b) it will probably become a topic of discussion, because some will see it as an undesirable precedent--any easing of a regulatory burden being equated with a retreat. Nevertheless, we are convinced that it is an appropriate goal, and that it can be accomplished if pursued in a reasonable and prudent manner. The EPA is continuing, therefore, to move ahead and develop a generally applicable standard with BRC criteria. We anticipate issuing the proposed LLW standard with BRC criteria sometime in 1987. In addition to the Federal Register Notice, we will have available a Background Information Document and Economic Impact Assessment document to provide a technical treatise on the risk assessment and provide a presentation of the cost-effectiveness of the regulatory options.

REFERENCES

1. U.S. Environmental Protection Agency, 40 CFR Part 193, "Environmental Radiation Protection Standards for Low-Level Radioactive Waste Disposal, Advance Notice of Proposed Rulemaking," Federal Register, 48 (170): 39563, August 31, 1983.
2. The White House, President R. Nixon, "Reorganization Plan No.3 of 1970," Federal Register, 35(194): 15623-15626, October 6, 1972.
3. Atomic Energy Act of 1954, as Amended; 42 U.S.C 2011.
4. Low-Level Radioactive Waste Policy Amendment Act of 1985, Public Law 99-240, January 15, 1986.
5. U.S. Nuclear Regulatory Commission, 10 CFR Part 2, "Radioactive Waste Below Regulatory Concern, Policy Statement," Federal Register , 51(168): 30839-30847, August 29, 1986.
6. U.S. Nuclear Regulatory Commission, 10 CFR Part 20, "Biomedical Waste Disposal, Final Rule," Federal Register, 46(47): 16230-16234, March 11, 1981.