40 CFR Part 193
Environmental Radiation Standards
for Management and Land Disposal
of Low-Level Radioactive Wastes

EPA 520/1-87-012-2

DRAFT ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2

Economic Impact Assessment
Low-Level and NARM Radioactive Wastes

August 1987

U.S. Environmental Protection Agency
Office of Radiation Programs
Washington, D.C. 20460

U.S. Environmental Protection Agency
Region 5, Library (PL-12J)
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ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

TABLES AND FIGURES

Table		Page
F-16	Summary of Unit Volume Health Effects for Humid Permeable Region	F-31
F-17	Summary of Unit Volume Health Effects for Arid Permeable Region	F-44
F-18	LLW and BRC Waste Nuclide Concentration Matrix	F-57
G-1	Total Costs and Health Effects for DOE Waste Disposal	G-5
G-2	Evaluation of Alternative BRC Criteria for Commercial and DOE LLW Assuming Implicit Implementation on a National Basis	G-6
G-3	Evaluation of Alternative BRC Criteria for Commercial and DOE LLW Assuming Explicit Implementation on a National Basis	G-8
G-4	Evaluation of Alternative BRC Criteria for Commercial and DOE LLW Assuming Implicit Implementation on a Regional Basis	G-10
G-5	Evaluation of Alternative BRC Criteria for Commercial and DOE LLW Assuming Explicit Implementation on a Regional Basis	G-12

BACKGROUND

Under the authority granted by the Atomic Energy Act of 1954 (AEA) and Reorganization Plan #3 of 1970, the U.S. Environmental Protection Agency (EPA) is proposing a generally applicable environmental standard for radiation exposure from the land disposal of low-level radioactive waste (LLW). This standard includes several separate, individual parts: a general public exposure disposal standard, a standard for predisposal management, a groundwater protection standard, a "Below Regulatory Concern" (BRC) criterion for radiation exposure from the unregulated disposal of very low activity LLW, and, under the Toxic Substances Control Act (TSCA), limits for the regulated disposal of certain non-AEA radioactive wastes containing naturally-occurring or accelerator-produced radioactive materials (NARM).

LLW is defined as all manmade radioactive waste except high-level waste, spent nuclear fuel, transuranic waste, and uranium and thorium mill tailings. Depending on the waste source, disposal of LLW is regulated by either the Nuclear Regulatory Commission (NRC) or the Department of Energy (DOE) in accordance with EPA's standard. NARM waste is extremely diverse and includes items such as mining wastes, medical radiation sources, and luminescent instrument dials. All types of NARM waste contain naturally-occurring radionuclides, principally uranium-238, thorium-232, and radium-226. NARM waste is currently unregulated by Federal authorities and is regulated to different degrees by State agencies.

From 1985 to 2004, EPA estimates that 2,900,000 cubic meters of LLW will be generated by commercial sources, as well as 1,800,000 cubic meters from DOE sources. It is estimated that the amount of NARM waste found to be appropriate for regulation at this time will be approximately 6,600 cubic meters over the same 20-year period.

Economic Impact Assessment

The purpose of this Economic Impact Assessment (EIA) is to quantify the costs and benefits of EPA's proposed standards. Cost is defined as the incremental cost of disposal practices (in comparison to current practice) required to comply with the standards, including costs for packaging, processing, transporting, and disposing low-level waste. These costs, as shown in this summary and in the main analysis, are discounted at a 10 percent real rate over the 20-year operating period of a disposal facility, and are expressed in 1985 constant dollars. Benefits include both reductions in general population health effects (expected fatal cancers and first generation genetic effects) estimated over 10,000 years, and reductions in the maximum annual dose to a member of the Critical Population Group (CPG). Population health effects have not been discounted. Compliance with EPA's standards is defined in terms of the expected effective whole body dose-equivalent (in millirems per year) to a member of the CPG.

The EIA focuses on the economic impacts associated with the disposal of commercial LLW and NARM under alternative standards for which detailed cost and risk analyses were conducted. While EPA's proposed standards will also apply to DOE LLW, a detailed analysis of these impacts was not performed due to limitations in the data available to characterize DOE waste. However, impacts on DOE waste were calculated for comparison purposes using EPA assumptions. These EPA assumptions treat DOE waste as if it were closely analogous to commercial waste (see Appendix G).

SUMMARY OF PROPOSED RULE

EPA's Proposed Rule includes the following three principal parts:

1. LLW Disposal Standard: EPA is proposing that regulated disposal of manmade LLW should comply with a generally applicable exposure standard of 25 millirem per year to a member of the CPG.

2. BRC Criterion: EPA is proposing that exposures of less than 4 millirem per year to a member of the CPG are "Below Regulatory Concern." Wastes for which unregulated disposal results in CPG exposures of less than 4 millirem per year are thus deemed to be suitable for disposal without regard to their radionuclide content.

3. NARM Limits: EPA is proposing to regulate the disposal of higher activity naturally-occurring or accelerator-produced radioactive material wastes whose specific activity exceeds 2 nanocuries per gram (2 nCi/g), with the exception of a few NARM wastes which are specifically excluded. Disposal of NARM wastes that exceed these limits is subject to a generally applicable exposure standard of 25 millirem per year to a member of the CPG.

EPA is also proposing two other components of the Proposed Rule. These are a groundwater contamination standard expressed as an annual CPG dose limit and graded by aquifer class, and a predisposal waste management standard. Two separate options are proposed for the groundwater protection standard. Under Option I, no degradation would be permitted for Class I aquifers (generally, essential community water supplies); high yield (over 10,000 gallons per day) Class II aquifers would be subject to a 4 millirem per year exposure limit; and Class II low yield and Class III aquifers (generally, non-potable water supplies) would be included in the 25 millirem per year disposal exposure limit. Under Option II, no degradation would be permitted for Class I aquifers; all Class II and Class III aquifers would be subject to a 4 millirem per year exposure limit. Under the predisposal management portion of the standard, cumulative exposure to the CPG from all pathways from radioactive waste management operations occurring prior to disposal and managed by DOE or licensed by the NRC would be limited to 25 millirem per year. Finally, EPA is proposing that the standards become effective at the time a commercial facility is licensed or relicensed, and, for DOE facilities, three years after promulgation of the standard.

Summary of Regulatory Alternatives

Summarized in Table 1-1 are the five alternative LLW standards considered in the EIA, along with the economic impacts associated with the four implementation assumptions. The five alternative LLW standards include CPG levels of 125, 75, 25, 10, and 4 millirem per year. Summarized in Table 1-2 are the five alternative BRC criteria considered and the economic impacts associated with each of these alternatives. The five alternative BRC criteria include CPG levels of 15, 4, 1, 0.1, and 0 millirem per year. The economic impacts are reported for four different assumptions regarding implementation of the LLW standard and BRC criterion by DOE and NRC. National implementation implies that a single disposal technology is used at all sites nationwide, while Regional implementation allows for different disposal technologies, depending on hydrogeologic conditions. Explicit implementation assumes that both population risk reduction and CPG risk are considered explicitly by DOE and NRC; Implicit implementation assumes that only CPG risk is considered in order to determine compliance with the standard. Only two regulatory alternatives were considered for NARM limits: the proposed specific activity limit of 2 nCi/g with an exclusion of specific NARM wastes and a 2 nCi/g specific activity limit without this exclusion.

Table 1-1

SUMMARY OF
LLW ALTERNATIVE STANDARDS
AND ECONOMIC IMPACTS

Implementation Assumption

LLW Standard Maximum CPG Dose (MREM/Year)	NATIONAL IMPLICIT		NATIONAL EXPLICIT		REGIONAL IMPLICIT		REGIONAL EXPLICIT	
	Incremental Costs	Avoided Health Effects	Incremental Costs	Avoided Health Effects	Incremental Costs	Avoided Health Effects	Incremental Costs	Avoided Health Effects
125	(680)	(160)	(440)	(13)	(680)	(160)	(630)	(27)
75	(450)	(28)	(440)	(13)	(560)	(150)	(510)	(15)
25	140	3	140	3	(270)	(150)	(220)	(12)
10	700	17	700	17	8	(150)	58	(10)
4	5,000	36	5,000	36	2,100	(140)	2,200	(0.27)

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included. DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. See Appendix G for further detail.

Table 1-2

SUMMARY OF
BRC ALTERNATIVE STANDARDS
AND ECONOMIC IMPACTS

	Implementation Assumption							
	NATIONAL IMPLICIT		NATIONAL EXPLICIT		REGIONAL IMPLICIT		REGIONAL EXPLICIT	
BRC Standard Maximum CPG Dose (MREM/Year)	BRC Savings	Additional Health Effects	BRC Savings	Additional Health Effects	BRC Savings	Additional Health Effects	BRC Savings	Additional Health Effects
Deregulate All Candidates	1,080	520	1,080	520	1,080	520	1,080	520
15	780	510	490	1.1	780	510	560	4.2
4	620	96	490	1.1	620	96	530	3.6
1	540	34	490	1.1	540	34	510	3.5
0.1	410	1.0	410	1.0	410	1.0	410	1.0
0	(1,500)	(20)	(1,500)	(20)	(1,500)	(20)	(1,500)	(20)

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included. DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. See Appendix G for further detail.

SUMMARY OF RESULTS

The major conclusions of the Economic Impact Assessment of EPA's Proposed Rule are presented below, followed by a brief discussion of each. The results are first presented for the three major components of the Rule -- the LLW standard, the BRC criterion, and the limits for the regulation of NARM wastes. Groundwater protection and predisposal management are discussed last.

Conclusions Regarding LLW Standard

1. The proposed CPG exposure standard of 25 millirem per year implies the minimum use of a combination of conventional and improved shallow land disposal in a manner consistent with NRC regulations codified at 10 CFR 61 (assuming one disposal method is used nationwide). Under 10 CFR 61, the maximum dose to the CPG is estimated by non-site-specific transport and exposure models to range from 0.0009 (in the arid permeable region) to 9.2 millirem per year (in the humid permeable region). Corresponding CPG lifetime risks would range from less than 0.03 in one million to nearly 270 in one million. The highest CPG risks would be found in the humid permeable region since water is the primary pathway of exposure to humans and water transport is most rapid in this region.

2. In two of the three hydrogeologic regions studied, however, a regulated sanitary landfill technology is sufficient to meet the 25 millirem per year standard if the NRC or DOE chooses to implement EPA's standard on a regional basis (that is, allows the disposal technology to vary to account for the influence of hydrogeologic conditions on CPG dose). Of course, the NRC and DOE must take into consideration many other factors that may result in a sanitary landfill design being deemed unsuitable.

These other factors include considerations such as intruder barriers and occupational exposure. Hence, the cost of EPA's rule depends strongly on both the NRC's and DOE's implementation. If the same disposal practice is used for LLW waste everywhere in the country, the proposed standard will cost $140 million over the current practice. This cost is attributable almost entirely to DOE waste and is largely represented by the differential between conventional shallow land disposal (DOE current practice) and a disposal method very similar to 10 CFR 61 near-surface technology for the DOE 20-year waste volume. Note that impacts on DOE waste were not estimated in detail but, rather, used aggregate EPA assumptions. Accordingly, the $140 million cost estimate represents a rough approximation of the expected economic impacts. Regional implementation, as mentioned above, could save a very large portion of this cost if DOE chose to implement in this fashion. Regional implementation could also result in a large savings versus current practice for the commercial sector (NRC, via 10 CFR 61, currently appears to prescribe the use of one disposal practice nationwide). However, the added cost of National implementation, which requires better engineering design, may be necessary to surmount local siting barriers and to meet other regulatory criteria. Nevertheless, at the proposed 25 millirem standard, Regional implementation could result in savings as high as $270 million in comparison to current practice.

3. Under the expected National implementation scenario, where the cost-effectiveness of avoiding population health effects is not explicitly considered, a 25 millirem standard will avoid approximately 3.2 health effects (as opposed to current practice) over a 10,000-year period. As with the incremental costs of this standard, these avoided health effects are attributable almost entirely to more stringent disposal of DOE waste. Similiar to the DOE cost estimates, however, this estimate of avoided health

effects represents a rough approximation of the expected impacts. The range in avoided health effects varies significantly depending on the implementation scenario. Although Regional implementation will result in substantial cost savings, as mentioned above, as many as 150 additional health effects could occur under this type of implementation.

4. Based on computer estimates which reflect generic disposal site parameters, exposure standards lower than 9.1 millirem per year cannot be met in humid permeable hydrogeologic regions unless disposal practices more stringent than near-surface 10 CFR 61 methods are employed.

5. Since commercial LLW generators regulated by NRC are already required to use a disposal practice which meets the 25 millirem standard (i.e., 10 CFR 61), this standard will have no financial impact on commercial generators. However, DOE facilities will be affected to the extent that current disposal practices must be upgraded to meet the standard.

Conclusions Regarding BRC Criterion

1. All of the alternative BRC criteria would reduce the regulated volume of waste substantially. Deregulated volume estimates range from 25 percent of the commercial and DOE LLW at a level of 0.1 millirem per year to 43 percent for a 15 millirem criterion. At the proposed 4 millirem criterion, 34 percent of all LLW could be disposed in an unregulated fashion. These numbers could be somewhat different depending on NRC and DOE implementation and variations on other waste management practices.

2. Estimates of savings resulting from the deregulation of BRC wastes range from $490 million to $780 million for the 15 millirem per year BRC alternative, depending upon implementation, to a projected <u>cost</u> of $1.5 billion for a zero BRC alternative due to the regulation of wastes that are currently unregulated (such as consumer wastes like smoke detectors and time pieces, and biomedical waste deregulated by the NRC). The savings (which are measured relative to current practice) for both the commercial and DOE sectors for the proposed 4 millirem BRC criterion are projected to be between $490 and $620 million, again depending upon the method of implementation. The corresponding range of additional health effects from a 4 millirem BRC criterion is from 1.1 to 96 over 10,000 years, again depending upon the method of implementation. The method of implementation clearly has a much larger impact on health effects than on costs.

3. The effect of the proposed BRC criterion is to reduce societal costs. However, about one-third of the savings (for commercial LLW) results from avoided LLW transportation. This savings represents an average loss of revenue to existing LLW transporters of less than 3.6 percent. Small businesses are unlikely to be affected since LLW disposal services are typically provided by large companies.

Conclusions Regarding Limits for the Regulation of NARM Wastes

1. A 2 nanocurie per gram limit with the proposed exclusion of specific NARM wastes would primarily result in the regulation of two major NARM waste streams -- radium sources and radium ion-exchange resins, although small numbers of other items also may be regulated. Regulation of these other items would not significantly affect the economic impact estimates.

2. The cost for the 20-year regulated disposal of radium sources would be approximately $3.3 million over the cost of unregulated disposal and would avoid 67 health effects, which implies a cost per avoided health effect of $50,000. Considerable uncertainty exists concerning the disposal practices that would be utilized for radium sources in the absence of any action on the part of EPA. Therefore, the base case against which to measure the impacts of the regulation of these items is also highly uncertain. Actual impacts (with respect to radium sources) may range anywhere from zero dollars and zero avoided health effects (assuming all sources would have been disposed of in a regulated manner, even in the absence of EPA action) to a cost of $3.3 million and a benefit of 67 avoided health effects over the next 20 years. If all 67 health effects were avoided as a result of EPA's regulation, clearly a favorable tradeoff would result; at a value per avoided health effect of $50,000 or more, radium sources would be cost-effective to regulate. Since the regulation of these items by EPA substantially increases the certainty that regulated disposal will occur, one could conservatively estimate that even in the case where only one health effect would be avoided over the 10,000-year analysis period, the cost-effectiveness ratio would be $3.3 million per health effect. That is, given a value per avoided health effect of $3.3 million or more, radium sources would be cost-effective to regulate.

3. Regulated disposal for radium-loaded ion-exchange resins will cost approximately $20 million over the 20-year period of disposal and will avoid approximately four health effects relative to unregulated disposal. These estimates imply a cost per avoided health effect of $5 million. As with radium sources, the disposal practice for ion-exchanging resins, absent EPA regulations, is uncertain. Therefore, economic impacts could range from zero additional costs and avoided health effects (assuming all ion-exchange resins

would be disposed of in a regulated manner in the absence of EPA action) to an incremental cost of $20 million with a benefit of four avoided health effects (assuming all ion-exchange resins would be disposed of in an unregulated fashion).

4. The NARM limit will have a relatively minor impact on municipalities that generate radium-loaded ion-exchange resins as waste. The impact on local small businesses is expected to be negligible since costs will be widely distributed.

Conclusions Regarding Groundwater Protection and Predisposal Management

1. A detailed quantitative analysis was not undertaken with respect to the two proposed options for the groundwater protection standard. However, incremental costs (beyond those estimated for the LLW standard, BRC criterion, and NARM limit) were approximated for these two options.

2. Under Option I, the groundwater limits would have no additional economic impact on sites located above Class III or Class II, low yield aquifers, since the groundwater CPG dose would already be limited to less than 25 millirem per year by the LLW standard.

3. The proposed groundwater limit under Option I could raise the costs of disposal site selection if a site must be relocated away from a Class I or Class II high yield aquifer. Resiting could range from $263,000 to $4.8 million per site, depending on the number of sites considered before an acceptable location is found; or for the 15 ultimate sites nationwide, the total maximum incremental cost (over the LLW standard) would be $3.9 million to $72 million. Note that since the potential benefit (health effects reduction) of resiting away from Class I or Class II high yield

aquifers could not be assessed quantitatively, the cost-effectiveness of the groundwater limit under Option I also could not be determined.

4. In contrast to resiting, the incremental cost of using more expensive technology to meet the groundwater limits could range up to $341 million per site (the incremental cost of concrete canister disposal). The total national cost could range from $2.1 billion (if NRC and DOE implement the standard on a Regional basis) to $5 billion (if implemented on a National basis).

5. The analysis of the potential impacts of the groundwater limits under Options I and II are similiar except that while more expensive disposal technology may not be needed under Option I, it is almost certainly required under Option II; since the groundwater pathway controls the CPG dose in the humid permeable region, a 4 millirem groundwater limit would require more expensive disposal technology (e.g., concrete canister). Relative to 10 CFR 61 disposal practice, the incremental cost could range from $2.1 to $5 billion (for commercial and DOE sites), depending on whether the limit is implemented on a Regional or National basis.

6. The costs and benefits associated with the predisposal management part of the standard have not been explicitly quantified. However, the costs are believed to be extremely small, with the associated benefits being increased protection of the population from radiation exposure.

Aggregate Economic Impact of the Standard

1. The combined quantifiable economic impact of the LLW standard, the BRC criterion, and the NARM limit is estimated to be a net

savings of between $327 and $890 million. The corresponding health risk over 10,000 years is expected to range from 73 avoided health effects (due primarily to the NARM portion of the standard) to 246 additional health effects. These estimates reflect alternative assumptions regarding the way in which the NRC and DOE would ultimately implement EPA's BRC criterion and LLW standard and upon assumptions regarding current practice for NARM (with respect to radium sources and ion-exchange resins).

2. The incremental costs associated with the two proposed options for the groundwater protection standard could range from $3.9 million to $5 billion, depending on NRC and DOE implementation and on whether resiting or more expensive disposal technology is necessary to meet the proposed groundwater standard.

3. The costs and benefits of the predisposal management portion of the standard are expected to be relatively small.

Under the authority of the Atomic Energy Act of 1954 as amended [AEA54], the U.S. Environmental Protection Agency (EPA) is proposing a generally applicable environmental standard for land disposal of Low-Level Radioactive Waste (LLW) that includes general public exposure standards, disposal standards for predisposal management, groundwater protection, a "Below Regulatory Concern" (BRC) criterion, and, under the Toxic Substances Control Act (TSCA), limits for the regulated disposal of certain non-AEA radioactive wastes. The purpose of this Economic Impact Assessment (EIA) is to assess the costs, benefits, and cost-effectiveness of each part of EPA's proposed action. Executive Order 12291 requires EPA to conduct a Regulatory Impact Analysis of Major Rules, generally defined to include actions with an annual economic impact greater than $100 million. While EPA does not consider this action to be a Major Rule, the EIA has been prepared in a manner consistent with the requirements of Executive Order 12291. Thus, the EIA quantifies the costs and benefits (in the form of health risk reduction) of EPA's proposed standards and compares these to the costs and benefits of regulatory alternatives.

The EIA focuses on the economic impacts associated with the three major components of the standards package: (1) a 25 millirem annual whole-body exposure standard for disposing of LLW, (2) a 4 millirem annual exposure criterion that would allow unregulated disposal of BRC radioactive waste, and (3) regulation under TSCA of certain non-AEA wastes composed of naturally-occurring and accelerator-produced radioactive materials (NARM).

Two other components of the standard, a groundwater protection standard (ranging from "no degradation" to 25 millirem per year, depending on aquifer class) and a 25 millirem per year predisposal operations and management standard, also are discussed in this EIA, as are the economic implications of the proposed effective date of the standards. However, since EPA expects the economic impacts associated with these latter provisions to be small (except perhaps for the groundwater standard, depending on the option chosen), it did not undertake extensive formal analysis of the costs and risks of alternatives.

REGULATORY AND LEGAL FRAMEWORK

To a large extent, the economic impact of EPA's proposed standards depends on the actions of State and Federal agencies outside of EPA, as well as on legal constraints arising from both Federal and State statutes. These complexities affect the assessment of economic impacts by circumscribing the regulatory alternatives available, limiting the degree to which cost and risk are used as criteria for comparing alternative standards, determining the manner in which EPA's standards are implemented by other agencies, and, finally, determining the costs and risks of the current predisposal and disposal practices of LLW generators, transporters, and disposal site operators.

Statutory Authorities

Under the AEA and Reorganization Plan #3 of 1970 [AEA54, EPA70], EPA has the authority to set "generally applicable environmental standards for the protection of the general environment from radioactive material." EPA has interpreted the term "generally applicable" to mean that it is prevented from establishing site-specific standards. EPA has the authority to issue standards in a variety of forms, including "limits on radiation exposures or levels, or concentrations or quantities of radioactive material." EPA's standards apply to "the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material." Thus, disposal site operators must comply with EPA's disposal standard outside the disposal site perimeter during the periods of licensed operation, site closure, and institutional care. Thereafter, the boundary effectively disappears and the standard applies outside the disposal area itself. Similarly, EPA's predisposal management standard applies at the perimeter of facilities that process waste for disposal, such as regional incineration or waste transfer facilities. Finally, EPA's BRC standard applies to exposures either onsite or offsite at unregulated disposal facilities, since such facilities and transporters are not controlled with respect to radiological hazards.

EPA is also proposing groundwater protection standards under its AEA authority. These standards apply to exposures received from drinking water. The standard varies by aquifer class. Aquifer classes reflect the relative importance of various groundwater supplies as sources of drinking water.

EPA subscribes to the ALARA (As Low As Reasonably Achievable) principle and has adopted a policy of setting AEA radiation standards that consider cost, as well as risk, as a criterion for choosing among alternatives.* Moreover, EPA has extended this approach to its determination of an exposure level which is BRC. LLW for which unregulated disposal meets the BRC standard is deemed suitable for disposal without regard to its radioactive content. Thus, cost is considered by EPA to be an important criterion for choosing among alternative BRC standards.

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* Of course, a variety of other important policy concerns are also considered. However, the analysis in this EIA is limited to a discussion of the costs and risks of regulatory alternatives.

EPA has authority to regulate the disposal of commercial NARM waste under Section 6(a)(6) of TSCA [TSCA76] when it finds that, without this regulation, disposal of NARM waste "presents or will present an unreasonable risk of injury to health or the environment." In promulgating a rule under Section 6(a)(6), EPA must, among other things, publish a statement of the health and environmental effects of unregulated disposal and the economic consequences of regulation. In this action, EPA is proposing to regulate the disposal of certain NARM wastes in a manner consistent with other LLW since the radioactive hazards and appropriate disposal mechanisms are similar.

Implementation and Applicability of Existing Regulations

While EPA has the authority to promulgate a LLW disposal standard, other Federal or State agencies are given the task of implementing this standard. Since implementation ultimately determines both the costs and health risks of disposal, EPA must anticipate implementation of the standard to determine economic impact. For commercial LLW sources, the Nuclear Regulatory Commission (NRC) or its Agreement States license the land disposal of commercial LLW according to regulations in 10 CFR 61. Under the AEA, the NRC has delegated its licensing authority to 27 Agreement States; the license requirements of these States must comply with EPA's standard and NRC regulations. For disposal at Department of Energy (DOE) sites, DOE itself is responsible for implementing EPA standards. Currently, disposal of DOE LLW is guided by "Radioactive Waste Management" DOE 5820.2 [DOE5820].

Pending EPA's BRC standard, neither DOE nor the NRC have implemented generic guidelines for designating BRC waste. However, the NRC has issued an Advance Notice of Proposed Rulemaking (ANPR) to address generic radioactive waste considered BRC [NRC86b]. Furthermore, the NRC is accepting waste-specific BRC applications from its licensees and has promulgated a rule describing certain biomedical waste as BRC ["the

BIOMED Rule"; NRC81a]. The NRC has also issued a policy statement concerning its plans to expedite specific waste stream BRC petitions [NRC86a].

Disposal of NARM waste is not currently regulated by EPA, but is controlled to various degrees by the license requirements of some States. In other States, NARM disposal is currently unregulated. Although EPA typically would implement a regulation under TSCA (the authority by which it is now proposing to regulate NARM), EPA expects to enter into agreements with the NRC and DOE for their implementation of NARM disposal regulation. However, EPA's proposed standard for NARM wastes will determine which NARM wastes will be regulated and fall within the LLW disposal, predisposal, and groundwater protection limits.

EPA's Clean Air Act [CAA67] standards for radionuclide emissions (40 CFR 61; Subparts H & I) already limit the radiation exposure from the air pathway from all LLW incineration facilities. Similarly, EPA's Fuel Cycle standards [EPA77] cover all pathway exposures at the boundaries of commercial nuclear power plants and uranium and fuel processing plants. Thus, some exposure pathways for some predisposal management activities already are regulated. In this action, EPA is proposing comprehensive predisposal management standards that will cover additional facilities (industrial and institutional generators; regional transfer or volume reduction facilities) and additional pathways (e.g., offsite migration due to spillage and runoff; direct gamma radiation beyond the facility boundary).

Finally, in 1976, EPA promulgated interim primary drinking water standards [EPA76] for radionuclides under the Safe Drinking Water Act [SDWA74]. These regulations, which apply to community water supplies at the point of use, amount to about 4 millirem per year for manmade beta- and gamma-emitting contaminants.

Several Department of Transportation (DOT) regulations also indirectly affect LLW disposal. Since these regulations are already in effect, they limit current practice and, therefore, the incremental impact of EPA's proposed LLW standard. DOT has issued regulations that limit the surface radiation dose rate of radioactive waste containers on transport vehicles and prescribe standards for waste packaging and labeling [DOT83]. Since these regulations, in part, determine transportation cost, they affect the analysis of volume reduction strategies and BRC determinations (which tend to reduce transportation costs).

Formation of State Compacts under LLWPA

Under the Low-Level Radioactive Waste Policy Act of 1980 [LLWPA80], as amended in 1985 [LLWPA85], States were given the option to join together to form Compacts for regional disposal of commercial LLW. Once a Compact is approved by Congress, it has the authority both to establish disposal sites within the Compact and to refuse disposal of waste generated outside the Compact, beginning in January 1993. Currently, seven multi-State disposal Compacts (including 39 States) have been ratified by Congress [LLWPA85] and two States (California and Texas) have elected to build their own sites (the status of California may change, however). The composition of some existing Compacts and the status of the remaining States are currently under debate; however, the wording of the existing Compact agreements suggests that out-of-Compact waste is unlikely to be accepted. In addition, individual States typically are expected to host a site for only 20 years at a time. The implication of these constraints is that the size of disposal sites receiving commercial LLW will be determined by the volume of waste to be disposed within a Compact, rather than by economic considerations of optimum scale. These constraints may not apply to DOE waste; DOE facilities are typically located very close to the point of waste generation.

For this EIA, EPA has assumed that inter-Compact transportation of commercial LLW, in fact, will not occur and, therefore, that waste generated within a Compact will also be disposed in that Compact. This assumption is recognized in the analysis of economic impacts by including a transportation cost based on a distance (650 miles) that is roughly consistent with intra-Compact disposal for the currently ratified Compacts (it should be noted that some commercial LLW is currently transported distances much greater than 650 miles, since only three commercial disposal facilities now accept LLW, i.e., Hanford, Washington; Barnwell, South Carolina; and Beatty, Nevada). Furthermore, an assumed average disposal site size of 250,000 cubic meters of waste (as generated) is based on an assumed eight to 10 commercial LLW disposal sites, each of which operates for 20 years. It is anticipated that some specific regional facilities will receive much more or much less than this average amount. The implications of this volume variation (which is only likely to affect commercial LLW) are investigated in Chapter 8.

An important final implication of intra-Compact disposal and accompanying transportation restrictions is that they may preclude LLW generated in regions where hydrogeologic disposal conditions are less favorable (e.g., in a Compact with only humid permeable hydrogeologic characteristics) from being disposed of in sites where better site characteristics are expected to result in better containment (e.g., in arid permeable regions).

REGULATORY OBJECTIVES

To assess regulatory impacts, it is necessary to translate the statutory criteria of the AEA and TSCA into objectives suitable for economic analysis. The economic analysis is evaluated by EPA in conjunction with other policy considerations (e.g., a desire to avoid disrupting current progress toward Compact formation and toward siting and constructing new LLW disposal facilities) to choose among alternative standards.

This EIA uses the economic framework described in Executive Order 12291 to evaluate alternatives. Executive Order 12291 requires that, to the extent possible, both costs and benefits must be quantified in monetary terms and that the regulatory alternative which maximizes net benefits to society should be adopted if possible. Since the statutory objectives of the AEA and TSCA relate, in this case, to protection of human health from radiological hazards, net benefits are defined as the difference between the value of reducing radiation-induced human health risk (the benefits) and the cost of more stringent disposal practices.

Two factors serve to complicate the assessment of costs and benefits. First, two different measures of risk reduction are included in the analysis: (1) reduction in total health effects to the general population and (2) reduction in the risk to the Critical Population Group (CPG) (a measure of risk to an individual, as will be described in Chapter 3). Second, neither measure of risk reduction is quantified explicitly in monetary terms. Cost-effectiveness analysis is used to compare the costs, general population health effects, and CPG risk of alternative standards. Given monetary values for a reduction in total health effects (i.e., a "value of life") and for a reduction in CPG risk (e.g., a value per incremental reduction in the maximum individual risk of fatal cancer), the net benefits of each alternative standard could be quantified. Except for purposes of illustration, these values are not inferred or made explicit in this EIA.

SCOPE OF ANALYSIS AND ORGANIZATION OF THE REPORT

The bulk of this EIA covers the economic analyses of regulatory alternatives for the BRC and LLW standards and for NARM. Chapter 3 outlines the methodology used for these analyses and Chapter 4 discusses EPA's choice of regulatory alternatives. Chapter 5 characterizes LLW, and Chapter 6 characterizes NARM and presents an impact analysis of the proposed NARM limit. Chapters 7, 8, and 9 cover specific segments of this proposed action and are described separately below. Chapter 10 addresses the distributional impact of the proposed standards in qualitative terms.

The Low-Level Waste Disposal Standard

LLW essentially includes all radioactive waste except waste specifically excluded under the LLWPA. Thus, low-level waste does not include high-level radioactive waste, transuranic waste, spent nuclear fuel, or uranium and thorium mill tailings. These radioactive waste categories are defined and regulated under previous EPA rulemakings such as 47 FR 58196 and the Uranium Mill Tailings Radiation Control Act [UMTRCA78]. While NARM is not covered under the AEA, EPA has the authority to regulate the disposal of NARM under Section 6(a) of TSCA if it is determined to present an unreasonable risk of injury to health or the environment. EPA expects its proposed limit to be exceeded by primarily two types of NARM wastes -- radium sources and radium-loaded ion-exchange resins.* Both of these NARM wastes are generated by commercial rather than DOE sources.

Commercial sources of LLW include nuclear power reactors; uranium hexafluoride conversion and fuel fabrication facilities; industries involved in the manufacture of radiochemicals, radiopharmaceuticals, sealed sources, or articles made of uranium metals; and institutions generating LLW during medical and research activities. In addition to these commercial sources, a significant volume of LLW is generated during activities of the Federal government at DOE facilities involved in nuclear fuel enrichment, defense, and research activities.

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* As discussed in Chapter 6, EPA also considered regulating a number of other NARM wastes. EPA currently expects to consider regulation of large-volume diffuse NARM wastes in a future action.

LLW is also generated during decontamination and decommissioning (D&D) activities in conjunction with specifically mandated remedial action programs. These programs include DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP) for rehabilitating sites formerly used by the Manhattan Engineer District and the U.S. Atomic Energy Commission, and the Surplus Facilities Management Program (SFMP). In some cases, radioactive waste sites are included in the National Priorities List of hazardous waste sites and remedial actions are carried out under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Under the Superfund Amendments and Reauthorization Act of 1986 (SARA), disposal of LLW generated during CERCLA cleanups should comply with Applicable or Relevant and Appropriate Regulations and Standards (ARARS) -- including the LLW standard. The D&D of commercial power reactors will also constitute a significant future source of LLW. Finally, decontamination of Three Mile Island, activities at the West Valley Demonstration Project, and potential future nuclear fuel recycling processes will all also produce LLW. Because these sources are expected to produce relatively small volumes of waste or because the waste has not been sufficiently characterized to allow the development of regulation at this time, they are not considered further in this analysis.

While the volume of LLW generated by DOE activities will be significant, EPA's quantitative analysis of alternative standards focuses principally on disposal of commercial LLW and NARM at commercial sites licensed by the NRC. DOE has informed EPA that it believes that the sources of DOE waste are similar to those of commercial waste and that similar disposal would be appropriate.* Moreover, EPA believes that public information regarding the volumes, form, and radioactive content of DOE waste currently is insufficient to allow EPA to perform a detailed cost and risk analysis necessary to evaluate alternative standards. In lieu of

* EPA's position is based on a letter dated June 11, 1982 from Goetz K. Oertel, Director of the Office of Defense Waste and By Products Management, Department of Energy [DOE82a]. DOE has subsequently reaffirmed EPA's approach [MEY86c].

this information, EPA has relied on DOE's appraisal of the content and volume of its waste in its consideration of alternative standards and has based its choice of a standard on the analysis of commercial LLW and NARM. Moreover, EPA has implicitly assumed that DOE waste, such as remedial action program waste, and D&D waste (which each may differ in composition and form from commercial LLW) will be disposed of in disposal facilities separate from commercial LLW facilities. Thus, it is analytically unnecessary to consider these wastes to estimate the health risks prevailing at commercial LLW disposal sites under alternative EPA standards.* Accordingly, while estimates of the volumes of LLW from DOE sources are presented in Chapter 5, estimates of the costs and risks resulting from disposal under alternative standards are quantified in detail for commercial LLW and NARM only. In addition, based on EPA's assumption that the economic impacts from disposal of commercial and DOE wastes are similar, the relative disposal volumes of DOE and commercial low- level waste were used to develop an estimate of the total costs and risk associated with disposal of DOE waste under both EPA's proposed LLW standard and BRC standard. DOE waste is not known to include a NARM component, at least not one of sufficient volume to quantify it.

Below Regulatory Concern Standard

In addition to the proposed 25 millirem LLW disposal standard, EPA is also proposing a 4 millirem annual exposure standard for unregulated disposal of LLW. Wastes for which unregulated disposal meets the BRC criteria are deemed suitable for disposal without regard to their radioactive content. The EIA evaluates a number of commercial LLW which are potentially suitable for unregulated disposal. In general, these BRC "candidates" are characterized by their very low radionuclide concentrations. As discussed in Chapter 7, BRC candidates likely to meet the standard include wastes generated by hexafluoride conversion and fuel fabrication facilities, special source trash and waste generated by industrial

* For simplicity, we also assume unit disposal costs are unaffected by the inclusion or exclusion of DOE waste from the market for LLW disposal.

facilities, liquid scintillation vials generated by institutions engaged in medical and research activities, and certain low activity wastes generated by power plants (waste oils and secondary condensate polishing resins). Since these low activity wastes constitute a significant fraction of the total LLW volume, a considerable cost savings will be realized as a result of EPA's proposed 4 millirem BRC standard. These savings are quantified in Chapter 7 ("Results of BRC Standards Analysis"), as are the savings from alternative BRC standards. As explained in the analysis, these "candidates" have served as surrogates for the wastes that NRC or DOE may actually deregulate, in order to estimate the impact of the BRC criterion.

Regulation of NARM

The third major segment of EPA's proposed LLW standards considers the disposal of naturally-occurring and accelerator-produced radioactive material. EPA's analysis focuses on the specific activity and total activity of radium-226, uranium-238, and thorium-232 decay series. While EPA expects that its proposal will affect only two NARM wastes (radium sources and radium-loaded ion-exchange resins), the EIA evaluates the costs and risks of regulated and unregulated disposal of other discrete sources of NARM, such as radium dial clocks, smoke detectors, illumination equipment, and fluorescent lamps, among others. Large volume and diffuse sources of NARM (such as potash, ammonium phosphate, concrete alum shale, certain scrap metals, fly ash, and boiler ash) are considered only briefly since EPA will be considering the evaluation of these types of NARM in a future regulatory action. Chapter 6 of the EIA describes the NARM wastes more fully, discusses a preliminary analysis of both diffuse and discrete NARM sources, and presents a final cost-effectiveness impact analysis of specific discrete NARM wastes.

Other Components of the Proposed Standard

EPA is also proposing a groundwater standard (graded depending on aquifer class) and a predisposal management standard as part of this action. Quantitative cost and risk analyses for these standards were not performed; however, EPA believes that the incremental cost of these provisions will probably be small (except perhaps the groundwater standard, depending on the option chosen). Each standard is discussed qualitatively in Chapter 9.

Finally, EPA is proposing that its post-disposal standards and pre-disposal management standard apply to commercial facilities seeking new or renewed licenses (but not to facilities already licensed). Application of these standards is proposed for three years after promulgation for both new and existing DOE facilities if they are to continue operation. The economic implications of these implementation dates are also discussed qualitatively in Chapter 9.

METHODOLOGY Chapter 3

OVERVIEW

This EIA has two primary objectives:

1. To evaluate the impacts of alternative levels of a standard.
2. To compare the impacts of the proposed standard to current practice.

The purpose of this chapter is to describe each of the analytical steps required to achieve these objectives, as they apply to the analysis of the proposed BRC criteria, NARM limits, and LLW standards.

At the outset, the analysis requires quantification of the key parameters upon which the economic comparisons are based: cost, population health effects, CPG dose, CPG risk, and cost-effectiveness. Since cost, health effects, and risk in turn depend on waste characteristics, disposal practice, and hydrogeologic/climatic setting, these factors must also be defined and quantified. Thus, the first seven steps of the methodology logically are as follows:

1. Waste Definition
2. Disposal Practice Definition
3. Hydrogeologic/Climatic Setting Definition
4. Estimation of Cost
5. Estimation of Population Health Effects
6. Calculation of Cost-Effectiveness
7. Definition and Estimation of CPG Dose and CPG Risk

Once the first seven steps are complete, two additional analytic tasks are necessary. First, a base case set of disposal practices is designated for convenience, to aid in evaluating alternative practices. Choosing the base case as current practice also facilitates the accomplishment of the second task -- comparing the proposed standards to current practice. Finally, it is necessary to state explicitly what it means to comply with a standard. In effect, since impacts are ultimately caused by the disposal practices used to meet a standard, it is necessary in the EIA to predict which practices will be used (for each waste, in each setting) to comply with each alternative standard. Two separate considerations are used to predict compliance. First, it is assumed that waste generators will attempt to meet the standard at least cost, after accounting for other existing constraints on disposal practice (e.g., Compact formation and existing regulations). This basic economic assumption is the primary linkage between a comparison of disposal practices and the comparison of alternative standards. Second, it is recognized that implementation of EPA's standards by the NRC and DOE may further constrain the disposal practices available to generators to meet the standard. The implementation assumptions described at the end of this chapter generally reflect the degree to which population risk (as well as CPG risk) and the regional variation in health effects and CPG risk are considered when choosing among alternative disposal practices.

To summarize, then, the last two steps in the analysis are:

8. Definition of the Base Case - Current Practice
9. Definition of Compliance with Alternative Standards

Each of the first eight steps is described more fully in the sections that follow. Since the relevant implementation assumptions (Step 9) vary depending on which part of the standard is considered, implementation assumptions will be described individually in Chapter 6 (for the NARM limit), Chapter 7 (for the BRC criterion), Chapter 8 (for the LLW standard), and Chapter 9 (for the remaining parts of the standard).

WASTE DEFINITION

Low-Level Wastes

Low-level radioactive waste is generated by a variety of commercial and DOE sources. However, as indicated in Chapter 2, insufficient information is available to characterize fully the wastes from the approximately 15 active DOE facilities that generate LLW. EPA does not possess detailed, publicly available DOE waste form, radionuclide content, or site characterizations, which would be needed for an in-depth risk analysis. A calculation of DOE health effects and disposal costs was made, however, by scaling the results associated with commercial LLW disposal on the basis of DOE's relative aggregate waste volume to commercial LLW volume. As described in Chapter 5 and Appendix A, projected DOE LLW volumes for the 1985 to 2004 period are drawn from recent DOE projections [DOE86].

Based on detailed records of past LLW disposal at operating commercial sites and recent NRC analysis, much more information on commercial LLW was available for EPA's analysis. EPA has segmented low-level waste from commercial sources into 25 separate waste streams. These 25 waste streams divide the total commercial LLW into relatively homogeneous categories based on four factors: volume, source of generation, waste form, and radionuclide content. These four factors are the principal waste-dependent determinants of cost and risk. To a large extent, the waste segmentation represents a tradeoff between analytic convenience and precision. In the present analysis, some variation within waste streams still remains which could potentially affect disposal costs and risks; however, large variations have been accounted for. For example, under current NRC 10 CFR 61 regulations, different disposal practices are required for different classes of wastes, depending on radionuclide content and waste form. Sufficient disaggregation is included to model the impact of these regulations. Conversely, if waste generators could segregate some low activity waste from a waste stream that otherwise would be regulated, BRC savings in addition to those estimated in this analysis might be realized. Of course, the risk associated with disposal of the remaining waste would also be affected by such segregation. (Segregation of additional BRC waste is considered in the Chapter 7 sensitivity analysis.) Since a number of other factors also limit the accuracy of the analysis (particularly the assumptions used to estimate risk), the designation of 25 wastes represents a reasonable tradeoff between simplicity and precision for purposes of analyzing alternative LLW and BRC standards.

EPA's LLW segmentation is based principally on the definitions used by the NRC in its detailed assessment [DM81, DM86]. EPA's 25 wastes represent a simple aggregation of waste streams identified by the NRC in its updated database [DM86], prepared in support of the 10 CFR 61 regulations. DM86 considered 148 low-level wastes, of which 70 are directly included in EPA's assessment. The other 78 NRC "non-routine" waste sources include: TMI 2, West Valley, mixed-oxide fuel fabrication, fuel reprocessing, and D&D wastes. Most of these wastes are either small in volume or nonexistent in current practice. Moreover, projections of future volumes and radionuclide content are speculative at this point. Because of their speculative nature, and the fact that these wastes would not be expected to significantly affect the analysis over the 20-year period for which other low-level wastes are projected, they were not included in the EPA source term.

The NRC updated database also characterized seven NARM wastes (contained in two of EPA's six discrete NARM wastes) and two military wastes that are occasionally disposed of at commercial facilities. EPA's analysis does not include military LLW in its commercial LLW source term and EPA has independently characterized its NARM wastes (see Chapter 6). The 70 different LLW streams from DM86 that are reflected in EPA's analysis were characterized using records of LLW actually disposed of at commercial LLW facilities. The characterization reflects the source of the waste, the waste form, and the average radionuclide content. EPA's 25 waste streams are listed in Table 3-1, together with the corresponding NRC streams (using NRC mnemonics as in DM86) and a mnemonic which will be used to reference individual wastes throughout the remainder of this EIA. Table 3-1 also notes the waste form assumed for purposes of risk analysis. Four waste forms are considered: Trash (TR); Absorbed Waste (AW); Activated Metal (AM); and Solidified Waste (SW). A further description of commercial LLW (activity and volume) is presented in Chapter 5.

BRC Candidates

Of the 25 commercial wastes identified for the analysis of the LLW standard, 14 wastes (those with the lowest curie concentrations) were also evaluated as candidates for unregulated disposal under the BRC criterion. Candidates for unregulated disposal are a group of LLW waste streams that were designated as surrogate BRC wastes. The analysis was performed with surrogate waste streams since (1) such BRC wastes do not exist as yet and (2) EPA does not have the authority to deregulate any specific waste stream -- that responsibility falls to the NRC and DOE. Conducting the analysis in this manner allowed an estimate to be made of the potential impacts, both in terms of costs and risks, of alternative BRC criteria.

These 14 BRC candidates are designated as such in Table 3-1. In addition, EPA has characterized four other low-level wastes for analysis in conjunction with the BRC criterion (also shown in Table 3-1). Two of these wastes (americium smoke detectors and tritiated radioluminous timepieces) represent consumer wastes for which disposal is essentially unregulated. The other two wastes are substreams of two power reactor wastes that are included in the analysis. These substreams are LWR waste oil, which is a substream of LWR concentrated liquids, and PWR condensate resins, which is a substream of LWR ion exchange resins. Both substreams are generated during power reactor operations but, on average, contain very low levels of radioactivity. Since the NRC is already considering a

Table 3-1

CHARACTERIZATION OF LOW-LEVEL WASTE AND NARM

Waste Stream	Mnemonic*	Unprocessed Waste Form**	Description	Equivalent NRC Wastes*	BRC Candidate?
POWER REACTOR WASTES					
1. PWR Compactible Trash	P-COTRASH	TR	Paper, plastic, metal, etc.	P-COTRASH	Yes
2. BWR Compactible Trash	B-COTRASH	TR	Paper, plastic, metal, etc.	B-COTRASH	Yes
3. LWR Noncompactible Trash	L-NCTRASH	TR	Clothing, conduit, respiratory cartridges, etc.	P- and B-NCTRASH	No
4. LWR Ion Exchange Resins	L-IXRESIN	AW	Organic polymer beads, powder	P- and B-IXRESIN	No
5. PWR Filter Cartridges	P-FCARTRG	TR	Fabric; paper or steel mesh	P-FCARTRG	No
6. LWR Filter Sludge	L-FSLUDGE	AW	Solids mixed with some liquids	P- and B-FSLUDGE	No
7. LWR Concentrated Liquids	L-CONCLIQ	AW	Liquids containing some solids	P- and B-CONCLIQ	No
8. LWR Decontamination Resins	L-DECONRS	AW	Concentrated exchange resins from routine decontamination procedures	L-DECONRS	No
9. Nuclear Fuel Rod Components	L-NFRCOMP	AM	Activated metal, fuel channels, control rods, etc.	N-HIGHACT & L-NFRCOMP	No

Table continued on following page.

Table 3-1 (Continued)

CHARACTERIZATION OF LOW-LEVEL WASTE AND NARM

Waste Stream	Mnemonic*	Unprocessed Waste Form**	Description	Equivalent NRC Wastes*	BRC Candidate?
FUEL CYCLE WASTES					
10. Fuel-Fabrication Compactible Trash	F-COTRASH	TR	Paper, plastic, equipment, combustibles	F-COTRASH	Yes
11. Fuel-Fabrication Noncompactible Trash	F-NCTRASH	TR	Equipment, parts	F-NCTRASH	Yes
12. Fuel-Fabrication Process Waste	F-PROCESS	AW	Limestone, oxides, sludges, oil	F-PROCESS	Yes
13. UF_6 Processing Waste	U-PROCESS	AW	Calcium fluoride, lime	U-PROCESS	Yes
INDUSTRIAL WASTES					
14. Industrial Special Source Trash	N-SSTRASH	TR	Combustibles, saw blades, floor sweepings	N+ and N-SSTRASH	Yes
15. Industrial Special Source Waste	N-SSWASTE	AW	Slag, oxides, sludge	N-SSWASTE	Yes
16. Industrial Low-Activity Trash	N-LOTRASH	TR	Paper, gloves, labware, syringes	N+ and N-LOTRASH	Yes
17. Industrial Low-Activity Waste	N-LOWASTE	AW	Scintillating fluids, absorbed liquids, biowaste	N-LOWASTE	Yes

Table continued on following page.

Table 3-1 (Continued)

CHARACTERIZATION OF LOW-LEVEL WASTE AND NARM

Waste Stream	Mnemonic*	Unprocessed Waste Form**	Description	Equivalent NRC Wastes*	BRC Candidate?
18. Isotope Production Waste	N-ISOPROD	TR	Paper, plastic, glass, metal, inorganic aqueous solutions	six wastes	No
19. Tritium Waste	N-TRITIUM	TR	Lithium fluoride, trash, plastic, metal	18 wastes	No
20. Accelerator Targets	N-TARGETS	AM	Spent targets	N-TRIFOIL	No
21. Sealed Sources	N-SOURCES	AM	Encapsulated radiation sources	11 source wastes	No
INSTITUTIONAL WASTES					
22. Institutional Compactible Trash	I-COTRASH	TR	Paper, gloves, labware, syringes	I+ and I-COTRASH	Yes
23. Biological Waste	I-BIOWAST	AW	Carcasses, tissues, bedding, excreta	I+ and I-BIOWAST	Yes
24. Absorbed Liquids	I-ABSLIQD	AW	Scintillation fluids, aqueous and organic liquids	I+ and I-ABSLIQD	Yes
25. Liquid Scintillation Vials	I-LQSCNVL	AW	Flares, plastic, scintillation fluids	I+ and I-LQSCNVL	Yes

Table continued on following page.

Table 3-1 (Continued)

CHARACTERIZATION OF LOW-LEVEL WASTE AND NARM

Waste Stream	Mnemonic*	Unprocessed Waste Form**	Description	Equivalent NRC Wastes*	BRC Candidate?
LLW SUBSTREAMS					
S1. LWR Waste Oil	L-WASTOIL	TR	LWR waste oils	--	Yes
S2. PWR Condensate Resins	P-CONDRSN	TR	PWR exchange resins from secondary condensate polishing systems	P-CONDRSN	Yes
UNREGULATED CONSUMER WASTES					
C1. Time Pieces	C-TIMEPCS	TR	Tritiated radioluminous time pieces	--	Reference
C2. Smoke Detectors	C-SMOKDET	TR	Ionizing smoke detectors using americium-241	--	Reference
NARM WASTES					
1. Radium Sources	R-RASOURC	AW	Sealed radium and radium-berullium sources	--	Not Applicable
2. Radium Ion Exchange Resins	R-RAIXRSN	AW	Ion-exchange media from removal of radium from groundwater supplies	--	Not Applicable
3. Instruments - Diffuse, Widely Distributed	R-INSTDF1	TR	Radium timepieces, smoke detectors, static eliminators, uranium paints	--	Not Applicable

Table continued on following page.

Table 3-1 (Continued)

CHARACTERIZATION OF LOW-LEVEL WASTE AND NARM

	Waste Stream	Mnemonic*	Unprocessed Waste Form**	Description	Equivalent NRC Wastes*	BRC Candidate?
4.	Instruments - Diffuse, Collectible	R-INSTDF2	TR	Neutron dosimeters, military and commercial radium aircraft dials	--	Not Applicable
5.	Glass - Discrete, Widely Distributed	R-GLASDS1	TR	Ophthalmic glass, illumination equipment, fluorescent lamp, ion lamps, etc.	--	Not Applicable
6.	Glass - Discrete, Collectible	R-GLASDS2	TR	Uranium glassware	--	Not Applicable

* Prefix meanings:

P = PWR (Pressurized Water Reactor)
B = BWR (Boiling Water Reactor)
L = LWR (Light Water Reactor, either PWR or BWR)
N+ = Large industrial generator
N- = Small industrial generator
I+ = Large institutional generator
I- = Small institutional generator

** Key

TR = Trash
AW = Absorbed Waste
SW = Solidified Waste
AM = Activated Metal

BRC designation for these wastes (either on a plant-specific or generic level), they were included as BRC candidates in the analysis. The two consumer wastes are examples of items essentially unregulated for disposal but available to the public; they are used as a reference point for evaluating alternative BRC standards. Finally, commercial wastes already deregulated under the NRC's biomedical rule [NRC81a] will be considered briefly (such waste might be regulated under a very low BRC standard) and are given the mnemonic BIOMED in this report. Like I-BIOWAST and I-LQSCNVL, BIOMED contains biomedical wastes and liquid scintillation vials. However, BIOMED only includes waste which meets the NRC biomedical rule limits, while I-BIOWAST and I-LQSCNVL include only wastes in excess of these limits.

NARM Wastes

As explained more fully in Chapter 6, six NARM wastes have been designated for analysis in the EIA. These wastes are also listed in Table 3-1. Two of these wastes, radium sources and radium-loaded ion-exchange resins, are included in the analysis of alternative LLW standards since EPA's proposed NARM limit will require regulated disposal of these wastes. These two wastes are also evaluated in terms of the costs and risks resulting from unregulated disposal. In Chapter 7, both the costs and health effects of regulated disposal are compared to those of unregulated disposal to determine the incremental cost per avoided health effect.

DISPOSAL PRACTICE DEFINITION

Regulated Disposal Practices

The costs and risks of LLW disposal depend on the technology used to package and process the waste as well as the disposal technology. In some cases, DOT regulations for transportation also prescribe minimum packaging requirements [DOT83]. Thus, packaging, processing, transportation, and disposal method collectively define a disposal practice. Variations in any of these components would alter the costs and/or risks of disposal.

EPA has identified nine land disposal methods for analysis of alternative LLW standards. As shown in Table 3-2, these methods represent a broad spectrum of technologies, ranging from regulated sanitary landfill at one extreme to deep geologic disposal at the other. Only two of the nine options (SLD and ISD) are presently incorporated at operating commercial facilities in the U.S.; however, the other methods have received a considerable amount of engineering analysis and several have been tested in the U.S. or abroad. One of the methods (EMCB) comprises two subtechnologies which, in principle, could be used alone; however, separate use has not been considered in this EIA.

To estimate cost and health risks, each of the nine disposal methods is associated with an explicit set of engineering assumptions. The principal differences among the methods reflect variations in the site area and distribution of waste at the site (which affect CPG risk), the use of engineered structures, the trench depth, the trench cap integrity, and the trench cap thickness.

EPA has also considered engineering practices which change the waste volume and stability characteristics, including packaging the waste as generated, packaging the waste in a high integrity container (HIC), waste compaction, absorption of liquid waste, solidification as generated, and solidification after incineration. Since these practices alter both the costs and health risks of disposal, they represent "suboptions" that can be associated with almost any of the nine disposal methods.* By combining disposal methods and packaging/processing suboptions, a significant number of fully-specified disposal practices could be considered.

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* Since some of the methods require special waste forms (e.g., deep well injection and hydrofracture require liquid and slurry, respectively), suboptions are not always available.

Table 3-2

ALTERNATE DISPOSAL PRACTICES FOR LLW DISPOSAL

Disposal Method	Mnemonic	Description	Packaging/Processing Suboption
1. Regulated Sanitary Landfill	SLF	Disposal in shallow (2 meter) trenches with simple local soil cover (0.6 meter)	Waste form variation considered (suboptions vary by waste)
2. Shallow Land Disposal	SLD	Disposal in trenches 7 meters deep with a 2-meter engineered cover	Waste form variation considered (suboptions vary by waste)
3. Improved Shallow Land Disposal	ISD	Disposal in 8-meter deep slit trenches covered with a 5-meter cap and intruder barrier	Waste form variation considered (suboptions vary by waste)
4. Intermediate Depth Disposal	IDD	Disposal in 15-meter deep trenches with a 10-meter thick cover	Waste form variation considered (suboptions vary by waste)
5. Hydrofracture	HF	Onsite deep injection of waste and aggregate slurry into a porous geologic structure created by hydrofracture	Liquid wastes only (6 waste streams)

Table continued on following page.

Table 3-2 (Continued)

ALTERNATE DISPOSAL PRACTICES FOR LLW DISPOSAL

Disposal Method	Mnemonic	Description	Packaging/Processing Suboption
6. Deep Well Injection	DWI	Local deep injection of waste slurry into a porous geologic structure	Liquid wastes only (3 waste streams)
7. Deep Geologic Disposal	DGD	Permanent disposal in a deep, dry underground cavity as for High-Level Waste	Disposal in existing mine cavity or in shale formation. No distinction in risk model.
8. Concrete Canister	CC	Waste packaged in precast concrete overpacks placed in shallow burial trenches. Overpacks are recoverable	Solidified only.
9. Earth Mounded Concrete Bunker	EMCB	Emplacement in earth mounds or concrete bunkers using volume reduction and solidification pretreatment. Codisposal with high-level waste	Class A grouted; Classes B and C solidified.

A list and brief description of the disposal practices considered in this report are presented in Table 3-2. It should be noted that all regulated disposal practices assume an amount of waste packaging at least sufficient to meet existing DOT standards for transporting waste to the disposal site. Finally, not all disposal practices are appropriate for disposal of all wastes (e.g., deep well injection requires a liquid waste form; noncompactible waste cannot be compacted and need not be solidified). For practical reasons, EPA did not attempt to estimate the health effects, CPG risks, and costs for all of the waste, hydrogeologic region, disposal method, and packaging/processing suboption combinations. These limitations are reflected in Table 3-2. The combinations EPA did consider are listed later in Table 3-10.

Unregulated Disposal Practices

To evaluate alternative BRC standards, EPA has also estimated the costs, health effects, and CPG risks of unregulated disposal practices. While unregulated disposal can be compared to a single regulated disposal practice (such as SLD with waste "as generated"), there is no reason to expect that unregulated disposal of a given waste will be uniform across the country. Rather, if a waste is disposed of without regard to its radioactive content, a number of unregulated disposal practices are likely to be used for which the costs and health effects may vary.

To estimate the total costs and population health effects of unregulated disposal, EPA defined five representative disposal practices which differ by location (i.e., surrounding population and site size), the integrity of the site (a municipal dump versus a sanitary landfill), and whether incineration is used as part of the disposal practice. Specifically, the five unregulated disposal practices include the following:

1. Municipal Dump, Rural Setting
2. Suburban Sanitary Landfill, no incineration
3. Suburban Sanitary Landfill, onsite incineration
4. Urban Sanitary Landfill, no incineration
5. Urban Sanitary Landfill, onsite incineration

While these five unregulated disposal practices adequately describe unregulated disposal on average, for purposes of comparison, the costs and health effects of disposal at a medical or university incinerator were also quantified, since these facilities are sometimes used to destroy certain biomedical wastes. This sixth facility type was also used to estimate the costs and risks of unregulated disposal of the wastes deregulated by NRC81a (the biomedical rule). Table 3-3 lists the salient characteristics of the six unregulated disposal practices considered in the EIA.

The total costs and population health effects that would result from unregulated disposal of a given waste are calculated by combining the characteristics of the five primary unregulated disposal practices. The weighting of practices reflects an estimate of the proportion of the waste that would be disposed in each type of facility if disposal of the waste were unregulated. For example, fuel cycle waste is generated in plants located principally in rural or suburban areas; hence, over the next 20 years, it is assumed that 47.5 percent of this waste would be disposed of in municipal dumps, 47.5 percent in suburban landfills (with or without incineration), and five percent in urban landfills. The derivation of these weightings is discussed in more detail in Appendix B.

HYDROGEOLOGIC/CLIMATIC SETTING DEFINITION

To account for the impact of hydrogeologic and meteorologic characteristics on the estimation of health risk, EPA has characterized three sets of generic site conditions. The site characteristics have a substantial

Table 3-3

SALIENT CHARACTERISTICS OF UNREGULATED DISPOSAL PRACTICES

Disposal Practice	Acronym	Setting	Population Served	Size+ (Cubic Meters)	Length (Meters)	Onsite Incinerator	Aggregate VRF*
1. Municipal Dump	MD	Rural	60,000	2.1 Million	590	No	NA
2. Suburban Sanitary Landfill	SF	Suburban	175,000	6.0 Million	1,000	No	NA
3. Suburban Sanitary Landfill with Incineration	SI	Suburban	175,000	1.0 Million	408	Yes	6.0
4. Urban Sanitary Landfill	UF	Urban	1,000,000	34.7 Million	2,404	No	NA
5. Urban Sanitary Landfill with Incineration	UI	Urban	1,000,000	5.78 Million	982	Yes	6.0
6. Large University Medical Center with Dedicated Landfill and Onsite Incineration	LURO	Suburban	175,000	0.17 Million	169	Yes	6.0

+ Includes entire sanitary waste volume. Only a small fraction would be LLW meeting the BRC criterion (a uniform LLW distribution assumed).

* VRF = Volume Reduction Factor. Volume reduction occurs due to incineration.

SOURCE: Putnam, Hayes & Bartlett, Inc., September 1987. In all cases, a 0.6 meter cover thickness is assumed. Facilities with incineration are assumed to volatilize 90 percent of the tritium, 75 percent of the C-14, and one percent of all other nuclides. The waste depth is 6 meters.

impact on the estimates of population health effects and CPG risk and include the following salient features: (1) annual rainfall pattern; (2) soil permeability and composition; (3) relative distance from and local use of a well; (4) vertical distance to nearest aquifer; (5) horizontal distance from and use of a local stream; (6) aquifer velocity and thickness; (7) prevalence of local farming; (8) local wind conditions; and (9) local population. These three generic sites, which EPA assumes will encompass the potential characteristics of actual future LLW regulated disposal sites, are identified as follows:

1. Humid Permeable Region -- site of moderate rainfall with soil of moderate permeability.

2. Humid Impermeable Region -- site of moderate rainfall with soil of low permeability.

3. Arid Permeable Region -- site of low rainfall with soil of moderate permeability.

Except for the assumed local population and the distance to local streams and wells, these same hydrogeologic characteristics are used to assess regional variations in the health effects and CPG risks from unregulated disposal in the analysis of alternative BRC criteria. A similar analysis is used in the comparison of alternative NARM limits.

ESTIMATION OF COST

The objective of the cost analysis is to measure the incremental increase in costs to society that results from implementing EPA's standard. Costs are measured in constant 1985 dollars. In this EIA, social costs are characterized by the before-tax cash costs paid by the generator of LLW.* The general approach is to estimate unit costs (per cubic meter as generated) for each waste and each disposal practice. The unit costs are then multiplied by annual disposal volume to calculate total annual cost. Finally, the present value of costs is estimated by employing a real discount rate of 10 percent over an assumed 20-year horizon (the operating life of a disposal site), unless otherwise noted (a discount rate sensitivity analysis is included in Appendix E).

Costs include four components in the waste disposal process -- packaging, processing, transportation, and disposal method. For several of the shallow land disposal options, the first three cost components are the same for a given waste form. Thus, these components sometimes "cancel out" when incremental costs are calculated. However, some practices do require different waste processing (e.g., solidification and incineration) and some alter the assumed transportation distance (e.g., hydrofracture and deep well injection occur onsite or close to the point of waste generation). Thus, it is necessary to consider all cost components to quantify incremental cost correctly.

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* Various definitions of social cost have been employed in other studies. The definition used here is convenient, since it generally uses observable market prices as the measure of social cost. Other definitions (e.g., the summation of the before-tax values added at each stage in the production chain for each good or service consumed) presume that taxes distort the use of price as a market measure of social cost. This distortion is attributed to the assumption that taxes represent a transfer of wealth rather than a use of real resources. The definition used here assumes the other extreme -- that tax effects included in the prices are, in fact, social costs and represent levies on the use of public goods, e.g., law enforcement, public roadways, etc. In fact, taxes probably represent a combination of public goods and wealth redistribution.

Packaging and solidification costs are based on engineering estimates of the direct cost of labor and materials used for each waste. Average unit transportation costs were derived from actual tariffs for transporting LLW. In general, a 650-mile transport distance is assumed for regulated disposal. Other cost components, including compaction, incineration, and disposal method, are based on engineering cost analyses of hypothetical compaction, incineration, or disposal facilities, since most of these facilities do not presently exist (hence, market prices are not available). The analysis is constructed so that the facility operator (assumed to be a privately financed organization) earns a return on the required investment and pays tax at a 46 percent rate.* Based on explicit assumptions regarding site size and period of operation, the unit disposal cost is estimated in 1985 dollars to provide a 10 percent real return. The methodology employed in this engineering analysis is described in more detail in NRC81b, NRC82d, TRW83a, EEI84b, RAE86a, and in Appendix C.** The costs of disposal site closure, post-closure, and 100 years of institutional care are included. Sites for shallow land disposal and intermediate depth disposal are sized to receive 250,000 cubic meters of waste (as generated volume) over 20 years. This site size represents EPA's expectation for an average commercial LLW site. Given the volume estimates presented in Chapter 5, it implies that about eight commercial sites will be required. Site sizes for other disposal

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* Note that the disposal method unit costs were derived from previous work completed in 1986 or earlier, at which time a 46 percent corporate income tax rate represented a reasonable assumption for Federal income taxes. Hence, the impact of the Tax Reform Act of 1986 has not been considered, but could alter costs to the generator. Note that the discount rates used for these financial projections of private sector disposal service prices are not necessarily equal to the social rate of discount used to determine the present value of social costs.

** Most of the engineering costs and financial calculations represent modifications of the work originally presented in NRC81b, altered to reflect a smaller site size. Scale-dependent costs were assumed to vary in proportion to relative site volume raised to the 0.6 power.

practices are based on the probable volume fraction of the waste that would use the specific disposal method, out of a 250,000 cubic meter reference site volume, assuming co-location of different trench types (e.g., ISD and SLD).

As mentioned above, cost represents the sum of packaging, processing, transportation, and disposal. Since packaging and processing typically occur at the point of generation or at a regional facility, volume increases or reductions raise or lower the associated transportation and disposal costs. In order to account for such volume changes, estimates of the volume of LLW and NARM used to determine total cost (presented in Chapters 5 and 6) are based on the waste form "as generated," which is defined as the waste volume shipped for disposal prior to any special processing (e.g., compaction, incineration, or solidification). Volume increases and reductions thus serve to increase or decrease the effective unit cost of disposal, measured as the disposal cost per cubic meter of waste as generated. This procedure allows for comparison of unit costs across disposal practices on a consistent basis. Table 3-4 presents the unit cost of disposal for "as generated" waste for each disposal option. Table 3-7 presents the volume increase and reduction multipliers that apply to transportation and disposal cost for each low-level waste as a function of waste processing. The cost of packaging, processing, and transportation (per cubic meter of waste handled) are shown in Tables 3-5, 3-6, and 3-8, respectively. Differences in costs across waste types reflect the greater handling costs and additional materials required to deal with higher activity waste. Note that while Tables 3-6 and 3-7 show costs and volume multipliers for compaction, solidification in cement, and incineration followed by solidification in cement, the health effects due to these processing options were not quantified. These options, therefore, are not considered further.

The costs of unregulated disposal include only transportation and disposal costs. Unregulated disposal packaging costs are assumed to be

Table 3-4

DISPOSAL COSTS
BY DISPOSAL PRACTICE

DISPOSAL OPTION	BURIAL COST (1985 Dollars per Cubic Meter)
REGULATED SANITARY LANDFILL	238
SHALLOW LAND DISPOSAL	393
IMPROVED SHALLOW LAND DISPOSAL	907
INTERMEDIATE DEPTH DISPOSAL	732
DEEP WELL INJECTION	5,244
HYDROFRACTURE	3,027
DEEP GEOLOGICAL DISPOSAL	959
EARTH MOUND/CONCRETE BUNKER	520/4,040
CONCRETE CANISTER	540

Table 3-5

PACKAGING COST DATA

EPA WASTE STREAM MNEMONIC		PHB ESTIMATE (1) (1985 dollars per cu. meter. as generated)	VOLUME INCREASE FACTORS
P-COTRASH	(2)	303	1.0
B-COTRASH	(2)	303	1.0
L-NCTRASH	(3)	383	1.0
L-IXRESIN	(4)	449	1.0
P-FCARTRG	(5)	449	1.0
L-FSLUDGE	(4)	449	1.0
L-CONCLIQ	(4)	512	1.0
L-DECONRS	(4)	449	1.0
F-COTRASH	(2)	303	1.0
F-NCTRASH	(3)	355	1.0
F-PROCESS	(2)	303	1.0
U-PROCESS	(2)	303	1.0
N-SSTRASH	(2)	303	1.0
N-SSWASTE	(2)	303	1.0
N-LOTRASH	(2)	303	1.0
N-LOWASTE	(2)	303	1.0
L-NFRCOMP	(6)	501	1.0
N-ISOPROD	(7)	449	1.0
N-TRITIUM	(5)	501	1.0
N-TARGETS	(5)	501	1.0
N-SOURCES	(5)	501	1.0
I-COTRASH	(2)	303	1.0
I-BIOWAST	(8)	1,451	1.92
I-ABSLIQD	(8)	1,879	3.0
I-LQSCNVL	(8)	1,879	3.0
R-RASOURC	(9)	501	2914.0
R-RAIXRSN	(10)	449	1.0

NOTES:

(1) ALL ESTIMATES INCLUDE COMPONENT COSTS FOR LABOR, MATERIALS, AND UTILITIES, AND REFLECT VOLUME INCREASES WHERE APPROPRIATE.

(2) ESTIMATE REFLECT PACKING IN A DRUM ONLY. COSTS ALSO INCLUDE LABOR (FOR A TOTAL PER DRUM COST OF $50 IN 1980, OF WHICH $22 REPRESENTS THE COST OF THE DRUM ALONE).

(3) ESTIMATE REFLECTS MIX OF DRUMS AND BOXES AND INCLUDES LABOR. COSTS ARE ALSO ASSUMED TO DEPEND ON ACTIVITY (HIGHEST FOR B-COTRASH, THEN P-COTRASH, THEN F-NCTRASH).

(4) ESTIMATE REFLECTS DRUM PACKING, BUT ALSO REFLECTS DEWATERING COST AND ASSUMES THAT DRUMS WILL BE SHIPPED IN REUSABLE SHIELDED CASKS (CASK COST INCLUDED IN TRANSPORT COST).

(5) ESTIMATE REFLECTS MIX OF DRUMS AND (APPARENTLY) BOXES, AND INCLUDES LABOR. COSTS ARE ALSO ASSUMED TO DEPEND ON ACTIVITY. FILTER CARTRIDGE ESTIMATE REFLECTS TRW83a ASSUMPTION THAT FILTER CARTRIDGE COSTS ARE THE SAME AS RESINS AND SLUDGES.

(6) ESTIMATE REFLECTS MIX OF DRUMS AND (APPARENTLY) BOXES, AND INCLUDES LABOR. COSTS ARE ALSO ASSUMED TO DEPEND ON ACTIVITY.

(7) ESTIMATE REFLECTS TRW83a ASSUMPTION FOR PACKAGING AT A COST EQUAL TO RESINS. THIS COST IS APPROXIMATELY THE SAME AS 1/2 L-CONCLIQ AND 1/2 F-NCTRASH, SINCE N-ISOPROD IS HALF LIQUID AND HALF SOLID.

(8) ESTIMATE REFLECTS COST OF A DRUM, LABOR AND ABSORBENT, AND A VIF OF 1.92 (I-BIOWAST) OR 3.0 (I-ABSLIQD AND I-LQSCNVL).

(9) ESTIMATE REFLECTS ASSUMPTION THAT PACKAGING COSTS FOR R-RASOURC ARE THE SAME AS N-SOURCES.

(10) ESTIMATE REFLECTS ASSUMPTION THAT PACKAGING COSTS FOR R-RAIXRSN ARE THE SAME AS L-IXRESIN.

Table 3 6
PROCESSING COSTS PER CUBIC METER OF UNTREATED WASTE
(IN 1985 DOLLARS)

WASTE	COMPACT & PACKAGE	INCINERATE (6) & PACKAGE	SOLIDIFY W/ CEMENT & PACKAGE	SOLIDIFY W/ POLYMER & PACKAGE	INCINERATE, SOLIDIFY W/ CEMENT, & PACKAGE	INCINERATE, SOLIDIFY W/ POLYMER, & PACKAGE
P-COTRASH	420	2,428	1,606	3,064	2,448	2,467
B-COTRASH	420	2,428	1,606	3,064	2,448	2,467
L-NCTRASH	1,644 (1)	-	1,606	3,064	-	-
L-IXRESIN	-	2,428	1,606	3,064	2,518	2,599
P-FCARTRG	1,709 (1)	-	1,606	3,064	-	-
L-FSLUDGE	-	2,428	1,606	3,064	2,750	3,041
L-CONCLIQ	-	2,428	1,606	3,064	2,645	2,841
L-DECONRS	-	2,428	1,606	3,064	2,518	2,599
F-COTRASH	420	2,428	1,606	3,064	2,468	2,505
F-NCTRASH	1,615 (1)	-	1,606	3,064	-	-
F-PROCESS	-	-	1,606	3,064	-	-
U-PROCESS	-	-	1,606	3,064	-	-
N-SSTRASH	420 (2)	1,942 (7)	1,606	3,064	2,043	2,134
N-SSWASTE	-	-	1,606	3,064	-	-
N-LOTRASH	420 (2)	1,942 (7)	1,606	3,064	1,992	2,038
N-LOWASTE	-	2,428	1,606	3,064	2,479	2,524
L-NFRCOMP	-	-	1,606	3,064	-	-
N-ISOPROD	992 (3)	2,428	1,606	3,064	2,479	2,524
N-TRITIUM	566 (4)	2,581 (8)	1,606	3,064	2,661	2,733
N-TARGETS	1,762 (1)	-	1,606	3,064	-	-
N-SOURCES	-	-	1,606	3,064	-	-
I-COTRASH	420 (2)	1,942 (7)	1,606	3,064	1,992	2,038
I-BIOWAST	-	2,581 (8)	1,606	3,064	2,688	2,785
I-ABSLIQD	-	2,581 (8)	1,606	3,064	2,597	2,612
I-LQSCNVL	1,888 (5)	2,581 (8)	1,606	3,064	2,937	3,259
R-RASOURC	-	-	1,606	3,064	-	-
R-RAIXRSN	-	1,302 (9)	1,606	3,064	1,391	1,472

SEE NOTES ON FOLLOWING PAGE

Table 3-6 (Continued)

PROCESSING COSTS PER CUBIC METER OF UNTREATED WASTE

NOTES:

(1) Compaction done by hydraulic press at burial site, therefore packaging and transportation costs would remain the same although burial costs would be reduced because of volume reduction.

(2) Assumes small generators are included. Also, the option of using an improved compactor with VRFs of 5 to 6, but at a higher cost, is not considered.

(3) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-ISOTRSH* = 1,044 m^3 with VRF = 6, N-SORMFG1* = 56 m^3, with VRF = 6, N-SORMFG4* = 3,200 m^3 with VRF = 6, and all others = 5,667 m^3 with VRF = 1.

(4) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-NECOTRA* = 3,168 m^3 with VRF = 2, N-TRIPLAT* = 88.1 m^3 with VRF = 6, N-TRITRSH* = 478 m^3 with VRF = 6, and others = 3206.8 m^3 with VRF = 1.

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* These mnemonics refer to waste substreams as designated by NRC in DM86. See Table 3-1 and Appendix A for the correspondence to EPA estimates.

Notes continued on following page.

Table 3-6 (Continued)

PROCESSING COSTS PER CUBIC METER OF UNTREATED WASTE

(5) The cost of compaction and packaging is calculated by multiplying the volume increase factor for compaction by the cost of packaging, then adding in the cost of compaction.

(6) Fluidized Bed Incinerator at generator site unless otherwise noted.

(7) A weighted average is calculated where 50 percent of the waste is burned in a Pathological Incinerator and 50 percent is burned in a Fluidized Bed Incinerator at a regional facility.

(8) Pathological Incinerator at generator site. Also, assumes small generators are included in this scenario.

(9) Fluidized Bed Incinerator at regional processing center.

Table 3-7
VOLUME INCREASE FACTORS

WASTE	COMPACT & PACKAGE	INCINERATE & PACKAGE	SOLIDIFY W/ CEMENT & PACKAGE	SOLIDIFY W/ POLYMER & PACKAGE	INCINERATE, SOLIDIFY, W/ CEMENT & PACKAGE	INCINERATE, SOLIDIFY, W/ POLYMER & PACKAGE
P-COTRASH	0.333	0.013	1.4	2.0	0.017	0.025
B-COTRASH	0.500	0.013	1.4	2.0	0.017	0.025
L-NCTRASH	0.167	-	1.4	2.0	-	-
L-IXRESIN	-	0.056	1.4	2.0	0.078	0.111
P-FCARTRG	0.100	-	1.0 (6)	1.0 (6)	-	-
L-FSLUDGE	-	0.200	1.4	2.0	0.280	0.400
L-CONCLIQ	-	0.135 (3)	1.4	2.0	0.189	0.270
L-DECONRS	-	0.056	1.4	2.0	0.078	0.111
F-COTRASH	0.667	0.025	1.4	2.0	0.035	0.050
F-NCTRASH	0.167	-	1.4	2.0	-	-
F-PROCESS	-	-	1.4	2.0	-	-
U-PROCESS	-	-	1.4	2.0	-	-
N-SSTRASH	0.667	0.063	1.4	2.0	0.088	0.125
N-SSWASTE	-	-	1.4	2.0	-	-
N-LOTRASH	0.500	0.031	1.4	2.0	0.044	0.063
N-LOWASTE	-	0.031 (4)	1.4	2.0	0.044	0.063
L-NFRCOMP	-	-	1.4	2.0	-	-
N-ISOPROD	0.641 (1)	0.031 (4)	1.4	2.0	0.044	0.063
N-TRITIUM	0.704 (2)	0.050 (5)	1.4 (7)	2.0 (7)	0.069	0.099
N-TARGETS	0.167	-	1.0 (6)	1.0 (6)	-	-
N-SOURCES	-	-	1.4	2.0	-	-
I-COTRASH	0.500	0.031	1.4	2.0	0.044	0.063
I-BIOWAST	-	0.067	1.4	2.0	0.093	0.133
I-ABSLIQD	-	0.010	1.4	2.0	0.014	0.020
I-LQSCNVL	0.781	0.221	1.4	2.0	0.310	0.442
R-RASOURC	-	-	1.4	2.0	-	-
R-RAIXRSN	-	0.056	1.4	2.0	0.078	0.111

SEE NOTES ON THE FOLLOWING PAGE

Table 3-7 (Continued)

VOLUME INCREASE FACTORS

(1) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-ISOTRSH* = 1,044 m^3 with VRF = 6, N-SORMGF1* = 56 m^3, with VRF = 6, N-SORMFG4* = 3,200 m^3 with VRF = 6, and all others = 5,667 m^3 with VRF = 1.

(2) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-NECOTRA* = 3,168 m^3 with VRF = 2, N-TRIPLAT* = 88.1 m^3 with VRF = 6, N-TRITRSH* = 478 m^3 with VRF = 6, and others = 3,206.8 m^3 with VRF = 1.

(3) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: P-CONCLIQ* = 226,703.8 m^3 with a VRF = 8 and B-CONCLIQ* = 103,942.4 with VRF = 6.4.

(4) VRF for incineration assumed to be equal to 32.

Table continued on following page.

Table 3-7 (Continued)

VOLUME INCREASE FACTORS

(5) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-NECOTRA* = 3,168 m^3 with VRF = 20, N-TRISCNT* = 26 m^3 with VRF = 4.52, and N-TRILIQD = 141.9 m^3 with VRF = 100. All other substreams were not included.

(6) Volume does not increase since solidifying agent is used only to fill voids in shipping package.

(7) If not incinerated, VRF = 1.0 since volume does not increase because solidifying agent is used only to fill voids in shipping package.

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* These mnemonics refer to waste substreams as designated by the NRC in DM86. See Table 3-1 and Appendix A for the correspondence to EPA wastes.

Table 3-8

TRANSPORATION COSTS PER CUBIC METER
ASSUMING NO PROCESSING
(IN 1985 DOLLARS)

	650 MILES	2300 MILES
P-COTRASH (1)	134	405
B-COTRASH (1)	134	405
L-NCTRASH (2)	548	1,380
L-IXRESIN (1)	1,176	3,991
P-FCARTRG (1)	1,176	3,991
L-FSLUDGE (1)	1,176	3,991
L-CONCLIQ (1)	821	2,782
L-DECONRS (3)	542	1,820
F-COTRASH (1)	134	405
F-NCTRASH (2)	455	1,148
F-PROCESS (1)	134	405
U-PROCESS (1)	134	405
N-SSTRASH (1)	134	405
N-SSWASTE (1)	134	405
N-LOTRASH (1)	134	405
N-LOWASTE (1)	134	405
N-NFRCOMP (3)	542	1,820
N-ISOPROD (3)	311	923
N-TRITIUM (3)	542	1,820
N-TARGETS (3)	542	1,820
N-SOURCES (3)	542	1,820
I-COTRASH (1)	134	405
I-BIOWAST (3)	271	813
I-ABSLIQD (3)	271	813
I-LQSCNVL (3)	271	813
R-RASOURC (4)	542	1,820
R-RAIXRSN (5)	1,176	3,998

NOTES:

(1) THESE COSTS WERE CALCULATED DIRECTLY FROM SL80; COSTS WERE REPORTED FOR THREE WASTE CATEGORIES--DRY ACTIVE WASTE, RESINS & SLUDGES, AND CONCENTRATES.

(2) THESE COSTS WERE REPORTED IN TRW83a BASED ON ANALYSIS IN: "A HANDBOOK FOR LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITIES," ROGERS & ASSOCIATES ENGINEERING CORPORATION, RAE-20-5, SEPTEMBER 1982.

(3) THESE COSTS WERE ADOPTED DIRECTLY FROM TRW83a. COSTS WERE FIRST DEFLATED FROM 1982 TO 1980 DOLLARS BY USING A FACTOR OF 1.2 THEN WERE INFLATED FROM 1980 DOLLARS TO 1985 BY USING A FACTOR OF 1.3.

(4) COST ASSUMED TO BE EQUAL TO N-SOURCES.

(5) COST ASSUMED TO BE EQUAL TO L-IXRESIN.

negligible and the transportation distance is much smaller (disposal occurs at a local site near the waste generator). Costs are based on a 1986 survey of tipping fees conducted by the National Solid Waste Management Association and reflect charges for transfer stations, transportation, and landfilling [NSWMA86]. Table 3-9 presents the unit disposal costs used for each of the six unregulated disposal practices, as well as the weighting each practice is given in calculating average unregulated disposal costs and health effects for each waste category. As before, the present value of disposal cost is calculated from the unit disposal costs using a 20-year horizon and a 10 percent real discount rate. Appendix C provides more detailed documentation of how these regulated and unregulated disposal costs were derived.

ESTIMATION OF POPULATION HEALTH EFFECTS

Population health effects represent one of two risk measures and are defined as the cumulative fatal cancers and serious genetic effects to the general population that result from a given disposal practice. Serious genetic effects are defined as genetic effects which result in death, hospitalization, or major surgery. Cumulative population health effects incurred over a 10,000-year period (undiscounted) are compared to the base case population health effects to calculate the benefits of alternative standards in the form of population risk reduction. It should be noted that only human health effects from radiologic hazards are included in the estimate of benefits; thus, reduction in other health effects or environmental impacts due to the standard are not considered quantitatively.

More specifically, population health effects are calculated as the sum of expected fatal cancers and expected first generation serious genetic effects resulting from radiation. Morbidities resulting from non-fatal cancers are not quantified. In addition, fatal cancers and genetic effects have been

Table 3-9

UNIT COST AND WEIGHTING BY WASTE CATEGORY FOR UNREGULATED DISPOSAL PRACTICES

		Scenario Weightings for Unregulated Disposal (%)							
Unregulated Disposal Practice	Unit Cost ($/m³)	Power Reactor Waste	Fuel Fabrication Waste	UF_6 Process Waste	Industrial Waste	Radium Ion-Exchange Resins	Insti-tutional Waste	Consumer & All Other NARM Waste	Deregulated BIOMED Waste
1. Rural Municipal Dump	14.78	25.0	47.5	50	25	25	5.0	5.0	0
2. Suburban Sanitary Landfill	14.78	25.0	23.75	25	25	25	23.75	23.75	0
3. Suburban Sanitary Landfill with Incineration	16.27	25.0	23.75	25	25	25	23.75	23.75	0
4. Urban Sanitary Landfill	14.78	12.5	2.5	0	12.5	12.5	23.75	23.75	0
5. Urban Sanitary Landfill with Incineration	16.27	12.5	2.5	0	12.5	12.5	23.75	23.75	0
6. University/Medical Center Landfill with Incineration	$16.27	0	0	0	0	0	0	0	100
TOTAL		100%	100%	100%	100%	100%	100%	100%	100%
Average Unregulated Disposal Cost (Per Cubic Meter)		$15.34	$15.17	$15.15	$15.34	$15.34	$15.49	$15.49	$16.27

NOTE: Costs are in 1985 dollars. Cost estimates are based on [NSWMA86] data. The disposal practices shown are "unregulated" with respect to radiological hazards, but may be subject to other regulatory requirements.

given equal weighting as measures of risk. This treatment of genetic effects is environmentally conservative (i.e., benefits are overstated) if the value attributed to an avoided health effect is interpreted as a "value of life" and the value of avoiding a genetic effect is smaller than the value of avoiding a fatal cancer. Practically, however, expected genetic effects are generally much fewer than expected fatal cancers, so the impact of this assumption on the calculation of health effects is very small.

Linear, No Threshold Dose/Response Assumption

In estimating population health effects, EPA assumes that health risks are proportional to the level of exposure and that this linear relationship is constant down to zero exposure. This assumption has two important consequences for the analysis of economic impacts. First, it implies that an exposure threshold (below which health effects are either zero or decline rapidly) cannot be used to justify a de minimis level of exposure, since any incremental exposure causes at least some additional health effects. This is one reason why the economic analysis of alternative BRC criteria considers both the costs and health effects of alternative criteria rather than just the level of risk. Second, the "Linear, No Threshold" assumption implies that the total incremental health effects resulting from LLW disposal are independent of the level of risk faced by any single individual. Thus, population health effects are the same when 1,000 people face an individual risk of one in one million and when a single person faces a risk of one in 1,000 (the total population risk is one in 1,000 in both cases). In addition, risks that may result from background radiation do not affect the analysis of incremental risk due to LLW disposal and, thus, need not be quantified.* The BRC criterion and LLW standard are, therefore, defined in terms of "above background" exposure limits.

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* Strictly speaking, since EPA uses a relative risk projection model which depends on the underlying vital statistics of the cohort group, background risks do affect the calculation of health effects. See the Background Information Document for further discussion of EPA's health risk calculations [EPA87].

Exposure Pathways and Time Horizon Included in Analysis

The analysis of population health effects was conducted using the PRESTO family of computer models.* The analysis considers a 10,000-year horizon. Health effects incurred from exposure to the local population during the first 1,000 years (referenced hereinafter as the Primary Analysis) are modeled in detail based on explicit transport mechanisms and exposure pathways. Health effects incurred outside of the local population or beyond 1,000 years (referenced hereinafter as Basin Effects) are estimated using a more aggregate procedure employed in earlier EPA analyses.** In brief, Basin Effects depend on the total activity reaching a stream before 10,000 years, the fraction of this activity that causes exposure (which depends on EPA assumptions regarding regional water consumption), and the health effects per unit of activity released. Only two mechanisms result in no exposure from a radionuclide: (1) radionuclide decay before release from the trench or the ground (i.e., to a stream or well) and (2) radionuclide capture in the trench or failure to reach a stream or well through groundwater transport within 10,000 years. In all other cases, radionuclides are released to the environment and at least some exposure is assumed to occur.***

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* See the Background Information Document and the User's Manuals for a description of these models [EPA85a, EPA85b, EPA85c, EPA85d, EPA87]. The models include PRESTO-EPA-POP, PRESTO-EPA-DEEP, and PRESTO-EPA-BRC.

** See EPA85e.

*** The health risks due to atmospheric releases of radionuclides during LLW incineration are not quantified in the analysis relative to this standard setting activity. Atmospheric releases from waste incinerators were one of the releases examined in establishing Radionuclide Clean Air Act Standards (40 CFR 61) and are subject to those requirements. However, the activity remaining in the incinerated LLW ash is reduced by the activity released to the air.

During the Primary Analysis period, the movement of radionuclides is traced through the local environment to the local population via each of five basic exposure pathways. The analysis tracks 40 radionuclides which represent essentially all radionuclides present in significant concentrations with half-lives greater than five years, as well as six nuclides with shorter half-lives that are present in significant concentrations in some waste. Of the nuclides, 16 are present only in NARM waste (the dominant NARM nuclides are uranium, thorium and radium). The population health effect exposure pathways modeled in the analysis include the following: (1) ingestion of water from a local well or stream; (2) ingestion of plants irrigated with contaminated groundwater drawn from a local well or stream or contaminated through deposits of airborne radionuclides; (3) ingestion of animals (e.g., beef, poultry) contaminated through local contaminated plant food or through drinking contaminated groundwater from a local well or stream; (4) inhalation of airborne radionuclides; and (5) direct gamma exposure from contaminated air or surface soil.

The population health effects due to exposure outside the Primary Analysis period (the Basin Effects) are estimated indirectly by quantifying the amount of radionuclides that reach a stream within the first 10,000 years (excluding the radionuclides for which exposure is already accounted for in the Primary Analysis). As mentioned above, these Basin Effects radionuclides are assumed to cause a fixed number of health effects per unit of activity released, based on an estimate of the fraction of nuclides likely to cause exposure (which depends principally on water consumption habits in the area) and on an estimate of the health risk per unit of radionuclide exposure. This aggregate risk estimation procedure is identical to that employed in previous EPA analyses.

Differences Between Estimates for the LLW and BRC Standards

The estimation of population health effects for the regulated and unregulated disposal alternatives is identical, with minor exceptions. First, the population health effects from nuclides released into the air from unregulated incinerator scenarios are quantified explicitly, assuming even release over 20 years (constant operation); this exposure pathway is not modeled in the case of regulated disposal. Furthermore, in the analysis of regulated disposal options, risks resulting from disposal operations and waste transport are excluded. Exposure to onsite workers and transporters for regulated disposal are excluded from this rule, under AEA authority; therefore, their risks have no basis for being factored into this analysis. Regulated radiation workers are subject to other EPA actions and EPA has recently issued new Federal Guidance on these exposures which is obligatory for all Federal agencies, including DOE and NRC. In contrast, worker risks are included in the risk estimates for unregulated disposal. Transportation CPG risks are also included in the estimates for unregulated disposal but not in the estimates for regulated disposal. DOT has statutory responsibility for regulating the shipment and transportation of radioactive materials and for protecting the public from unwarranted exposures to radioactive materials while in transit.

From an economic perspective, it might also be argued that laborers knowingly working in the presence of a radiologic hazard are assumed to charge a risk premium for their work; in contrast, workers in municipal waste disposal do not knowingly assume such a hazard and the cost of this hazard is not included in their wages.* Provided that the premium each worker charges is equal on average to the value placed on avoided risk, this treatment yields an estimate of societal net benefits identical to that derived by explicit analysis of worker and transportation risks from regulated LLW disposal.

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* This is a conservative assumption, since some economists might argue that workers in municipal disposal in fact may be aware of such hazards, thus charging a risk premium for their work. In addition, wage rate assumptions used in the cost analysis are the same for all regulated disposal options, so worker risk differences may not be fully captured in the analysis.

CALCULATION OF COST-EFFECTIVENESS

To facilitate comparing alternative standards, a cost-effectiveness (C-E) ratio was defined for each alternative, in which the letter "r" represents the real discount rate and "t" represents time in years. For any single disposal practice:

$$\text{Total Cost} = \sum_{t=1}^{20} \sum_{a=1}^{3} \sum_{i=1}^{25} \frac{UC_i * VOL_{tai}}{(1+r)^t}$$

$$\text{Health Effects} = \sum_{n=24}^{10024} \sum_{t=1}^{20} \sum_{a=1}^{3} \sum_{i=1}^{25} UHE_{ain} * VOL_{tai}$$

and:

t	=	index across years*
a	=	index across hydrogeologic regions (three regions)
i	=	index across wastes (25 commercial LLW)
r	=	social discount rate for costs (10 percent real rate is assumed)
n	=	year in which health effects occur
VOL_{tai}	=	volume (m^3) of waste i in region a, year t
UC_i	=	unit cost of disposal practice (dollars per cubic meter) for waste i, assumed to be constant in real terms
UHE_{ai}	=	unit health risk (fatal cancers and genetic effects per cubic meter) over 10,000 years, from disposal of waste i in region a

* "t" equals 20 in the final year since costs and health effects are based on a site with a 20-year life.

The C-E ratio is then defined as follows, comparing any two disposal practices A and B:

$$\text{C-E Ratio} = \frac{\text{Total Cost (B) - Total Cost (A)}}{\text{Health Effects (A) - Health Effects (B)}}$$

The C-E ratio represents the incremental cost (dollars) per avoided health effect (fatal cancers plus serious genetic effects) of each alternative, compared to another alternative (normally, the base case of current disposal practice). If current practice is used for the comparison as practice A, given a value per avoided health effect, alternatives with C-E ratios less than or equal to this value would result in positive net benefits to society, based solely on population health effects reduction.

A C-E ratio comparing any two alternatives can also be constructed (named the "marginal" cost-effectiveness ratio) to determine the preferred alternative given a value per avoided health effect. If the marginal C-E ratio is greater than the value per avoided health effect, alternative A is preferred; otherwise, alternative B is preferred. However, in some cases, an alternative has both higher costs and greater health effects compared to the base case or some other alternative. These alternatives are said to be "dominated" since another option clearly is preferred no matter what the value per avoided health effect. Dominated options, which typically result in a negative C-E ratio, can be eliminated from consideration without regard to cost-effectiveness.

In addition to the overall C-E ratio defined above, the cost-effectiveness of different disposal practices was assessed for each waste within each hydrogeologic region.

To calculate the C-E ratio comparing alternative LLW standards, the disposal practice required to comply with each alternative must be determined. Since unit costs and unit health effects are quantified for each disposal practice, a single disposal practice must be associated with each waste stream in each hydrogeologic region for each regulatory alternative. This association is determined by finding the least costly disposal practice that complies with the standard, given assumed implementation actions by the NRC or DOE. These implementation actions determine whether the disposal practice for a given waste must be the same in all hydrogeologic regions (referred to hereinafter as National implementation) or whether it may vary from one hydrogeologic region to another to account for the impact of hydrogeology on CPG risk (referred to hereinafter as Regional implementation).

Two further distinctions regarding implementation can also be made. If compliance with the standard depends only on meeting the CPG dose level (i.e., population health effects are not considered), the term Implicit implementation is used. This connotes the fact that protection of the general population is implicit or inherent in the protection of the Critical Population Group. That is, by imposing a limit on annual CPG dose, it is assumed that the general population is receiving at the same time the appropriate and prudent level of protection. In the case where an explicit consideration of population protection is made by considering not only the CPG limit but also the cost-effectiveness of imposing more stringent requirements on disposal, the term Explicit implementation is used. The various combinations of these four different implementation assumptions produce four separate implementation cases. These four cases -- National Implicit, National Explicit, Regional Implicit, and Regional Explicit -- are each examined in this EIA. The implementation assumptions are described further in Chapters 6, 7, and 8.

DEFINITION AND ESTIMATION OF CPG DOSE AND CPG RISK

CPG dose is a committed effective whole body dose equivalent and is defined as the maximum annual exposure in millirems per year to an individual within the Critical Population Group. CPG risk is the incremental carcinogenic risk resulting from a given CPG dose, measured as the probability of fatal cancer (expressed as a fraction), assuming that the CPG dose is received every year over a 70.7565-year lifetime [MEY86a]. A time horizon of 10,000 years is used in the analysis of CPG risk; maximum risks are assumed to occur within the local area and are measured at the boundary of the disposal site. CPG dose was typically only calculated over the first 1,000 years since initial model runs verified that maximum doses were received within this period. Basin Effects are assumed to be much lower on an individual basis. The relationship between CPG risk and CPG dose is derived from EPA's DARTAB model of radiologic dose/response (DARTAB is also used to analyze population risk and represents a subpart of PRESTO). This relationship is constant: the lifetime risk from a 1 millirem per year CPG exposure is equal to about 2.8×10^{-5} [MEY86a]. Maximum CPG dose is used in all cases to determine compliance with alternative LLW standards and BRC criteria.

Critical Population Group Exposure Calculations

To determine maximum CPG dose and risk, a different approach is used to model disposal. While determining total cost and total health effects depends on average conditions at representative disposal sites, maximum CPG dose and risk depend on credible "maximum exposure" conditions (generally, the maximum volume of a specific mix of wastes that could be disposed at a single site). EPA has defined 13 CPG scenarios for unregulated disposal, as described later in this chapter. In addition, maximum CPG dose and risk were estimated for direct gamma exposures to transportation workers when hauling BRC waste from a generator site to a disposal site. The methodology employed in this analysis is described in EPA87, RAE86c, RAE86d, and PEI86a. The 13 CPG scenarios each assume one of the six disposal practices defined above (including the university incinerator); in addition, each CPG scenario also includes assumptions regarding the volume and mix of low-level waste at the disposal site. The volume and mix assumptions reflect the assumed waste generators and are described in EPA87 and later in this chapter. Appendix D outlines the general methodology used in estimating the CPG dose and risk for each scenario, based on EPA's risk modeling results.

CPG dose is determined by estimating the exposure in the year of maximum exposure over the first 1,000 years in each CPG scenario. The maximum CPG dose is then defined as the maximum exposure across all CPG scenarios. Each CPG "scenario" embodies an explicit set of assumptions which define how a single individual could be exposed to radiation from one or more pathways. The CPG dose scenarios differ for the regulated and unregulated disposal practices, as explained below.

CPG Scenarios For Regulated Disposal Practices

The estimation of CPG dose for regulated disposal practices as used in the LLW standard analysis is described more fully in EPA87. All of the pathways included in the population health effects analysis are also included in the CPG dose analysis. However, the CPG dose analysis employs scenarios which assume, in effect, that an individual is exposed at the boundary of the LLW disposal site instead of at an average distance away. The total CPG dose from regulated disposal includes component exposures from four pathways: (1) ingesting water from a site-boundary well; (2) ingesting plant or animal food grown or grazed at the site boundary; (3) inhaling airborne material at the site boundary; and (4) direct external gamma radiation from site boundary contamination. It should be noted that the CPG dose from regulated disposal used in the comparison of alternative LLW standards does not include ingestion of food grown onsite or external gamma radiation exposure from exposed waste. Excluding these "intruder" scenarios reflects EPA's view that such incidents are not reasonably controlled by a generic, generally applicable standard. EPA is considering more qualitative guidance to accompany the standards as a more effective approach. Table 3-10 describes the CPG scenarios quantified in the analyses of LLW standards (including sensitivity analyses).

Table 3-10

ANALYSIS OF CPG RISKS FROM REGULATED DISPOSAL
PRESTO-CPG SCENARIOS

SCENARIO NUMBER	WASTES INCLUDED	WASTE[2] MIX	HYDROGEOLOGIC REGION	WASTE FORM[1]				AS GEN. WASTE VOLUME (1000 cu.m)	TIME HORIZON (YEARS)	DISPOSAL OPTION[3]				CPG PATHWAYS INCLUDED
				CLASS A	CLASS B	CLASS C	NARM			CLASS A	CLASS B	CLASS C	NARM	
1,2,3	LLW-BRC + NARM	U.S. Average	All	As Is	As Is	As Is	As Is	250	1000	SLD	SLD	SLD	SLD	Normal[4]
4,5,6	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal
7,8,9	LLW-BRC + NARM	U.S. Average	All	As Is	As Is	As Is	As Is	250	1000	SLF	SLF	SLF	SLF	Normal
10,11,12	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	ISD	ISD	ISD	ISD	Normal
13,14,15	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	IDD	IDD	IDD	IDD	Normal
16,17,18	LLW-BRC + NARM	U.S. Average	All	Gr	Sol	Sol	Sol	250	1000	EM	CB	CB	CB	Normal
19,20,21	LLW-BRC + NARM	U.S. Average	All	Sol	Sol	Sol	Sol	250	1000	CC[10]	CC	CC	CC	Normal
22	Special[5]	U.S. Average	Humid Permeable	---	See	Footnote 5	---	15.2	1000	HF	HF	HF	HF	Normal
23	Special[6]	U.S. Average	Humid Impermeable	---	See	Footnote 6	---	6.72	1000	DWI	DWI	DWI	DWI	Normal
24	Special[7]	U.S. Average	Arid Permeable	---	See	Footnote 7	---	118.5	1000	DGD	DGD	DGD	DGD	Normal
25	LLW-BRC + NARM	U.S. Average	Arid Permeable	Sol	Sol	Sol	Sol	250	1000	DGD	DGD	DGD	DGD	Normal

T[illegible]ntinued

Table 3-10 (Continued)

ANALYSIS OF CPG RISKS FROM REGULATED DISPOSAL
PRESTO-CPG SCENARIOS

SCENARIO NUMBER	WASTES INCLUDED	WASTE[2] MIX	HYDROGEOLOGIC REGION	WASTE FORM[1] CLASS A	WASTE FORM[1] CLASS B	WASTE FORM[1] CLASS C	WASTE FORM[1] NARM	AS GEN. WASTE VOLUME (1000 cu.m)	TIME HORIZON (YEARS)	DISPOSAL OPTION[3] CLASS A	DISPOSAL OPTION[3] CLASS B	DISPOSAL OPTION[3] CLASS C	DISPOSAL OPTION[3] NARM	CPG PATHWAYS INCLUDED
26,27,28	LLW-BRC + NARM	U.S. Average	All	Incin or As Is[8]	Incin or Sol[8]	Incin or Sol[8]	Incin or As Is[8]	250	1000	SLD	SLD	SLD	SLD	Normal
29,30,31	LLW-BRC + NARM	U.S. Average	All	Incin or As Is[8]	Incin or Sol[8]	Incin or Sol[8]	Incin or As Is[8]	250	1000	SLD	SLD	ISD	ISD	Normal
32,33,34	LLW-BRC + NARM	U.S. Average	All	As Is	HIC[11]	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal
35,36,37	LLW-BRC + NARM	U.S. Average	All	HIC	HIC	HIC	HIC	250	1000	SLD	SLD	ISD	ISD	Normal
38,39,40	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	SLD	SLD	Normal
41,42,43	LLW-BRC + NARM	U.S. Average	All	As Is	As Is	As Is	As Is	250	1000	SLD	ISD	ISD	ISD	Normal
44,45,46	LLW-BRC + NARM	U.S. Average	All	As Is	As Is	As Is	As Is	250	1000	SLD	SLD	ISD	ISD	Normal
47,48,49	LLW + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	373	1000	SLD	SLD	ISD	ISD	Normal
50,51,52	LLW + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal
53,54,55	LLW + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	170	1000	SLD	SLD	ISD	ISD	Normal
56,57,58	LLW	U.S. Average	All	As Is	Sol	Sol	---	366	1000	SLD	SLD	ISD	---	Normal

Table 3-10 (Continued)

ANALYSIS OF CPG RISKS FROM REGULATED DISPOSAL
PRESTO-CPG SCENARIOS

SCENARIO NUMBER	WASTES INCLUDED	WASTE[2] MIX	HYDROGEOLOGIC REGION	WASTE FORM[1]				AS GEN. WASTE VOLUME (1000 cu m)	TIME HORIZON (YEARS)	DISPOSAL OPTION[3]				CPG PATHWAYS INCLUDED
				CLASS A	CLASS B	CLASS C	NARM			CLASS A	CLASS B	CLASS C	NARM	
59,60,61	LLW	U.S. Average	All	As Is	Sol	Sol	---	250	1000	SLD	SLD	ISD	ISD	Normal
62,63,64	LLW	U.S. Average	All	As Is	Sol	Sol	---	170	1000	SLD	SLD	ISD	ISD	Normal
65,66,67	LLW-BRC + NARM - CLASS "D"[9]	U.S. Average	All	As Is	As Is	As Is	As Is	249	1000	SLD	SLD	SLD	SLD	Normal
68,69,70	LLW-BRC + NARM - Class "D"	U.S. Average	All	As Is	Sol	Sol	Sol	249	1000	SLD	SLD	ISD	ISD	Normal
71,72,73	LLW-BRC + NARM	U.S. Average	All	As Is	As Is	As Is	As Is	500	1000	SLD	SLD	SLD	SLD	Normal
74,75,76	LLW-BRC + NARM	U.S. Average	All	As Is	As Is	As Is	As Is	100	1000	SLD	SLD	SLD	SLD	Normal
77,78,79	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	500	1000	SLD	SLD	ISD	ISD	Normal
80,81,82	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	100	1000	SLD	SLD	ISD	ISD	Normal
83,84,85	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal + "Intruder" Farming

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Table 3-10 (Continued)

ANALYSIS OF CPG RISKS FROM REGULATED DISPOSAL
PRESTO-CPG SCENARIOS

SCENARIO NUMBER	WASTES INCLUDED	WASTE[2] MIX	HYDROGEOLOGIC REGION	WASTE FORM[1]				AS GEN. WASTE VOLUME (1000 cu.m)	TIME HORIZON (YEARS)	DISPOSAL OPTION[3]				CPG PATHWAYS INCLUDED
				CLASS A	CLASS B	CLASS C	NARM			CLASS A	CLASS B	CLASS C	NARM	
86,87,88	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal + "Adjacent" Farming
89,90,91	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	ISD	ISD	ISD	ISD	Normal + "Intruder" Farming
92,93,94	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	1000	IDD	IDD	IDD	IDD	Normal + "Intruder" Farming
95	LLW-BRC + NARM	Southeast Compact	Humid Permeable	As Is	As Is	As Is	As Is	250	1000	SLD	SLD	SLD	SLD	Normal
96	LLW-BRC + NARM	Northeast Compact	Humid Impermeable	As Is	As Is	As Is	As Is	250	1000	SLD	SLD	SLD	SLD	Normal
97	LLW-BRC + NARM	Rocky Mtn. Compact	Arid Permeable	As Is	As Is	As Is	As Is	250	1000	SLD	SLD	SLD	SLD	Normal
98	LLW-BRC + NARM	Southeast Compact	Humid Permeable	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal
99	LLW-BRC + NARM	Northeast Compact	Humid Impermeable	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal
100	LLW-BRC + NARM	Rocky Mtn. Compact	Arid Permeable	As Is	Sol	Sol	Sol	250	1000	SLD	SLD	ISD	ISD	Normal
101	LLW-BRC + NARM	Southeast Compact	Humid Permeable	As Is	Sol	Sol	Sol	590	1000	SLD	SLD	ISD	ISD	Normal

Table Continued

Table 3-10 (Continued)

ANALYSIS OF CPG RISKS FROM REGULATED DISPOSAL
PRESTO-CPG SCENARIOS

SCENARIO NUMBER	WASTES INCLUDED	WASTE[2] MIX	HYDROGEOLOGIC REGION	WASTE FORM[1]				AS GEN. WASTE VOLUME (1000 cu m)	TIME HORIZON (YEARS)	DISPOSAL OPTION[3]				CPG PATHWAYS INCLUDED
				CLASS A	CLASS B	CLASS C	NARM			CLASS A	CLASS B	CLASS C	NARM	
102	LLW-BRC + NARM	Northeast Compact	Humid Impermeable	As Is	Sol	Sol	Sol	470	1000	SLD	SLD	ISD	ISD	Normal
103,104,105	LLW-BRC + NARM	U.S. Average	All	As Is	Sol	Sol	Sol	250	10000	SLD	SLD	ISD	ISD	Normal

Footnotes on following page.

Table 3-10 (Continued)

ANALYSIS OF CPG RISKS FROM REGULATED DISPOSAL
PRESTO-CPG SCENARIOS

SOURCE: Putnam, Hayes & Bartlett, Inc., 15 January 1986.

NOTES:

1 "As Is" means as generated or unsolidified (TR, AW, or AM); "Sol" means solidified (SW); "Incin" means incinerated and solidified (IN); N-SOURCES and R-RASRCES are always As Is. N-SSTRASH is always solidified. GR means supercompacted and grouted as per RAE85e. For correspondence between "As Is" and TR/AW/AM, see RAE85e.

2 Fraction of 20-year LLW volume generation implicit in Table 2. U.S. average NARM mix is used in all cases.

3 Where more than one disposal option is used, a colocated facility is implied. A separate PRESTO-CPG run is needed for each facility.

4 "Normal" means all pathways turned on except for "intruder" onsite farming and except for "adjacent" farming, including radon when NARM is present.

5 Includes: L-CONCLIQ, I-ABSLIQD, L-DECONRS, I-FSLUDGE, L-IXRESIN, and R-RAIXRSN.

6 Includes: L-CONCLIQ, I-ABSLIQD, and L-DECONRS.

7 Includes: Class C waste and L-IXRESIN.

8 Use Incin waste form where possible; otherwise use form indicated.

9 Class "D" is defined as N-SOURCES, R-RASOURC, and L-DECONRS.

10 "CC" means concrete canister disposal method.

11 "HIC" means waste is placed in a high integrity container in the "As Is" waste form.

Definitions:

LLW = all 24 low-level waste streams.

BRC = N-SSTRASH, N-SSWASTE, F-COTRASH, F-NCTRASH, U-PROCESS, F-PROCESS, I-LIQSCVL.

Class B = IXRESIN, L-FSLUDGE, N-TRITIUM, N-TARGETS.

Class C = N-ISOPROD, L-DECONRS, N-SOURCES.

NARM = R-RASOURC (combined radium and Ra-Be sources), R-RAIXRSN (both also considered Class C).

Class A = all wastes not Class B or C.

CPG Scenarios for Unregulated Disposal Practices

For CPG doses from unregulated disposal, as used in the BRC criterion analysis, 11 exposure pathways are considered in each of 13 scenarios. The 13 CPG scenarios represent different unregulated disposal "sites" and are listed in Table 3-11. Unlike the regulated disposal CPG scenarios, some unregulated disposal CPG pathways affect an individual within the site boundary. The 11 exposure pathways considered in each CPG scenario are described in EPA87. These pathways also include direct gamma exposures to transportation workers from unregulated disposal. In contrast to the analysis used for the regulated LLW standard, for the unregulated disposal CPG scenarios, the entire radionuclide inventory present at an unregulated disposal site can contribute to the dose received from each pathway (that is, it is not assumed for the analysis of any one pathway that the inventory is depleted through the movement of nuclides through the other available pathways). Hence, the maximum CPG dose represents the maximum single pathway exposure across all pathways and scenarios rather than the sum of exposures in each scenario across the 11 pathways.* The summation of doses from the different pathways is unnecessary since it can be shown that from any given scenario, one pathway will dominate. The unregulated disposal CPG methodology is discussed more fully in EPA87.

While the waste volumes and site characteristics for each unregulated disposal CPG scenario are based on EPA assumptions, the rationale for each scenario is generally as follows (Scenarios 11 and 12 represent two additional reference scenarios not used in the actual analysis):

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* This approach tends to overstate the maximum CPG dose; however, in practice, only a few of the pathways turn out to be significant.

Table 3-11

CPG SCENARIOS FOR ANALYSIS OF
UNREGULATED DISPOSAL PRACTICES USING PATHRAE

As Generated Waste Volume (m^3), Waste Form, and Disposal Practice by Scenario

	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7		Scenario 8	
Disposal Option:	PWR-MD		BWR-MD		LUMC-UF		MAFC-SF		MAFC-SI		PWRHU-MD		UHX-MD		UF-MD	
BRC Candidate	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form
P-COTRASH	12500	TR														
B-COTRASH			32413	TR												
I-COTRASH																
I-ABSLIQD																
I-BIOWAST																
I-LQSCNVL																
N-LOTRASH																
N-LOWASTE																
N-SSTRASH																
N-SSWASTE															49000	TR
															8647	TR
F-PROCESS																
U-PROCESS																
F-COTRASH													10693	AW		
N-NCTRASH																
P-CONDRSH	347	AW														
L-WASTOIL	445	AW	1153	AW												
C-TIMEPCS																
C-SMOKDET																
R-RASOURC																
R-RAIXRSN																
R-INSTDF1																
R-INSTDF2																
R-GLASDS1																
R-GLASDS2																

Table continued on following page

Table 3-11 (Continued)

CPG SCENARIOS FOR ANALYSIS OF
UNREGULATED DISPOSAL PRACTICES USING PATHRAE

As Generated Waste Volume (m^3), Waste Form, and Disposal Practice by Scenario

	Scenario 9		Scenario 10		Scenario 11		Scenario 12		Scenario 13		Scenario 14		Scenario 15	
Disposal Option:	CW-SF		CW-UF		LURO-ON*		LURO-ON**		LURO-ON		LMACW-SI		LMACW-UI	
BRC Candidate	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form	Vol.	Form
P-COTRASH											8333	IN	8333	IN
B-COTRASH														
I-COTRASH									3573	IN	3573	IN	7146	IN
I-ABSLIQD									141	IN	141	IN	282	IN
I-BIOWAST									95	IN	95	IN	190	IN
I-LQSCNVL									191	IN	191	IN	382	IN
N-LOTRASH											3583	IN	7165	IN
N-LOWASTE											2130	IN	4259	IN
N-SSTRASH														
N-SSWASTE														
F-PROCESS														
U-PROCESS														
F-COTRASH														
F-NCTRASH														
P-CONDRSN														
L-WASTOIL											231	IN	231	IN
C-TIMEPCS	7	TR	38	TR							297	IN	297	IN
C-SMOKDET	60	TR	335	TR							7	IN	38	IN
											60	IN	335	IN
BIOMED					4000^4	IN	4000^4	IN						

Table continued on following page.

Table 3-11 (Continued)

CPG SCENARIOS FOR ANALYSIS OF
UNREGULATED DISPOSAL PRACTICES USING PATHRAE

NOTES:

(1) Assumes 100 percent volatilization of H-3 and C-14 (no stack recovery).

(2) Assumes 50 percent stack recovery of H-3 and C-14.

(3) Assumes 90 percent volatilization of H-3 and 75 percent volatization of C-14.

(4) Represents a waste at BIOMED Rule limits (10 CFR 20,306), i.e., H-3 and C-14 concentrations should each be 4.45 E-2 Ci/m^3.

SOURCE: Putnam, Hayes & Bartlett, Inc., September 1987.

Scenarios 1 and 2: Represent a three-unit PWR and two-unit BWR complex, respectively, contributing waste to a municipal dump in a rural setting. These volumes represent the actual worst case (i.e., highest volume) reactor complexes underlying our U.S. volume assumptions.

Scenario 3: Represents the equivalent of two large universities, medical centers, or hospitals in an urban setting. For each complex, a total volume of 4,000 cubic meters (as generated) is assumed; this total is apportioned among the four institutional wastes based on U.S. total volumes. The 4,000 cubic meter assumption is derived from earlier BRC analyses.

Scenarios 4 and 5: Represent the equivalent of a large university, medical center, or hospital, several low-activity waste generators, and one fuel fabrication facility in a suburban setting. Low activity waste volumes represent one-half of the largest contribution by any single State, as estimated by PHB's total volume projections, which reflect historical State-by-State industrial waste generation patterns. Fuel fabrication waste volumes represent an actual "average" facility (e.g., in South Carolina). Scenario 5 is the "waste incineration" version of Scenario 4; volumes are reduced by the volume reduction factor in incineration, which is assumed to be 6.

Scenario 6: Represents a two-unit PWR complex, small university or hospital, and low activity industrial generators in a rural setting. PWR volumes (three wastes) are two-thirds of Scenario 1 volumes; since Scenario 1 included a three-unit reactor. All other volumes (six wastes) represent one-eighth of urban setting volumes (as in Scenario 4), which represents a reduction slightly greater than the three to one population ratio.

Scenario 7: Represents a single uranium hexafluoride processing facility. Volumes reflect estimates for an actual facility derived from U.S. total volume projections.* Since only two facilities exist, the scenario volume is about one-half the total U.S. volume. A rural setting is used (to reflect, for example, the Kerr-McGee facility in Sequoyah County, OK).

Scenario 8: Represents a spent uranium foundry generating special-source wastes in a rural setting. The N-SSTRASH volume is derived from earlier BRC analyses; the N-SSWASTE volume is based on the ratio of U.S. total volumes for N-SSTRASH and N-SSWASTE.

Scenarios 9 and 10: Represent consumer wastes disposed in suburban and urban settings, respectively. Volume estimates reflect the product of the assumed local populations for these facilities (175,000 and 1,000,000, respectively), and the per capita volume generation assumptions underlying the U.S. total volume projections. These scenarios are for reference purposes, since neither consumer waste is currently disposed in regulated facilities.

Scenarios 11 and 12: Represent a reference analysis based on the NRC's biomedical waste rule limits (10 CFR 20.306). A total waste volume of 4,000 meters is assumed, as in Scenario 3.

Scenario 13: Represents a large university/medical center/hospital with onsite incineration and a dedicated landfill, in a suburban setting. Volumes (as generated) are derived from Scenario 3.

Scenarios 14 and 15: Represent large metropolitan areas with consumer waste, a two-unit PWR complex, and one large university/medical center/hospital in a suburban and urban setting, respectively, with incineration at the disposal site. Volumes are derived from previous scenarios (3, 4, 7, 10, and 11).

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* Generation of COTRASH and NCTRASH at UF_6 facilities is not explicitly considered in the State-by-State total waste volume estimates. Fuel fabrication facility volumes are used as surrogates.

Determination of Maximum CPG Dose and Risk

In addition to the exposure pathways and scenarios, the estimation of CPG dose and risk also depends on the volume and mix of LLW disposed at a site. For regulated LLW facilities, the waste mix and cumulative LLW volume depend on the BRC criterion (since this criterion determines which wastes are unregulated and, hence, which are available for unregulated versus regulated disposal). Accordingly, it is necessary to account for a variety of waste volume and mix assumptions to analyze alternative BRC criteria. The analysis of BRC criteria is described before the analysis of alternative LLW standards, so that the rationale for deleting certain wastes from the LLW analysis can be presented (i.e., those wastes expected to meet the proposed BRC criterion).

In the BRC analysis, the contributions of individual wastes to the CPG dose from unregulated disposal are assumed to be approximately independent (see Appendix D for methodology). This assumption is made for computational convenience, since it allows consideration of many different waste mix assumptions with a limited number of computer model runs. Provided that the year at which the maximum CPG dose is attained does not change with a different combination of BRC wastes, this computational assumption holds true. Hence, the CPG dose resulting from alternative waste mix combinations could be calculated easily as a linear combination of unit CPG dose contributions, based on a single computer analysis of the unregulated disposal site. In theory, the CPG dose from disposal of radioactive waste is not a linear combination of individual waste contributions, nor can the nonlinear relationship be easily approximated outside of the computer model. When an individual waste is no longer assumed to be included in the disposal trench, the mix of radionuclides changes along with the volume of waste; this can alter the maximum CPG dose in a nonlinear fashion by changing the peak year, the dominant pathway, or the dominant disposal scenario. In fact, our analysis of regulated disposal indicates that maximum CPG risk is sensitive to the volume of waste included at a site (in large part because the site dimensions are affected). Conversely, the independence assumption for the BRC analysis appears to be a good approximation, since the most significant factor, total site volume, is not greatly affected by the volume of BRC waste. The principal difference between regulated and unregulated disposal is that, at an unregulated site, volume is determined principally by the large amount of municipal waste assumed to be present.

At a regulated disposal site which includes only radioactive wastes, total disposal volume (and, hence, site volume) will change significantly by excluding individual wastes from the analysis. Since CPG dose depends strongly on site dimensions, separate computer runs were required for each LLW waste mix evaluated. Furthermore, since the analysis of alternative LLW standards requires an estimate of the least-cost method of compliance, it is conceptually necessary to consider a range of waste/disposal option combinations before the least-cost disposal practice is determined. Since only a limited number of computer runs could be performed, the least-cost disposal practice could only be approximated for each alternative LLW standard evaluated. However, this approximation is believed to be a very close one.

Relationship Between Population Health Effects and CPG Risk

Population risk and CPG risk are distinct measures of health risk which incorporate different exposure assumptions. As used in this EIA, population risk refers to the total statistical health effects in all exposed individuals on an expected value basis. In contrast, the CPG risk refers to the maximum risk to a single individual in the Critical Population Group, assuming that exposure occurs. In theory, CPG risks should be included in population risk on an expected value basis, by weighting each CPG exposure scenario by its probability of occurrence. In practice, the contribution of CPG risks to total expected risk is assumed to be negligible, so this explicit analysis is not required.*

DEFINITION OF BASE CASE - CURRENT PRACTICE

To determine economic impact (as opposed to the cost-effectiveness) of a level of a standard, the costs and benefits of alternatives are compared to a base case. The base case differs for different categories of waste. For this proposed standard, EPA has defined the base case to be "current disposal practice." That is, without EPA's standard, current practice is assumed to continue for at least 20 years. Under current practice, commercial LLW is disposed of in compliance with 10 CFR 61, where shallow land disposal (SLD) is used for NRC designated Class A waste in the as-generated waste form; SLD is used for solidified Class B waste and improved shallow land disposal (ISD) is used for solidified Class C waste (hereinafter, this combined practice is designated 10 CFR 61 disposal). For purposes of quantifying the impact of alternative standards, 10 CFR 61 is assumed to be the practice that would be used in the absence of an EPA standard. 10 CFR 61 disposal combines two of nine land disposal practices explicitly considered by EPA; thus, it is associated with particular assumptions regarding site size, period of operation, trench depth, integrity of trench cover, and post-closure and institutional care. These assumptions underlie in both the cost and risk analyses and are explained further below. 10 CFR 61 is also used as the base case for comparing alternative

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* This assumption is based upon the determination that the collective exposure to the relatively small CPG is very small as compared to the collective exposure of all releases and exposures of all members of the population over thousands of years. However, it should be noted that the value of CPG risk reduction derives principally from equity considerations (i.e., a desire to prevent any member of the population from bearing a high risk), rather than from efficiency considerations (reduction of overall risk, no matter how that risk is distributed). Both types of risks have been considered in evaluating alternative standards.

BRC criteria. For each alternative BRC criterion, the total cost savings and additional health effects of deregulation are measured by comparison to the costs and risks of 10 CFR 61 disposal for commercial LLW. However, since almost all BRC candidates originate from Class A commercial LLW and Class A LLW under 10 CFR 61 are disposed of using SLD, this comparison is normally equivalent to a simple comparison with the SLD practice (as generated).

Disposal of DOE LLW currently conforms to DOE5820. This practice is most nearly characterized by SLD (waste as generated) within the framework of this analysis. Hence, the base case disposal practice for DOE waste is SLD. The base case for NARM limit is considered separately in Chapter 6.

Finally, current practice for NARM waste varies by waste stream and is subject to varying and inconsistent State regulations. Current practice for NARM, and State-to-State variations in disposal requirements, are discussed in detail in Chapter 6. Since these wastes are not currently regulated at the Federal level and since there is inconsistency and voids in the State regulation of NARM wastes, current practice for these wastes is uncertain. Therefore, a range of possible base cases is assumed; at one extreme, R-RASOURC and R-RAIXRSN are assumed to be currently regulated with the other four NARM being treated as unregulated waste; at the other extreme, all six NARM wastes are assumed to be unregulated.

For each section of the Proposed Rule, EPA has considered several alternatives. Both the form and the level of the standard vary between the different sections. The form varies from an exposure standard for LLW and BRC versus a specific activity limit for NARM. The alternatives considered vary in level from 4 millirem per year to 125 millirem per year for LLW and zero to 15 for BRC. The alternative NARM limits vary not by level but by form, i.e., a specific activity limit of 2 nanocuries per gram with certain wastes explicitly exempted, or alternatively, with no exemptions. EPA has described its choice of regulatory alternatives more fully in the Preamble to the proposed standard.

The purpose of this chapter is (1) to establish the relationship between the costs and benefits of alternative levels of the standard and the various forms of the rule EPA has considered, and (2) to define explicitly those regulatory alternatives included in this analysis. Since the statutory authority for regulating NARM is different than that used for the LLW and BRC standards, the NARM alternatives are discussed separately in Chapter 6.

FORM OF THE LLW AND BRC STANDARDS

EPA is proposing LLW and BRC standards based on the maximum annual whole-body effective dose equivalent to an individual in the Critical Population Group (CPG). The definition of the CPG was discussed in Chapter 3. An annual dose equivalent (measured in millirems per year) is defined as the yearly average absorbed dose received by an organ, after accounting for the differing degrees of biological damage caused by different types of radiation (e.g., photons; beta and alpha particles). A whole-body effective dose equivalent normalizes the individual dose equivalents from specific radionuclides to specific organs in terms of external radiation to the body, at a level of equivalent total risk. A whole-body dose of 1 millirem per year is equal to a risk of fatal cancer of about 2.8×10^{-5} over a 71-year life [MEY86a].

It is useful to note the relationship between different forms of the standard and the results of the cost/benefit analysis. Among the forms EPA considered, seven can be summarized as follows:

1. A limit on expected population health effects
2. A limit on cumulative population exposure
3. A maximum individual lifetime risk
4. A maximum annual whole-body dose equivalent to the CPG (the form chosen)
5. A generic limit on the total activity released per site
6. Specific activity limits on individual radionuclides released to the surrounding environment
7. Site-specific design standards

With respect to economic impacts, the critical difference between these various forms is the degree to which they are correlated with the costs and the benefits of EPA's rule. Site-specific design standards (alternative 7) are directly related to the cost of the rule, since costs are determined by the actual disposal practices used to comply with the standard. Depending on how such design standards are constructed, they could also be well correlated with both measures of the benefits of the rule -- reduction in population risk and reduction in individual (CPG) risk. From an economic perspective, one could thus expect that site-specific design standards would result in the most "efficient" rule,* i.e., one which maximized net

* Assuming that the regulators are as informed as the site operators when determining the most cost-effective design that would meet the regulatory objective.

benefits in all hydrogeologic regions and for all waste types. However, EPA is effectively proscribed from choosing this form due to its limited authority under the AEA. Rather, site-specific design requirements are devised by the NRC or DOE in response to EPA's standard.

Alternative forms 1 through 4 differ primarily in whether they are strongly correlated with reductions in total risk (alternatives 1 and 2) or with limits on individual risk (alternatives 3 and 4). Since EPA has chosen a form of the standard based on individual exposure, the standard is "efficient" with respect to individual risk reduction, but not always with respect to reductions in total population risk. The differences between alternatives 1 through 4 relate primarily to whether the dose/response function (which determines the risk received from a given dose) is incorporated implicitly in the standard (alternatives 1 and 3) or whether its consideration is left to implementation of the standard (as in alternatives 2 and 4). Finally, neither alternative 5 nor 6 would a priori be expected to be as well correlated with population risk reduction or individual risk reduction as standards phrased explicitly in terms of these benefit measures. In addition, alternatives 5 and 6 might be difficult to implement. However, either form potentially could result in a more efficient standard overall, since they reflect factors which relate both to individual and population risk rather than to just one of these two. Such a determination of related economic efficiency would require empirical analysis not included here; however, waste activity does appear to be well correlated with population risk, as discussed in Chapter 8.

CHOICE OF STANDARDS FOR ANALYSIS

For the LLW and BRC standards, EPA has chosen several discrete levels of the standard for inclusion in this EIA. These alternatives, which all refer to maximum annual whole-body effective dose equivalents to an individual in the CPG, are as follows:

Low-Level Waste Disposal Alternative CPG Dose Standards:

1. 125 millirem per year
2. 75 millirem per year
3. 25 millirem per year
4. 10 millirem per year
5. 4 millirem per year

Below Regulatory Concern Alternative CPG Dose Standards:

1. 15 millirem per year
2. 4 millirem per year
3. 1 millirem per year
4. 0.1 millirem per year
5. 0 millirem per year (i.e., no BRC waste)

For the LLW alternatives, the 25 millirem standard is similar to the existing EPA standards and to the NRC LLW performance standards at 10 CFR 61. The 4 millirem alternative is identical to the 4 millirem National Interim Primary Drinking Water Standard for manmade radionuclides (which reflects a single exposure pathway). In total, the LLW alternatives span a range such that only a regulated sanitary landfill (the least-cost regulated option) would be required for all waste (at the 125 millirem per year option) to a point where at least some disposal sites would be required to use practices more stringent than the 10 CFR 61 standards of the NRC (4 millirem). The 4 millirem standard is essentially equal to "Best Available Technology" for LLW disposal, given the range of disposal practices considered in this EIA.

The BRC alternatives likewise span a range in which most of the BRC candidates would be deregulated (15 millirem per year) to a point where only a few of them would be suitable for unregulated disposal and where some currently unregulated consumer wastes would require regulated disposal (0.1 millirem). As with LLW disposal, 4 millirem is also included as an option. The 0 millirem standard is equivalent to a prohibition of the unregulated disposal of LLW.

This chapter discusses briefly the nature of the 25 commercial LLW streams, two LLW substreams, two consumer wastes, and BIOMED waste, as designated by EPA for analysis. Although the EIA presents a rough calculation based on EPA assumptions of the economic impacts associated with Department of Energy (DOE) conventional LLW, an explicit analysis of the risks and costs resulting from disposal of DOE low-level waste was not performed due to the limited availability of data. However, DOE has estimated that 1.83 million cubic meters of conventional LLW will be generated by DOE facilities between 1985 and 2004, as well as 1.53 million cubic meters of other types of low-level wastes (principally contaminated soils and building debris) from DOE-administered remedial action programs [DOE86].* As noted in Chapter 2, this EIA does not consider low-level waste generated from DOE-administered remedial action programs or from future decontamination and decommissioning (D&D) of nuclear power reactors. DOE's "Integrated Data Base for 1986" [DOE86] provides some information regarding the classification and radionuclide content of the D&D waste. Based on an assumed 40-year operating life, seven currently operating nuclear power plants are expected to shut down between 1985 and 2004. In addition, however, D&D activities are likely at five nuclear facilities which have already ceased operation: Shippingport (Pennsylvania), Humboldt Bay (California), Three Mile Island 2 (Pennsylvania), Dresden 1 (Illinois), and Indian Point 1 (New York). The quantity of D&D generated low-level waste anticipated from these 12 facilities has not been estimated. Waste generated by the Fort St. Vrain (Colorado) high temperature gas reactor also has not been included.

* The 20-year period from 1985 to 2004 was chosen by EPA as the period of analysis for waste generation included in this EIA.

The following discussion is divided into two parts. First, the estimates conducted for this EIA of the total LLW volume generated over the 1985 to 2004 period are presented; key sources of variation in these estimates are also discussed. An estimate of DOE conventional LLW volume by hydrogeologic region is also included.* Second, the nature of LLW is briefly reviewed, focusing on the key determinants of cost and risk (waste form and radionuclide content) and on the classification of certain LLW streams under the NRC's 10 CFR 61 waste classification scheme.

ESTIMATED VOLUME OF LLW: 1985-2004

In total, 2.9 million cubic meters of commercial LLW will be generated between 1985 and 2004. The two LLW substreams (P-CONDRSN and L-WASTOIL) account for 29,000 cubic meters of this volume. The two consumer waste streams account for an additional 102,000 cubic meters. Waste already deregulated by NRC81a (BIOMED waste) and not included here is estimated to total 267,000 cubic meters over the same 20-year period. Estimates of the volume of each LLW stream are listed in Table 5-1. The estimates are presented for each of the three hydrogeologic regions for which population risks and CPG risks have been estimated. A further description of the methodology used to derive the regional volume estimates in Table 5-1 is presented in Appendix A.

Four key factors are likely to contribute significantly to variations between these estimates and the actual LLW generation over the next 20 years: (1) differences between expected completion dates for nuclear power reactors and actual completion and operation dates; (2) changes in the use of nuclear technologies; (3) use of volume reduction techniques; and (4) uncertainty in the composition of Compacts under LLWPA86.

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* The term "conventional" LLW is used to differentiate this DOE LLW from other LLW generated during DOE remedial action programs, or from D&D activities. The latter sources of LLW are not considered in this EIA.

Table 5-1

PROJECTED COMMERCIAL LLW BY REGION, 1985-2004
Cubic Meters as Generated

Waste	Humid Permeable	Humid Impermeable	Arid Permeable	U.S. Total
Commercial LLW				
P-COTRASH	151,330	54,941	59,014	265,285
B-COTRASH	169,128	153,568	9,521	332,217
L-NCTRASH	245,540	156,736	75,934	478,210
L-IXRESIN	46,590	37,766	14,772	99,128
L-FSLUDGE	68,784	56,218	5,768	130,770
L-CONCLIQ	208,845	77,450	44,352	330,646
P-FCARTRG	7,006	2,873	2,954	12,833
L-DECONRS	1,340	800	101	2,241
L-NFRCOMP	38,056	16,160	10,294	64,510
F-COTRASH	121,688	7,359	50,434	179,481
F-NCTRASH	21,510	1,301	8,915	31,725
F-PROCESS	40,312	2,438	16,708	59,457
U-PROCESS	21,387	0	0	21,387
I-COTRASH	105,963	106,035	69,749	281,747
I-BIOWAST	2,828	2,830	1,862	7,520
I-ABSLIQD	4,184	4,187	2,754	11,126
I-LQSCNVL	5,656	5,660	3,723	15,040
N-SSTRASH	112,307	180,054	67,101	359,462
N-SSWASTE	19,819	31,774	11,841	63,435
N-LOTRASH	51,901	30,621	18,940	101,462
N-LOWASTE	30,849	18,200	11,258	60,307

Table continued on following page.

Table 5-1 (Continued)

PROJECTED COMMERCIAL LLW BY REGION, 1985-2004
Cubic Meters as Generated

Waste	Humid Permeable	Humid Impermeable	Arid Permeable	U.S. Total
N-ISOPROD	3,207	1,700	5,060	9,967
N-TRITIUM	468	6,130	344	6,941
N-TARGETS	20	190	13	223
N-SOURCES	290	182	110	582
Total	1,479,008	955,173	491,522	2,925,702
LWR Substreams				
P-CONDRSN*	4,360	1,419	1,590	7,368
L-WASTOIL**	12,667	6,646	1,934	21,246
Consumer Waste				
C-TIMEPCS	5,124	2,534	2,742	10,400
C-SMOKDET	45,323	22,419	24,258	92,000
Biomedical Waste				
BIOMED	100,300	100,300	66,100	266,700

* Substream of L-IXRESIN
** Substream of L-CONCLIQ

SOURCE: Putnam, Hayes & Bartlett, Inc., March 1987. Projections based on State-by-State generation estimates, as detailed in Appendix A.

DOE86 also estimates the volume of LLW generated by commercial power reactors over the next 20 years. However, DOE's estimates reflect "officially announced" commercial operation dates for power reactors, including some reactors which have since been formally cancelled or for which completion dates are highly uncertain. As a result, DOE's estimate of as generated waste volume from commercial power reactors is 11 percent higher than that presented in Table 5-1, which is based on power reactor completion dates assumed in DM86 (also likely to be an optimistic forecast). DOE's 1986 projected volumes were reduced from DOE's 1984 projections [DOE84] to meet allocation numbers in the Low-Level Radioactive Waste Policy Act of 1985 [LLWPA85]. Volumes reported in DOE86, which represent as-shipped waste, are 50 percent lower than those presented in Table 5-1, reflecting the volume reduction that would be necessary to comply with the volume limits set in LLWPA85. Nonetheless, substantial uncertainty does exist regarding the completion of about 35 nuclear power plants. The degree of difference between these two estimates only partially reflects the magnitude of this uncertainty.

The degree to which new nuclear technologies are used in the future, and to which existing ones grow or decline in use, will determine the actual volume of LLW generated by institutional and industrial generators. The estimates in Table 5-1 are based on the different historical growth rates for institutional and industrial waste, but assume that no new technologies creating large quantities of LLW will arise. In addition, the year-to-year growth in institutional and industrial waste is also likely to vary. This variation would affect estimates of cost (on a present value basis), but may not necessarily affect aggregate volume estimates.

The use of volume reduction techniques also contributes to uncertainty in the volume estimates, which in turn affect both cost and health effects estimates. Estimates of waste volume in this EIA are presented on an "as generated" basis, and the effect of waste processing (e.g., solidification or incineration) on volume is accounted for in the analysis. Some generators and disposal site operators may choose to use volume reduction techniques in order to reduce cost, since the cost of volume reduction may be more than offset by transportation and disposal cost savings. If it occurs, the volume reduction will also change waste form and the as disposed volume, which affect the estimates of risk. Based on the cost estimates underlying the unit costs used in this EIA, volume reduction techniques do not, on average, result in overall cost savings; hence, volume reduction was not generally assumed to occur unless it was necessary to meet the standard. Finally, a significant amount of volume reduction may be necessary under LLWPA85. The estimates of commercial LLW volume as disposed presented in DOE86 reflect this mandatory volume reduction (unlike Table 5-1, which reflects "as generated" volume).

After 1993, some Compacts may require volume reduction as part of their inter-State agreements or simply require that disposal sites be used as efficiently as possible. Based on the potential volume reduction through incineration, total commercial LLW volume could be reduced as much as 58 percent.* Such reduction could either reduce the total number of commercial operating sites from eight to four, or reduce the average size of a site (and, hence, increase the unit disposal cost) from about 250,000 cubic meters (as disposed) to about 105,000 cubic meters of waste, assuming the same 20-year operating life.

An additional factor influencing the per-site disposal volume is the formation of waste Compacts. While several Compacts were ratified by LLWPA85, the grouping of the other States into proposed Compacts is still uncertain. The significance of this uncertainty for this analysis stems from two factors. First, the number of Compacts formed is likely to determine

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* Based on volume reduction factors in DM86.

the number of disposal sites constructed and, hence, the average volume of waste disposed at each site. Moreover, the composition of individual Compacts (by including or excluding States) determines the volume of waste to be disposed of within a Compact. Since disposal sites presumably will be sized to handle the waste generation of all the States in the Compact, some Compacts may not reach an economically "efficient" scale (i.e., they will not handle enough waste to make unit disposal costs as low as could otherwise be the case). Second, the particular States in a given Compact determine the range of potential sites to be chosen. Hence, changes in Compact status may change the volume of waste disposed in the most favorable hydrogeologic regions and, thus, the overall estimate of population health effects. Since most proposed Compacts include only contiguous States, this impact is likely to be small. Finally, it should be noted that each Compact agreement may include other specifications regarding waste transportation and disposal. These specifications may also affect the impact of EPA's proposed standards, since they can limit the degree of flexibility in disposal practice that would be present in the absence of EPA's standard.

Finally, DOE86 was used as the basis for projecting DOE LLW volume by hydrogeologic region from 1985-2004. Table 5-2 presents the results of this analysis and shows that 1.83 million cubic meters of DOE waste will be generated. All of the DOE waste volume projections in DOE86 assume a constant generation rate.

Using the historical five-year generation of the major DOE sites and known location of these sites, DOE86 data were also used to assign the projected DOE waste generation to hydrogeologic region. As shown in Table 5-2, virtually no waste is generated in humid impermeable regions and over half is generated in arid permeable regions. The remainder is generated in humid permeable regions.

Table 5-2

PROJECTED DOE LLW VOLUME BY REGION, 1985-2004

Cubic Meters As Generated

Humid Permeable	Humid Impermeable	Arid Permeable	U.S. Total
795,360	403	1,035,937	1,831,700

SOURCE: Putnam, Hayes & Bartlett, Inc., March 1987. Based on Tables 4.4 and 4.13 in DOE86. Excludes saltcrete produced at the Savannah River Plant. See Appendix A for further details.

WASTE CHARACTERISTICS AND NRC CLASSIFICATION

The 25 commercial LLW streams, two power reactor substreams, two consumer product wastes, and BIOMED waste were described briefly in Chapter 3 (see Table 3-1). These wastes represent the generation from five different types of generators: commercial nuclear power reactors (PWR and BWR wastes); uranium conversion and fuel fabrication facilities; institutional generators (hospitals, medical and educational research labs); industrial generators (including generation of source and special nuclear material trash and waste, low activity waste and trash, and high activity wastes); and consumer products (tritiated radioluminous dials and smoke detectors using americium-241). Waste form assumptions for each of the wastes were presented in Table 3-1 and are repeated in Table 5-3. However, it should be noted that solidified and incinerated wastes are treated the same in the risk analysis, assuming that incinerated wastes are always solidified before disposal. Table 5-3 also presents the estimated specific activity (in curies per cubic meter) and total activity of each waste, including all of the 40 radionuclides in EPA's analysis. The breakdown of these activities by the 40 radionuclides tracked individually in the risk analysis is presented for each waste in EPA87.

Under the classification scheme presented in the NRC's regulations at 10 CFR 61, certain high activity wastes and wastes with unstable forms (e.g., liquid wastes) are designated as Class B or Class C waste. These wastes must be disposed of using more stringent practices (such as more stable containers and, in the case of Class C wastes, in deeper disposal trenches -- a practice designated as "improved shallow land disposal" in this analysis).

In anticipation of later analysis in Chapter 7, the wastes exceeding the Class A concentration and form criteria are noted in Table 5-3. Seven of the 25 LLW streams are thus designated as Class B or C: L-IXRESIN, L-FSLUDGE, L-DECONRS, N-TARGETS, N-TRITIUM, N-SOURCES, and

Table 5-3

WASTE FORM, ACTIVITY, AND CLASS OF COMMERCIAL LLW

Waste	As Generated Waste Form+	Average Specific Activity++ (Ci per m^3)	Total Activity++ 1985-2004 (Curies)	NRC Waste Class
Commercial LLW				
P-COTRASH	TR	6.73 E-2	1.784 E+4	A
B-COTRASH	TR	3.18 E-2	1.056 E+4	A
L-NCTRASH	TR	3.35 E-1	1.605 E+5	A
L-IXRESIN	AW	1.45 E+1	1.437 E+6	B
L-FSLUDGE	AW	8.46 E+0	1.108 E+6	B
L-CONCLIQ	AW	1.29 E+0	4.253 E+5	A
P-FCARTRG	TR	4.54 E+0	5.824 E+4	A
L-DECONRS	AW	2.34 E+1	5.243 E+4	C
L-NFRCOMP	AM	1.00 E+2	6.450 E+6	A
F-COTRASH	TR	3.24 E-5	5.796 E+0	A
F-NCTRASH	TR	3.09 E-5	9.805 E-1	A
F-PROCESS	AW	6.28 E-4	3.739 E+1	A
U-PROCESS	AW	7.45 E-4	1.593 E+1	A
I-COTRASH	TR	1.18 E-1	3.314 E+4	A
I-BIOWAST	AW	2.15 E-1	1.616 E+3	A
I-ABSLIQD	AW	2.13 E-1	2.365 E+3	A
I-LQSCNVL	AW	9.60 E-3	1.440 E+2	A
N-SSTRASH	TR	1.15 E-5	4.129 E+0	A
N-SSWASTE	AW	2.23 E-4	1.417 E+1	A
N-LOTRASH	TR	3.67 E-2	3.705 E+3	A
N-LOWASTE	AW	2.21 E-2	1.332 E+3	A

Table continued on following page.

Table 5-3 (Continued)

WASTE FORM, ACTIVITY, AND CLASS OF COMMERCIAL LLW

Waste	As Generated Waste Form⁺	Average Specific Activity⁺⁺ (Ci per m^3)	Total Activity⁺⁺ 1985-2004 (Curies)	NRC Waste Class
N-ISOPROD	TR	8.37 E+1	8.339 E+5	C
N-TRITIUM	TR	2.21 E+2	1.536 E+6	B
N-TARGETS	AM	7.80 E+2	1.739 E+5	B
N-SOURCES	AM	9.81 E+2	5.711 E+5	C
LWR Substreams				
P-CONDRSN*	AW	8.95 E-4	6.613 E+0	B
L-WASTOIL**	AW	6.56 E-5	1.391 E+0	A
Consumer Waste				
C-TIMEPCS	TR	3.62 E+1	3.765 E+5	A
C-SMOKDET	TR	2.17 E-3	1.996 E+2	A
Biomedical Waste				
BIOMED	AW	4.50 E-2	1.198 E+4	A

\+ TR = trash, AW = absorbed waste, AM = activated metal.

++ Activity for 40 nuclides included in EPA's risk assessment. See EPA87.

* Substream of L-IXRESIN. This waste is designated Class B due to waste form, not radionuclide content.

** Substream of L-CONCLIQ.

SOURCE: Putnam, Hayes & Bartlett, Inc., March 1987. Projections based on State-by-State generation estimates, as detailed in Appendix A. The BIOMED specific activity is likely to be a high estimate but is used as a conservative estimate.

N-ISOPROD. In addition, it should be noted that the NRC stream B-NCTRASH would also be classified as Class B or C waste; however, the aggregate EPA stream, L-NCTRASH, meets the Class A criteria and, thus, will be treated as Class A waste in this analysis. Furthermore, while the variation in the radionuclide content of all the LLW received at a given site is likely to be close on average to the values listed in Table 5-3, individual shipments from certain generators are likely to deviate significantly from the average. For example, the NRC study of the BRC waste stream, P-CONDRSN, indicated that individual samples varied by a factor of 1,310 and that only 75 percent of the samples had a total curie content within one order of magnitude of the average [DM84]. In this EIA, variations in the radionuclide content of individual waste shipments are assumed not to affect the disposal practice employed for the waste (i.e., designation of "substreams" is assumed not to occur). However, the substream issue will be addressed in sensitivity analyses.

Unlike LLW, naturally-occurring and accelerator-produced radioactive material (NARM) is not subject to AEA regulation, which covers only uranium or thorium ores used for nuclear fuel and manmade radionuclides associated with nuclear fission or defense activities.* While disposal of NARM waste is currently unregulated by Federal authorities, it is regulated to differing degrees by State agencies as a result of licensing and registration requirements.

EPA is proposing to regulate, under the authority of the Toxic Substances Control Act (TSCA), the disposal of higher activity NARM wastes, defined as wastes whose specific activity exceeds 2 nCi per gram. In addition, some types of wastes will be exempted from this proposed limit of 2 nCi per gram due to the high costs associated with their regulated disposal. These wastes generally are widely distributed among consumers, resulting in high collection costs if regulated. Because of this wide distribution, unregulated disposal of these wastes generally involves dispersion throughout the environment. However, in order to prevent large individual risks from a possible large source or a package containing many sources, an overall total activity cut-off of 0.05 mCi per item or package also is specified as part of EPA's proposed regulation of NARM. If any item or package containing NARM items exceeds 0.05 mCi, that item or package would no longer be exempted from the proposed 2 nCi per gram limit.

* Technically, the AEA covers "source, byproduct, and special nuclear material."

In support of this regulation, EPA has investigated the many different sources of NARM waste and has characterized these wastes at a level sufficient to estimate the costs and risks of regulatory alternatives. The primary purpose of this chapter is to summarize the characteristics of NARM waste (such as waste volume, form, and radionuclide content) that affect the Economic Impact Assessment.

Materials that contain naturally-occurring radionuclides (including, principally, uranium-238, thorium-232, and radium-226 and their decay products) are diverse.* In some cases, the NARM nuclides are incidental contaminants (as in certain building materials and coal) and, in other cases, they are recovered from naturally-occurring ores to provide specific properties (such as radium used as a source for medical radiation therapy and thorium used in metal alloys). When the use of such materials or devices ends, a waste containing NARM radionuclides is generated (e.g., demolition building materials, boiler ash, obsolete sources, and scrap metal). NARM waste can also arise from target irradiation during the use of accelerators for physics research (which results in radioactive waste during operations and eventually during decommissioning of the facility) and when ion-exchange resins are used to remove naturally-occurring radium or uranium from groundwater (resulting in radium- or uranium-loaded waste resins).

The NARM analysis was conducted in two parts. A preliminary scoping analysis was conducted to determine which types of NARM waste warranted further consideration for purposes of establishing a regulatory

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* NARM includes a large number of nuclides. CRCPD81 lists 41 examples of naturally-occurring nuclides and 50 examples of accelerator-produced nuclides. However, the great majority of these nuclides have short half-lives and, therefore, decay quickly and are not a disposal problem. While uranium and thorium are often contained in AEA materials, some natural ores contain an insufficient concentration of fissionable material (e.g., U-235) to be classified as source materials under the AEA. Hence, U-238 and Th-232 are also contained in NARM.

limit. The preliminary analysis was followed by a more detailed assessment of these remaining NARM wastes. On the basis of preliminary analysis, "diffuse" NARM wastes (i.e., those wastes characterized by relatively large volume and low average radionuclide concentration) were not included in the detailed cost and risk assessment presented below. The disposal technologies that are likely to be most appropriate for diffuse wastes differ substantially from those generally considered for LLW; EPA believes that these different technologies may require consideration in a later regulatory action. Finally, the NARM wastes considered in the preliminary analysis do not specifically contain accelerator-produced radionuclide material, since a detailed radiological characterization of accelerator waste is not currently available. However, the radioactive waste generated by currently operating accelerators is extremely small (about one drum per year); this waste is disposed in regulated disposal facilities, usually in conjunction with AEA material [PEI85a, Appendix A].

Appendix H presents the results of the preliminary scoping analysis which considers nine NARM waste categories. This appendix characterizes the wastes and compares the costs and risks of regulated and unregulated disposal of the four "diffuse" wastes and five other wastes (labeled "discrete"). The preliminary analysis supports the notion that "diffuse" NARM wastes are generally not cost-effective to regulate (using typical LLW disposal technologies), while some discrete NARM are generally very cost-effective to regulate. Consequently, the first section of this chapter presents a more detailed characterization of the remaining five discrete NARM categories; this characterization provides the background for the final cost and risk analysis, which is presented in the last section of this chapter and is summarized in Chapter 8. For the final analysis, these five NARM categories were rearranged into six categories to provide a more accurate analysis of the costs and risks of various disposal practices. In part, this redefinition of discrete NARM waste categories was necessary to incorporate the consideration of collection costs that would be incurred if certain NARM wastes were disposed in regulated facilities; collection costs are also discussed in the first section of this chapter. The second section of the chapter describes current disposal practice for discrete NARM wastes and the various State requirements for NARM disposal. Current disposal practice for some NARM, as described here, is somewhat uncertain. Since current practice normally would define the base case against which the economic impacts of regulation would be measured, this uncertainty results in a range of possible base cases. Finally, the last section of the chapter presents the economic impacts associated with regulating certain NARM waste streams.

CHARACTERIZATION OF DISCRETE NARM SOURCES FOR FURTHER ANALYSIS

Description and Segmentation

Based on the preliminary NARM analysis, discrete NARM wastes were redefined for the final analysis. This redefinition was prompted by three considerations: (1) the unit costs and risks of disposal for radium and radium-beryllium sources appear to be fairly similar; (2) some substreams of the NARM category R-INSTDIF are frequently already disposed of in regulated facilities; and (3) many other NARM substreams would require unusually high regulated disposal costs not included in the preliminary analysis. These high costs arise from the need to identify and collect these items from widely distributed locations (these items are generally in the possession of consumers who may be unaware of their radioactive content). The redefinition resulted in six discrete NARM waste categories, as follows:

1. R-RASOURC: This category includes the preliminary categories of R-RABESRC and R-SOURCES. It includes radium-beryllium neutron sources, medical radium sources (needles, plaques, cells, and nasopharyngeal applicators), radium thickness gauges, and

oilwell borehole logging instruments containing radium. In general, medical sources are assumed to account for more than 80 percent of the projected waste volume [PEI85a, Appendix B]. The different types of sources contain between 14 and 1,000 millicuries of radium-226 each. The generation and radionuclide assumptions for this waste category are based on PEI85a; however, the NRC [DM86] has also characterized two of the sub-streams (radium-beryllium neutron sources and four different types of medical radium sources), as well as a "non-medical source" category. The NRC characterization is based in part on data collected by EPA's Montgomery, Alabama, Eastern Environmental Radiation Facility (EERF). The EERF data also provide the basis for the NRC regional allocation of waste volume presented in DM86.

2. R-RAIXRSN: Radium ion-exchange resins are used to filter groundwater used for public water supplies to remove radium-226 dissolved in the water and to process waste water from uranium recovery operations. These resins are still being developed and are not yet in widespread use. Known areas of radium-contaminated groundwater are located in Maine, Iowa, Illinois, and New Hampshire; however, few U.S. public water supplies have been fully characterized. According to DM86, a pilot program conducted by Dow Chemical Company predicts that waste resins will have a radium loading of 1 millicurie per cubic foot (35.3 mCi per cubic meter), but expects that commercial generation will not begin until the 1990s. PEI85a assumes a lower average concentration of 18 mCi per cubic meter. This lower concentration is used in EPA's risk assessment, but is associated with a higher 20-year waste volume (6,600 cubic meters) than would be predicted by DM86, which assumes generation of 212.4 cubic meters per year starting in 1990, for a total of 3,186 cubic meters between 1985 and 2004. Hence, the total disposed radium

activity differs by less than six percent between the NRC and EPA analyses.

3. R-GLASDS1: This category includes all of the substreams originally included in R-GLASDIS, except uranium glassware. These substreams include: ophthalmic glass, sun and germicidal exterior lamps, incandescent mantles (uranium-238 and thorium-232), illumination equipment and high-pressure mercury vapor lamps, fluorescent lamps, and ceramic artificial teeth. The wastes in R-GLASDS1 are generally believed to be widely dispersed and currently in the possession of consumers who may be unaware of their radioactive content. As discussed below and in Appendix C, regulated disposal of these wastes would be more costly than for typical LLW, since the cost to identify and collect them for shipment to a regulated facility could be substantial.

4. R-GLASDS2: This category includes the single substream of uranium glassware. This material consists of certain types of glass and ceramic dinnerware that have been coated with a glaze containing uranium-238. PE185a reports that the use of such glazes is no longer permitted in the U.S.; however, some materials may enter the country inadvertently. EPA assumes that this very small volume waste would not be subject to the collection costs described above for R-GLASDS1 (although no additional costs are added in the analysis, cost would depend on the means of locating the material; some glassware may be intercepted at the point of import to the U.S.).

5. R-INSTDF1: This category includes all of the substreams originally included in R-INSTDIF, except for commercial and military radium aircraft dials and personnel neutron dosimeters (which contain thorium fluoride). About 80 percent of the waste volume is accounted for by timepieces (clocks and wristwatches) with faces that were painted with a radium-containing

radioluminous paint. Other substreams include radium-containing smoke detectors, static eliminators (containing polonium-210), radium-painted radioluminous aircraft dials used in private aircraft, radium dial watches (differentiated from timepieces by a higher radium content per piece, but much fewer in number), and uranium-containing paints (which constitute about 14 percent of the volume). All of the waste in this category is assumed to be subject to the collection costs described above for R-GLASDS1.

6. R-INSTDF2: This category contains radium dials used in military and commercial aircraft instruments, and personnel neutron dosimeters (which contain thorium fluoride). According to PEI85a, all of the items in this category are currently disposed of in regulated LLW facilities. Since these items are relatively easy to locate, and because a disposal system is currently in place, collection costs are assumed not to apply to these wastes.

Volume, Waste Form, and Radionuclide Content

Table 6-1 summarizes the regional volumes and waste form used in the final cost and risk assessment of discrete NARM wastes. Volume by hydrogeologic region is derived using the methodology described in Appendix A; in general, volumes for wastes other than R-RASOURC were allocated based on State population. Radium source volumes were allocated based on the NRC regional distribution cited in DM86 and by State population within NRC region. As in the preliminary NARM analysis, volume estimates assume a constant generation for 20 years, from 1985 to 2004.

Table 6-2 summarizes the average concentration of the three principal NARM radionuclides for each of the six wastes, together with total U.S. volume and the concentration in selected substreams. These data are used to determine compliance with alternative NARM limits, as discussed

Table 6-1

REGIONAL VOLUMES AND WASTE FORM FOR
FINAL ANALYSIS OF DISCRETE NARM WASTES

Waste Category	Relationship to NARM Wastes Used in Preliminary Analysis	Volume by Hydrogeologic Region, 1985-2004 (cubic meters as generated) Humid Permeable	Humid Impermeable	Arid Permeable	Total U.S.	As Generated** Waste Form
R-RASOURC*	Combines R-SOURCES and R-RABESRC	.180	.190	.075	.445	AW
R-RAIXRSN	Same	3,251	1,608	1,740	6,600	AW
R-GLASDS1	Substream of R-GLASDIS	28,065	13,882	15,020	56,968	TR
R-GLASDS2	Substream of R-GLASDIS	15.8	7.8	8.4	32	TR
R-INSTDF1	Substream of R-INSTDIF	2,478	1,326	1,225	5,030	TR
R-INSTDF2	Substream of R-INSTDIF	74.0	39.5	36.5	150	TR

NOTE: Regional volume estimates based on State-by-State and waste substream estimates described in Appendix A and total volumes in Table H-2 in Appendix H. Waste form assumptions from EPA87.

* Volumes for R-RASOURC reflect the volume of the sources themselves. Cost estimates assume disposal of one source per drum, using a volume 2,914 times higher.

** AW = absorbed waste; TR = trash.

Table 6-2

RADIONUCLIDE CONTENT FOR FINAL ANALYSIS
OF DISCRETE NARM WASTES INCLUDING SELECTED SUBSTREAMS

Waste	Ra-226 Ci/m³	Ra-226 nCi/g	U-238 Ci/m³	U-238 nCi/g	Th-232 Ci/m³	Th-232 nCi/g	As Generated Waste Volume (cubic meters, 1985 - 2004)
1. R-RASOURC	1.40 E+3	3.50 E+5	--	--	--	--	.445
2. R-RAIXRSN	1.80 E-2	20.0	--	--	--	--	6,600
3. R-GLASDS1	--	--	8.53 E-4	3.4 E-1	3.51 E-1	1.4	56,968
Incandescent Mantles - U	--	--	5.63 E-1	225	--	--	64
Incandescent Mantles - Th	--	--	--	--	3.13 E-2	12.5	80
Other	--	--	2.39 E-4	9.57 E-2	3.51 E-3	1.4	56,824
4. R-GLASDS2	--	--	3.13 E-2	12.5	--	--	32
Uranium Glassware	--	--	3.13 E-2	12.5	--	--	32
5. R-INSTDF1	1.63 E-2	4.07	2.58 E-4	6.50 E-2	--	--	5,030
Radium Watches & Dials	3.7 E-1	93	--	--	--	--	7.5 E-2
Timepieces	2.0 E-2	5.0	--	--	--	--	4,000
Smoke Detectors	5.6 E-3	1.4	--	--	--	--	350
Other	--	--	1.9 E-3	4.8 E-1	--	--	680
6. R-INSTDF2	1.86 E-4	4.65 E-2	--	--	2.2 E-4	5.5 E-2	150
Aircraft Dials-Commercial	1.6 E-1	40	--	--	--	--	5.0 E-2
Aircraft Dials-Military	1.6 E-1	40	--	--	--	--	1.3 E-1
Personnel Neutron Dosimeters	--	--	--	--	2.2 E-4	5.5 E-2	150

(Column group heading: Average Concentration of Principal Nuclides)

NOTE: Based on PEI85a, Appendix B. Conversion from Ci/m³ to nanocuries per gram (nCi/g) assumes densities shown in Table H-2 in Appendix H. The concentrations listed for R-RASOURC, used in the risk assessment, reflect the volume of the isolated sources. Cost estimates use a volume 2,914 times higher. A dash means that the radionuclide is not present in that particular waste. Average concentrations for the six NARM wastes are calculated by taking the weighted average of all substreams, including the substreams represented by a dash.

later in this chapter, and are based on average substream concentration estimates presented in Appendix B of PEI85a. As with the preliminary NARM analysis, the concentration of the long-lived decay products of the principal radionuclides was determined, assuming secular equilibrium. Because of limitations in the PRESTO-EPA risk assessment models, three radionuclides were dropped from the final assessment (bismuth-212, radium-224, and thorium-230). Radon risks were calculated outside of the PRESTO-EPA models using a separate methodology.

Collection Costs

The derivation of costs for typical regulated LLW facilities includes component costs for packaging, processing, transportation, and disposal. The cost derivation assumes that the cost of identifying the waste is small and that a sufficient volume of waste is generated at each generator facility for economic transportation quantities (e.g., a full truckload) to be available. For low-level wastes (e.g., from power reactors), these implicit assumptions are generally true. However, for consumer-type wastes (such as those included in R-GLASDS1 and R-INSTDF1), identification and collection costs could be significant, since each "generator" possesses a very small volume of waste. While unregulated disposal would simply entail discarding the item in the trash, any regulated disposal practice would incur unusual collection costs.

Appendix C includes a detailed derivation of collection costs for consumer-type wastes. In general, the analysis assumes that the waste would be transported by the consumer to a local post office, where it would be returned by mail to the manufacturer. The manufacturer is then assumed to incur a disposal cost that is typical of LLW, since economic disposal quantities would be present. The collection cost analysis includes seven separate cost components, including packaging, transportation, postage, and the value of time required to package and mail the item. The analysis does not include other potentially significant cost items, such as the cost of helping consumers identify those items needing regulated disposal.

Based on the average weight and density of an item [PE185a], collection costs for regulated disposal of R-GLASDS1 and R-INSTDF1 are as follows:

Waste	Collection Cost ($/cubic meter)
1. R-GLASDS1	$220,000
2. R-INSTDF1	$250,000

As can be observed by comparing these estimates with other typical LLW disposal cost components (described in Chapter 3), collection costs are very significant on a per-cubic-meter basis; these costs, therefore, have a substantial impact on the cost-effectiveness ratios that are calculated later for these wastes.

STATE REGULATION OF NARM AND CURRENT DISPOSAL PRACTICE

The NRC is the Federal agency with responsibility for licensing all commercial AEA radioactive material. The NRC has delegated its licensing authority to 27 States, called "Agreement States." Agreement State licensing requirements must abide by NRC guidelines. However, under the Atomic Energy Act of 1954 and Reorganization Plan #3 of 1970, only certain radioactive material falls under NRC purview, namely nuclear source, byproduct, and special nuclear material. Therefore, NRC's authority does not encompass wastes containing NARM.

Currently, proper disposal of NARM waste is left within the domain of State jurisdiction. In general, if a State has statutory authority to license possession of NARM, it also has authority to regulate proper disposal. Usually, licenses are granted with provisions which govern the acquisition, distribution, use, possession, transfer, and disposal of all radioactive material. However, disposal requirements are often no more specific than requiring transfer to an authorized recipient. Among non-Agreement States, regulation of NARM is also inconsistent, as summarized in Table 6-3.

States that issue licenses for possession of NARM and regulate its disposal must draw such authority from their own enabling legislation. This is typically done in two ways. The NRC may delegate licensing authority to the State (which becomes an Agreement State), provided that the State incorporates Federal regulations (or more stringent requirements) on licensing and waste disposal into State statutes. Agreement States usually have enabling legislation which redefines radioactive material to include NARM (or at least naturally-occurring radium). Currently, 33 States license NARM. A non-Agreement State can also draft comprehensive legislation that separately regulates licensing and disposal of NARM radioactive waste. Non-Agreement States that license NARM are the following: Delaware, Illinois, New Jersey, Pennsylvania, South Dakota, and Virginia. Licensing States have often relied on the "Suggested State Regulations for Control of Radiation" (SSRCR), which are published and sponsored by the Conference of Radiation Control Program Directors, Inc. (CRCPD), to formulate licensing requirements for naturally-occurring radium. A recent revision to Part D of the SSRCR has incorporated a Class C limit of 100 nCi/g for radium. On May 18, 1986, the CRCPD adopted a resolution urging each State to provide for disposal of discrete NARM sources in their regional LLW disposal facility in addition to urging DOE to promote within Congress the acceptance of above-Class C NARM at DOE disposal facilities.

Table 6-3

1986 LEGAL AND REGULATORY STATUS OF NARM WASTE BY STATE

State	No Regulation *	Registration Only **	NRC Agreement State ***	Non-Agreement Licensing State #	License Terms Known to Specify Disposal Practice ##
Alabama			X		
Alaska		X			
Arizona			X		
Arkansas			X		
California			X		X
Colorado			X		
Connecticut	X				
Delaware				X	X
D.C.		X			
Florida			X		
Georgia			X		X
Hawaii		X			X
Idaho			X		X
Illinois				X	X
Indiana		X			
Iowa		X			
Kansas			X		
Kentucky			X		
Louisiana			X		
Maine	X				
Maryland			X		X
Massachusetts		X			
Michigan		X			
Minnesota		X			
Mississippi			X		
Missouri		X			

Table continued on following page.

Table 6-3 (Continued)

1986 LEGAL AND REGULATORY STATUS OF NARM WASTE BY STATE

State	No Regulation *	Registration Only **	NRC Agreement State ***	Non-Agreement Licensing State #	License Terms Known to Specify Disposal Practice ##
Montana	X				
Nebraska			X		
Nevada			X		
New Hampshire			X		X
New Jersey				X	X
New Mexico			X		
New York			X		X
North Carolina			X		X
North Dakota			X		
Ohio		X			
Oklahoma		X			
Oregon			X		
Pennsylvania				X	X
Puerto Rico	X				
Rhode Island			X		
South Carolina			X		
South Dakota				X	X
Tennessee			X		
Texas				X	X
Utah			X		
Vermont		X			
Virgin Islands	X				
Virginia				X	X
Washington			X		X
West Virginia		X			
Wisconsin		X			
Wyoming		X			

Table continued on following page.

Table 6-3 (Continued)

1986 LEGAL AND REGULATORY STATUS OF NARM WASTE BY STATE

* NARM is neither registered nor licensed in these States. Disposal of NARM is not regulated. Disposal guidance may be offered.

** Possession of NARM material must be registered with the appropriate State agency. Although disposal of NARM is unregulated, informal inspections can determine how NARM waste is currently treated, and guidance regarding proper disposal is usually offered.

*** The NRC has delegated AEA licensing authority to these States. Comprehensive State legislation has expanded AEA definitions to include NARM. Possession of NARM requires license. Usually, license conditions for NARM disposal are not more specific than requiring transfer to an authorized recipent.

\# Possession and disposal of NARM regulated by terms of a State license. For these non-Agreement States, comprehensive enabling legislation has been drafted which specifically includes NARM materials. These licenses typically specify disposal alternatives, such as dilution, decay through storage, special encapsulation, or transfer to a licensed disposal facility.

\#\# These State licenses are known to have specific requirements for NARM disposal. In the case of NARM Agreement States, PHB has spoken to respective State representatives to determine how NARM is regulated under the terms of a typical license. In the case of Non-Agreement licensing States, alternative disposal practices have been identified by PHB.

SOURCE: Putnam, Hayes & Bartlett, Inc., 24 February 1987. Table includes 50 States, Puerto Rico, Virgin Islands, and the District of Columbia. 1985 status summary based on information provided to PHB in Table 64 of CRCPD85b. Status updated to 1986 by phone calls to State health representatives.

States that do not license NARM (and, therefore, do not regulate NARM disposal) usually register possession of radium sources. Unlike licensing States, registering States have much less control over conditions of possession, use, transfer, or disposal of radioactive material. The following States only register radium sources: Alaska, the District of Columbia, Hawaii, Indiana, Iowa, Massachusetts, Michigan, Minnesota, Missouri, Ohio, Oklahoma, Vermont, West Virginia, Wisconsin, and Wyoming. Currently, Connecticut, Maine, Montana, Puerto Rico, and the Virgin Islands neither register nor license NARM.

Current Disposal Practice

PEI85a reports that, in the past, R-RASOURC, R-RAIXRSN, and R-INSTDF2 usually have been disposed of in regulated LLW facilities, except for radium thickness gauges (a substream of R-RASOURC).* PEI85a also reports that past disposal practice for R-GLADS1, R-GLADS2, and R-INSTDF1 involved disposal at a public landfill; given the types of wastes involved (namely, consumer-like wastes), current disposal practice is not likely to deviate from past practice. However, in the case of those wastes previously disposed in regulated LLW facilities, considerable uncertainty exists with regard to current disposal practice due to the absence of Federal regulation and widely varying State requirements.

Licensing States usually regulate the disposal of NARM waste under the terms of the license. Typically, three general provisions affect radioactive waste disposal under State license. Radioactive waste may be released into sanitary sewage systems or landfills, if such wastes are diluted to acceptable concentrations, as provided in the State emission

* PEI85a also reports that lightning rods made with radium, uranium used in counterweights, uranium radiation shielding, and chemical catalysts containing antimony uranium oxide all also are disposed of at regulated LLW disposal facilities. Except for lightning rods, all of these wastes are diffuse wastes. None is included in the six discrete NARM wastes considered in the final analysis.

concentration table. Second, the waste material may be held in storage for decay until it decays down to levels suitable for disposal in a sanitary landfill. For instance, the State of Delaware has a provision that decay through storage is allowed for isotopes with half-lives no greater than 65 days. In the case of radium, which has a half-life of 1,620 years, this alternative clearly is not feasible, although storage for decay is practiced for accelerator-produced nuclides. Finally, radioactive waste may be transferred to an "authorized recipient," as provided for in the licensing regulations. An authorized recipient can be another user with a license that allows for such transfer, a licensed disposal site, or a Federally-licensed facility (such as a LLW disposal facility). In all cases, the recipient must be authorized to receive the specific radioactive material under the terms of its license.

As is evident in later discussion in this chapter, of the three NARM wastes that have been disposed of at regulated facilities in the past, characterizing current disposal practice is most important for two of those wastes, R-RASOURC and R-RAIXRSN, given their contribution to total cost and population health effects.

Because of the very high levels of activity for radium sources (R-RASOURC) and uncertainty over future regulatory requirements, the majority of this NARM waste is usually kept in storage or transferred for disposal to a regulated LLW facility. However, as of fall 1986, only two currently operating LLW facilities were accepting NARM (Hanford, Washington and Beatty, Nevada).* The Hanford facility will only accept discrete radium sources which are packaged so that the package activity does not exceed 100 nanocuries per gram by stabilized weight (this limit precludes disposal of many radium sources). Until recently, the Nevada

* Based on telephone conversations with William Dornsife of the CRCPD, September 11, 1986.

facility was accepting NARM in high tech sealed containers.* The cost for packaging NARM material can range up to $2,000 for one radium needle. As a result, most NARM waste remains in storage under licensed conditions or is transferred from one user to another for storage. At the same time, anecdotal evidence also suggests that some sources have been disposed of in an unregulated manner, or have been lost or misplaced.** Therefore, considerable uncertainty exists as to the appropriate base case to use in measuring the impacts associated with the regulation of R-RASOURC.

Disposal of radium-loaded water treatment ion-exchange resins (R-RAIXRSN) has also been guided by license requirements. In New Hampshire, radium-loaded resins previously were accepted for disposal in State sanitary landfills under the assumption that each resin filter did not exceed a certain activity level. Such disposal is no longer permitted. Ion-exchange resin disposal alternatives are currently under examination at the University of New Hampshire.*** Another significant source of uncertainty arises in determining the current disposal practice associated with R-RAIXRSN since large scale use of ion-exchange resins in municipal water facilities is not expected to occur until 1990.

Due to the greatly increased cost of disposal, and reluctance on the part of site operators to accept this type of waste, NARM was actively disposed of more in the past than it is today. From 1974 to 1981, NARM waste was collected and voluntarily stored at EPA's EERF in Montgomery, Alabama. The program represented a coordinated effort between the U.S.

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* The facility at Beatty, Nevada recently discontinued accepting NARM, according to statements by Terry Devine, Technical Assistant to the CRCPD, February 24, 1987.

** Memorandum from Sheldon Meyers, Director, Office of Radiation Programs, to Charles L. Elkins, Director, Office of Toxic Substances, U.S. Environmental Protection Agency, July 20, 1987.

*** Based on telephone conversations with Diane E. Tefft, Program Manager, Radiological Health Program, New Hampshire, September 22, 1986.

Department of Health, Education and Welfare (HEW) and EPA. While in operation, EERF collected about 150 grams of radium from 13,000 sources [NRC86a]. This waste was later transferred to the LLW disposal site at Hanford.* EPA and HEW maintained detailed records of these NARM materials; this database provides much of the NARM characterization data underlying this analysis.

A pilot project currently being undertaken by the CRCPD has estimated that at least 125 curies of orphaned discrete radium sources are still stored for disposal [CRCPD86].** The CRCPD obtained approval from the State of Nevada to use the Beatty disposal site. EPA agreed to furnish 6-M overpack containers to dispose of radium sources in conjunction with the use of a specialized 55 gallon drum containing a steel capsule for discrete source encapsulation.*** Some of these containers are being made available to selected States. In the context of this analysis, such disposal is probably closely analogous to using high integrity containers for solidified waste disposal.

The principal problem when determining the disposition of NARM waste comes from the great uncertainty in States which do not license NARM. As mentioned briefly, registering States do not regulate disposal. Although these States recommend that NARM waste be transferred to licensed disposal facilities, the high cost of disposal could result in improper disposal or

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* Based on conversations with Jeannine T. Lewis, Center for Devices and Radiological Health, Food and Drug Administration, January 1986.

** Although a definitive determination was not possible, conversations with CRCPD representatives suggest that new radium sources are no longer manufactured (radium has been replaced by other isotopes). PEI85a notes that radium sources are often still useful for calibration purposes due to the long half-life of radium.

*** Detailed disposal guidelines are contained in CRCPD86.

unsafe storage. Unlike licensees, which must renew their permits periodically to retain possession and continue use of NARM material, non-licensing States have only informal inspections and enforcement mechanisms. The net result is that disposition of NARM waste in non-licensing States is highly uncertain.

Base Case Assumption

For purposes of analysis, a base case assumption must be made so that the economic impacts associated with current practice (projected over 20 years) can be estimated. As mentioned above, disposal practice for R-GLADS1, R-GLASDS2, and R-INSTDF1 has in the past been consistent with unregulated disposal and is likely to remain as such. Therefore, the base case for these wastes assumes unregulated disposal as representative of current practice. Given the uncertainty with the current disposition of R-RASOURC and R-RAIXRSN, a range of possible base cases is assumed. Effectively, in the absence of Federal regulation, the base case could range from assuming all of R-RASOURC and R-RAIXRSN would be disposed of in a regulated manner to assuming all of these wastes would be disposed of in an unregulated manner. Since it is known that the majority of radium sources are stored currently, assuming that all of this waste would be disposed of in an unregulated manner might be viewed as an unrealistic assumption. However, significant health risks may be associated with improper storage or handling. EPA has not estimated these risks since storage is believed not to be amenable to risk modelling.* Since the costs and health effects associated with the regulated and unregulated disposal of R-INSTDF2 are very small, as highlighted in the next section, the significance of characterizing current practice is reduced. For simplicity, the base case assumes unregulated disposal for R-INSTDF2. Given the curie concentration and stability of R-RAIXRSN and R-RASOURC, these wastes would likely be treated as Class C, if regulated, while the other four NARM would likely be treated as Class A wastes.

* Memorandum from Sheldon Meyers to Charles L. Elkins, op. cit.

FINAL COST-EFFECTIVENESS ANALYSIS AND EVALUATION OF NARM LIMITS

This section presents the results of the economic analysis of alternative limits for NARM waste disposal. This analysis provides both a comparison of the costs and population health effects of regulated and unregulated disposal for the six NARM wastes and compares alternative levels of a limit for those shown to be the most cost-effective to regulate.

Wastes Included in the NARM Analysis

As described previously, six NARM waste categories are considered in the detailed analysis of alternative NARM standards, including: R-RASOURC, R-RAIXRSN, R-GLASDS1, R-GLASDS2, R-INSTDF1, and R-INSTDF2. For purposes of analysis, current disposal practice for these wastes will be considered to range from unregulated disposal for all six NARM to regulated disposal for R-RASOURC and R-RAIXRSN, with unregulated disposal for the other four NARM.

RESULTS OF THE NARM ANALYSIS

Costs, Population Health Effects, and Cost-Effectiveness

Table 6-4 presents the costs and population health effects of regulated and unregulated disposal of the six NARM wastes. Unregulated disposal would cost less than $500,000 (in present value terms) over the next 20 years, but would result in about 78 health effects. About 86 percent of the population health effects are attributable to R-RASOURC. While regulated disposal of the six NARM wastes would reduce the health effects by nearly 98 percent (to about 1.7 health effects), this reduction would cost nearly $5.9 billion, primarily as a result of the very high collection

Table 6-4

COSTS AND POPULATION RISKS
OF REGULATED AND UNREGULATED DISPOSAL
OF SIX NARM WASTES

	Unregulated Disposal*		Regulated Disposal**	
Waste	Cost ($ Millions)	Population Risk (Health Effects)	Cost ($ Millions)	Population Risk (Health Effects)
R-RASOURC	0.01	67	3.3	0.13
R-RAIXRSN	0.04	3.7	20	0.03
R-GLASDS1	0.38	4.7	5,300	0.94
R-GLASDS2	0.00	0.0	0.01	0.00
R-INSTDF1	0.03	2.3	540	0.64
R-INSTDF2	0.00	0.0	0.05	0.00
TOTAL	0.46	78	5,900	1.7

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Avoided health effects include fatal cancers and genetic effects over 10,000 years and are not discounted.

* Unregulated disposal represents a weighted average of five unregulated disposal facility types.

** Regulated disposal is CSD As Is, except for R-RASOURC and R-RAIXRSN which are both ISD Solidified.

costs associated with regulated disposal of the two consumer-like wastes, R-GLASDS1 and R-INSTDF1. The contribution to cost and health effects for both regulated and unregulated disposal is negligible for both R-GLASDS2 and R-INSTDF2.

The uneven distribution of cost and population health effects across wastes implies a large difference in the cost-effectiveness of regulated disposal. The cost-effectiveness ratios, which compare regulated and unregulated disposal for each of the three hydrogeologic regions and the U.S., are presented in Table 6-5. For the U.S. on average, ratios vary by nearly five orders of magnitude, from less than $50,000 per avoided health effect for regulation of R-RASOURC to nearly $1.4 billion per avoided health effect for regulation of R-GLASDS1. At values for an avoided health effect ranging from $6 million (a value which R-RASOURC and R-RAIXRSN would both fall under) just up to $28 million (which effectively excludes R-GLASDS2), only R-RASOURC and R-RAIXRSN are cost-effective to regulate. However, the economic impacts of values between $28 million and $320 million are virtually identical. Between these values, both R-GLASDS2 and R-INSTDF2 would be regulated and would contribute an insignificant incremental fraction of total costs and risks (less than $60,000 in cost and less than 0.01 health effects for either regulated or unregulated disposal).

Evaluation of Alternative NARM Standards

As discussed in Chapter 4, EPA has fairly broad regulatory authority under TSCA to establish a form of a standard; however, the EIA is limited to considering the alternate forms of a standard believed by EPA to be the most appropriate methods for regulating those NARM wastes thought suitable for regulation at this time.

The 25 millirem CPG standard proposed for the disposal of LLW includes higher activity NARM wastes. The rationale for this decision is that higher activity NARM wastes exhibit the same properties and hazards

Table 6-5

COST-EFFECTIVENESS OF REGULATION
FOR SIX NARM WASTES
BY HYDROGEOLOGIC REGION
(Regulated versus Unregulated Disposal)

Waste	Cost-Effectiveness Ratio ($ Millions Per Avoided Health Effect)			
	Humid Impermeable	Humid Permeable	Arid Permeable	Total U.S.
R-RASOURC	0.02	1.08	0.44	0.05
R-RAIXRSN	1.5	57	37	5.5
R-GLASDS1	1,010	6,090	670	1,400
R-GLASDS2	9.8	104	47	28
R-INSTDF1	94	3,800	1,500	320
R-INSTDF2	27	1,080	420	91

NOTE: Cost-effectiveness equals incremental cost divided by avoided health effects. Incremental costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Avoided health effects include fatal cancers and genetic effects over 10,000 years and are not discounted. Regulated disposal is SLD As Generated, except for R-RASOURC and R-RAIXRSN, which are both ISD Solidified. Unregulated disposal represents a weighted average of five unregulated disposal facility types.

as LLW and, therefore, should be disposed of in the same facilities subject to the same levels of control. This requirement is also the least burdensome since NARM volumes are very small; there is little economic justification for sending these higher activity NARM to sites other than those already sited and designed to accept LLW. The alternative disposal limits EPA considered for NARM waste disposal concern the values to use in delineating higher activity NARM covered by the LLW standard from the lower activity NARM not suitable for disposal in LLW facilities.

In considering methods of setting a limit for higher activity NARM waste, initial consideration was given to constructing a single method to define what constituted a higher activity NARM waste. A total activity limit was considered as a method of accomplishing this. However, a total activity limit alone was dismissed because NARM wastes vary from individual discrete sources to voluminous diffuse waste streams. Consequently, a single value for total activity might not completely define the NARM wastes that EPA intends to regulate (for example, large piles). Because of this, a limit relating to specific activity was also considered. Specific activity delineates higher activity NARM wastes resembling AEA wastes (those wastes that EPA believes are appropriate for inclusion in this regulation as low-level radioactive NARM wastes at this time). As a second alternative, a specific activity limit with certain waste streams explicitly exempted was considered as an alternative form to ensure the inclusion of those streams considered for regulation by EPA while excluding those deemed to be a very low risk and not cost-effective to regulate.

These last two alternatives, a specific activity limit and a specific activity limit with waste stream exemptions, were considered to be the two viable forms of the limit. A specific activity limit is measured in nanocuries (1.00 E-9 curies) per gram (nCi/g). For a discrete item (such as a source) that has a uniform size and weight, a specific activity limit is similar to a limit on total activity per item. The analysis in this section relies on the nuclide concentrations listed in Table 6-2 and the average density assumptions listed in Table H-2, Appendix H. The limit applies to the combined specific activity of the three nuclides, radium-226, uranium-238, and thorium-232 (and applies, of course, only to NARM wastes). The limit of the standard, 2 nCi per gram, is equal to the DOT limit on materials classified as radioactive for transportation packaging purposes.

The second form of the limit considered, a specific activity limit with waste stream exemptions, would retain the specific activity limit as outlined above but would exempt from regulation those wastes that are deemed to be a very low risk and not cost-effective to regulate. Those wastes explicitly exempted from the 2 nCi per gram limit include the uranium glassware (R-GLASDS2) and the waste substreams found in the two consumer-like NARM wastes -- R-GLASDS1 and R-INSTDF1.*

Tables 6-6 and 6-7 summarize the economic impacts of the two alternative NARM standards. The two impacts tables differ in the base case assumption made with regard to current disposal practice for NARM. These two assumptions concerning current practice cover the range of possible base cases and, therefore, the range of possible economic impacts. In Table 6-6, R-RASOURC and R-RAIXRSN are assumed to be regulated under current practice, whereas the other four NARM are assumed to be unregulated. In Table 6-7, the base case assumes that all of the six NARM waste volumes are unregulated under current practice. Based on this

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* Some substreams of R-GLASDS1 and R-INSTDF1 may not be explicitly exempted in the regulatory language proposed for the NARM limit since these substreams are expected to meet the 2 nCi per gram limit on average. Conceivably, a portion of these non-exempted items may exceed the 2 nCi per gram limit given variations in radionuclide concentrations over the particular substream; however, EPA expects this to occur infrequently. Therefore, the economic impacts will not be significantly different from those presented in this chapter.

Table 6-6

ECONOMIC IMPACTS OF ALTERNATIVE NARM STANDARDS

BASE CASE 1*

NARM Limit (nCi/g)	Incremental Cost Versus Current Practice ($ Million)	Avoided Health Effects Versus Current Practice	Regulated NARM Wastes	Cost-Effectiveness Versus Current Practice ($ Million Per Avoided Health Effect)	Marginal Cost-Effectiveness Versus Next Best Alternative ($ Million Per Avoided Health Effect)
2 nCi/g w/waste exemptions **	0	0	R-RASOURC R-RAIXRSN	N.M.	
2 nCi/g w/o waste exemptions	540	1.7	R-RASOURC R-RAIXRSN R-GLASDS2 R-INSTDF1	325	325

NOTE: Costs represent present values discounted at 10 percent (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted.

* Assumes at one end of a possible range in base cases that R-RASOURC and R-RAIXRSN are regulated under current practice, whereas the other four NARM are unregulated.

** R-INSTDF1, R-GLASDS1, and R-GLASDS2 are explicitly exempted from the 2 nCi per gram limit.

N.M. = Not meaningful since no deviation from current practice occurs.

Table 6-7

ECONOMIC IMPACTS OF ALTERNATIVE NARM STANDARDS

BASE CASE 2*

NARM Limit (nCi/g)	Incremental Cost Versus Current Practice ($ Million)	Avoided Health Effects Versus Current Practice	Regulated NARM Wastes	Cost-Effectiveness Versus Current Practice ($ Million Per Avoided Health Effect)	Marginal Cost-Effectiveness Versus Next Best Alternative ($ Million Per Avoided Health Effect)
2 nCi/g w/waste exemptions **	23	70.5	R-RASOURC R-RAIXRSN	.33	
					325
2 nCi/g w/o waste exemptions	563	72.2	R-RASOURC R-RAIXRSN R-GLASDS2 R-INSTDF1	7.8	

NOTE: Costs represent present values discounted at 10 percent (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted.

* Assumes at one end of a possible range in base cases that under current practice all six NARM wastes are unregulated.

** R-INSTDF1, R-GLASDS1, and R-GLASDS2 are explicitly exempted from the 2 nCi per gram limit.

analysis, a NARM standard consisting of only a 2 nCi per gram concentration limit would have an incremental cost of $540 to $563 million over current practice (depending on the base case assumption) and would avoid from 1.7 to 72.2 health effects. In addition to regulating R-RASOURC and R-RAIXRSN, this form of a standard would also require the regulation of R-GLASDS2 and R-INSTDF1, resulting in an average cost-effectiveness of $7.8 to $325 million per avoided health effect.*

The proposed form of the standard, the 2 nCi per gram concentration limit and an explicit exemption of some waste streams, has impacts that are drastically different due to the exclusion of two streams -- R-GLASDS2 and R-INSTDF1. The incremental cost ranges from zero to $23 million, depending on the base case, versus the $540 to $563 million for the 2 nanocuries limit alone, a savings of about $540 million regardless of which base case is assumed. In the case in which R-RASOURC and R-RAIXRSN are regulated under current practice, total health effects avoided are zero, as opposed to 1.7 for the 2 nCi per gram limit with no exemptions, a reduction of 1.7 avoided health effects. Or, in the base case where all wastes are currently unregulated, avoided health effects are 70.5 for the 2 nCi per gram limit with waste exemptions vis-a-vis 72.2 effects with no exemptions -- again, a reduction of 1.7 avoided health effects. Consequently, regardless of the base case assumed for current practice, the marginal cost-effectiveness ratio in moving from the 2 nanocurie specific activity limit without waste exemptions to the specific activity limit which includes exemptions is $325 million per avoided health effect. Since the marginal cost-effectiveness is a measure of this incremental cost per avoided health effect associated with moving from one form of the limit to another, this relatively high cost of $325 million per avoided health effect suggests

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* Without explicit exemptions, some substreams of R-GLASDS1 would be regulated at the 2 nCi/g limit, although, on average, R-GLASDS1 would meet this limit. Consistent with other analysis in the EIA, explicit consideration of the impacts on waste substreams was not considered.

that within a broad range of reasonable values for an avoided health effect, including waste exemptions would be an economically justified form of the NARM limit.

INTRODUCTION

This chapter presents the results of the economic analysis of alternative criteria for the non-regulated disposal of lesser activity LLW wastes (i.e., nonregulated with respect to the radioactive component only). Unregulated disposal of lesser activity LLW, termed "Below Regulatory Concern" (BRC) disposal, is congruent with EPA's BRC concept. This concept attempts to define radiation exposures associated with radioactive waste disposal that are so low that regulation of such waste with respect to its radiation hazard is not warranted. The establishment of a BRC level allows lesser activity wastes to be disposed of in a less restrictive manner at substantial cost savings without subjecting the public to any unreasonable or significant health risks.

The analysis relies principally on a comparison of the costs, population health effects, and CPG risks of regulated and unregulated disposal. By determining those wastes for which unregulated disposal is permitted under various standards, the costs and risks of alternative regulations are estimated. As discussed in Chapter 3, the BRC analysis focuses on commercial LLW, since a sufficient characterization of DOE waste is not available. However, the economic impacts of alternative BRC standards, including a hypothetical BRC component from DOE waste, are also calculated and shown later in this section. EPA must make several assumptions concerning the similarity of DOE and commercial waste characteristics in performing these calculations. These assumptions are detailed in Appendix C.

The BRC analysis addresses the primary question of which wastes are cost-effective to dispose in regulated facilities and which are suitable for disposal without regard to their potential radiation hazards. By identifying those wastes that are cost-effective to regulate, the results of this chapter allow for the calculation of the aggregate cost-effectiveness of alternative BRC levels and lay the groundwork for the analysis of alternative LLW disposal standards in Chapter 8.

Summary of BRC Methodology

To determine the cost-effectiveness of regulating a particular waste, both regulated and unregulated costs and population health effects must be estimated for comparison. In addition, CPG risks associated with unregulated disposal are estimated to determine what mix of wastes would meet the alternative BRC criteria.

The estimation of regulated and unregulated costs is explained in greater detail in Appendix C. To summarize briefly, the unregulated unit costs for transportation and disposal of waste is estimated for the five unregulated disposal settings -- Municipal Dump (MD), Suburban Sanitary Landfill (SF), Urban Sanitary Landfill (UF), Suburban Sanitary Landfill with Incineration (SI), and Urban Sanitary Landfill with Incineration (UI). To allow for a simple comparison of unregulated versus regulated disposal, a weighted average cost is calculated for these five disposal settings. As described in Appendix B, the weights were based on a subjective choice concerning what percentage of a given waste is placed at the five types of unregulated disposal settings. The weighted average unit cost for each waste is then multiplied by the waste volume to determine the total cost of unregulated disposal for that particular waste.

Regulated unit costs are calculated, assuming 10 CFR 61 disposal technology, for four separate components -- packaging, processing, transportation, and disposal. Each cost component has an associated volume increase factor; i.e., the as generated volume of waste may change due to items such as the inclusion of additional packaging materials or the incineration of the waste. Total unit costs are calculated by multiplying the unit cost of each component by the volume increase factor and then summing up costs over the four components. Total costs then are calculated by multiplying total unit costs by waste volume.

Given regulated and unregulated costs, the BRC savings associated with the set of wastes that meet an alternative BRC criterion can be calculated by the difference in these two costs. Since BRC savings are measured relative to current practice, a net savings will result if a waste is currently regulated, because regulated disposal is more costly than unregulated disposal. On the other hand, if a waste is currently unregulated (such as the consumer wastes), then additional costs (i.e., "negative" BRC savings) will result if a waste does not meet an alternative BRC criterion.

As with costs, the population health effects associated with regulated and unregulated disposal are compared in the BRC analysis. Unit health effects of unregulated waste disposal are calculated by the PRESTO-BRC risk model for the five unregulated disposal settings mentioned above. The same methodology employed in determining unregulated costs is used to calculate a weighted average for the population health effects associated with unregulated disposal. Total population health effects are calculated by multiplying the weighted average unit health effects by waste volume.

Unit population health effects associated with regulated disposal (using 10 CFR 61 technology) are calculated by the PRESTO-EPA risk model. Volumes are multiplied by unit health effects to estimate total health effects of regulated disposal. The additional health effects associated with alternative levels of the BRC criteria can be calculated by the difference between regulated and unregulated health effects. The cost-effectiveness of regulation can also be calculated by dividing the BRC savings by these additional health effects.

Finally, CPG risks are estimated for different mixes of wastes for purposes of determining what mix of wastes will meet a given level of the BRC criteria. The CPG risks associated with unregulated disposal are estimated by the PATHRAE computer model for 15 BRC disposal scenarios. (See Chapter 3 and Table 3-11 for the specification of these 15 scenarios.) Appendix D discusses in further detail the methodology used in the derivation of the maximum CPG dose for the BRC analysis. Briefly, the methodology involves an iterative process whereby the maximum CPG dose over all 15 disposal scenarios is estimated for different mixes of BRC wastes. As a result, the mix of wastes that will meet a given alternative BRC criterion can be determined.

The economic impacts of alternative BRC criteria can be evaluated given the above information on disposal costs, population health effects, and CPG risks. In addition, the economic cost of one alternative BRC criterion relative to another can be measured by the marginal cost-effectiveness between those two alternatives. Recall that the marginal cost-effectiveness is defined as the value per avoided health effect, i.e., the resources expended to avoid one additional health effect. Mathematically, the marginal cost-effectiveness equals:

$$\frac{\text{(BRC savings for alternative A - BRC savings for alternative B)}}{\text{(Additional H.E. alternative A - Additional H.E. alternative B)}}$$

where H.E. = Health Effects

Thus, the marginal cost-effectiveness associated with moving from one alternative to another measures the cost to society of avoiding an additional health effect.

Wastes Included in the BRC Analysis

As described in Chapter 3, 14 wastes (those with the least activity) of the 25 commercial LLW streams that are currently disposed of in regulated facilities have been included in the BRC analysis. In addition to these principal streams, the BRC analysis considers two substreams of commercial power reactor wastes (P-CONDRSN and L-WASTOIL, which are substreams of L-IXRESIN and L-CONCLIQ, respectively). These substreams have been segregated for purposes of analysis since NRC identified P-CONDRSN and L-WASTOIL as likely BRC wastes. Furthermore, a review of NRC documents suggested that the generation of these wastes is relatively homogenous and, thus, generally easy to segregate [DM81, DM84, DM86]. Current disposal practice for all 16 of these wastes conforms to the NRC's 10 CFR 61 requirements. Except for P-CONDRSN, all are Class A wastes according to NRC definitions; hence, 10 CFR 61 practice is modeled by shallow land disposal (SLD) of the waste as generated. Since L-IXRESIN is a Class B waste, current practice under 10 CFR 61 for its substream, P-CONDRSN, is modeled by SLD with the waste in a solidified form. Finally, the BRC analysis also considers two currently unregulated consumer wastes containing AEA nuclides (C-SMOKDET and C-TIMEPCS) and BIOMED waste, which refers to the biomedical waste that was deregulated under the NRC's Biomedical Waste Rule* [NRC81a]. These three wastes are included to provide a reference point for comparison with the other currently regulated wastes and, in the case of BIOMED waste, to evaluate the impact of very low (or zero) BRC standards when applied uniformly to all materials containing AEA radionuclides.

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* Two wastes that are currently regulated, I-LQSCNVL and I-BIOWAST, have similar characteristics to BIOMED. However, due to the higher activity of these wastes, I-LQSCNVL and I-BIOWAST have not been deregulated under NRC's Biomedical Waste Rule.

RESULTS OF THE BRC ANALYSIS

Results from the Analysis of Cost and Population Health Effects

Table 7-1 presents the total costs and population health effects resulting from regulated and unregulated disposal over the next 20 years for the 19 wastes included in the analysis. Since EPA does not have the authority to unilaterally deregulate any specific waste which also is regulated by the NRC and DOE, the wastes considered as candidates for BRC disposal generally will be referred to as BRC "surrogates" to emphasize that these wastes are representative of the wastes that could be considered for unregulated disposal. Unregulated disposal of all of the wastes in Table 7-1 is estimated to result in 310 health effects over the next 10,000 years, but would cost only $14 million in 1985 present value terms. Regulated disposal of all 19 wastes reduces population health effects by a factor of 22 compared to the risk from unregulated disposal; however, disposal costs increase by a factor of 157.

Five wastes (including I-COTRASH, I-BIOWAST, I-ABSLIQD, N-LOTRASH, and BIOMED) account for 93 percent of the population risk from unregulated disposal, but only 31 percent of the cost. This uneven distribution of cost and risk implies that the cost-effectiveness of regulation will vary significantly across wastes. Table 7-2 presents the cost-effectiveness ratios for each of the 19 wastes in each hydrogeologic region and for the U.S. on average (the incremental cost and avoided health effects by waste and region are listed in Appendix F). In general, the variation of cost-effectiveness across wastes is more significant than the variation across hydrogeologic regions. The cost-effectiveness ratios for different wastes vary by six orders of magnitude, from less than $1 million per avoided health effect for I-COTRASH and I-BIOWAST to more than $100 billion per avoided health effect for L-WASTOIL, N-SSTRASH, F-COTRASH, and F-NCTRASH. Eight currently regulated wastes have cost-effectiveness ratios exceeding $1 billion per avoided health effect in all three

Table 7-1

COSTS AND POPULATION RISKS OF REGULATED AND UNREGULATED DISPOSAL OF BRC SURROGATES

	Unregulated Disposal*		Regulated Disposal**	
Waste	Cost ($ Millions)	Population Risk (Health Effects)	Cost ($ Millions)	Population Risk (Health Effects)
P-COTRASH	1.7	2.6	94	0.06
P-CONDRSN	0.05	0.0	19	0.0
L-WASTOIL	0.14	0.0	16	0.0
B-COTRASH	2.2	1.6	120	0.01
I-COTRASH	1.9	230	100	8.5
I-BIOWAST	0.05	11	8.7	0.43
I-ABSLIQD	0.07	14	18	0.51
I-LQSCNVL	0.10	0.56	25	0.02
N-SSTRASH	2.3	0.0	130	0.0
N-SSWASTE	0.41	0.0	22	0.0
N-LOTRASH	0.66	23	36	1.03
N-LOWASTE	0.39	7.4	21	0.34
F-PROCESS	0.38	0.0	21	0.0
U-PROCESS	0.14	0.0	7.6	0.0
F-COTRASH	1.2	0.0	63	0.0
F-NCTRASH	0.20	0.0	16	0.0
C-SMOKDET***	0.61	1.4	670	0.25
C-TIMEPCS***	0.07	7.3	430	0.02
BIOMED***	1.8	14	417	2.9
TOTAL+	14	310	2,200	14

* Unregulated disposal represents a weighted average of five unregulated disposal facility types. (See Chapter 3 for a discussion of these unregulated disposal facilities.)

** Regulated disposal is SLD As Generated, except for P-CONDRSN which is SLD Solidified.

*** These wastes are currently unregulated.

\+ Figures do not add up due to rounding.

NOTE: Costs represent values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years and are not discounted. Costs and health effects are presented for commercial LLW only.

Table 7-2

COST-EFFECTIVENESS OF REGULATION FOR BRC SURROGATES
BY HYDROGEOLOGIC REGION
(Regulated versus Unregulated Disposal)

WASTE	Cost-Effectiveness Ratio ($ Million Per Avoided Health Effect) HUMID IMPERMEABLE	HUMID PERMEABLE	ARID PERMEABLE	TOTAL U.S.
I-COTRASH	71	0.22	0.46	0.45
I-BIOWAST	81	0.40	0.80	0.79
I-ABSLIQD	107	0.70	1.4	1.4
N-LOTRASH	160	0.94	2.9	1.6
N-LOWASTE	190	1.7	5.1	3.0
BIOMED	(760)	13	(160)	36
P-COTRASH	81	30	41	37
I-LQSCNVL	3,700	23	46	45
C-TIMEPCS	1,200	29	120,000	59
B-COTRASH	98	59	64	73
C-SMOKDET	150	43,000	11,000	590
N-SSWASTE	4,300	35,000	15,000	7,300
F-PROCESS	3,200	14,000	6,900	9,600
U-PROCESS	N.A.	12,000	N.A.	12,000
P-CONDRSN	16,000	34,000	59,000	30,400
N-SSTRASH	84,000	680,000	290,000	140,000
F-COTRASH	62,000	290,000	107,000	180,000
F-NCTRASH	95,000	440,000	160,000	270,000
L-WASTOIL	210,000	470,000	270,000	320,000

NOTE: Cost-effectiveness equals incremental cost divided by avoided health effects. Incremental costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Avoided health effects include fatal cancers and genetic effects over 10,000 years and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified). Unregulated disposal represents a weighted average of five unregulated disposal facility types. Wastes are sorted from low to high using the total U.S. cost-effectiveness ratio.

hydrogeologic regions (P-CONDRSN, L-WASTOIL, N-SSTRASH, N-SSWASTE, F-PROCESS, U-PROCESS, F-COTRASH, and F-NCTRASH). Clearly, regulated disposal of these wastes is very costly in terms of population risk reduction. Finally, regulated disposal of BIOMED waste actually increases population risk, versus unregulated disposal (as indicated by a negative ratio), in two hydrogeologic regions.* The cost-effectiveness of regulating consumer waste is $29 million or higher per avoided health effect in all three regions.

Results from the Analysis of CPG Risk and Dose

As mentioned in Chapter 3, maximum CPG risk is calculated over 11 exposure pathways and 15 exposure scenarios. (These pathways and scenarios are discussed more fully in EPA87.) Similar to the results presented on cost-effectiveness, contribution to maximum CPG dose also varies by waste and region, as shown in Table 7-3. (CPG dose and CPG risk are related by a constant factor of about 2.8 E-5 per millirem per year [MEY86a]; hence, while the following discussion is presented in terms of CPG dose, it applies equally well to CPG risk. See EPA87 for further discussions on the relationship between CPG dose and risk.) The CPG doses listed in Table 7-3 are not additive, however, since the maximum dose associated with each waste may occur in different CPG exposure scenarios.

In almost all cases, the direct gamma exposure pathway was the dominant pathway for each waste. Since gamma exposures do not depend on region, CPG doses from BRC CPG exposure scenarios exhibit very little variation by hydrogeologic region. At the high end, direct gamma exposures to workers during transportation of B-COTRASH and P-COTRASH

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* This counterintuitive result also occurs for some other wastes under a couple of the five unregulated disposal options, although when calculating the weighted average, this result is masked. See the discussion in the sensitivity section of this chapter for a possible explanation of this anomaly.

Table 7-3

CONTRIBUTION TO MAXIMUM CPG DOSE
BY WASTE AND REGION

WASTE*	HUMID IMPERMEABLE	HUMID PERMEABLE	ARID PERMEABLE	U.S. MAX	LIMITING SCENARIO**	LIMITING PATHWAY***
B-COTRASH	500	500	500	500	TRANSPORTATION	GAMMA
P-COTRASH	270	270	270	270	TRANSPORTATION	GAMMA
I-COTRASH	12	12	12	12	TRANSPORTATION	GAMMA
N-LOTRASH	1.7	1.7	1.7	1.7	MAFC-SI	GAMMA
I-ABSLIQD	1.3	1.3	1.3	1.3	TRANSPORTATION	GAMMA
N-LOWASTE	0.48	0.48	0.48	0.48	MAFC-SI	GAMMA
P-CONDRSN	0.22	0.22	0.22	0.22	TRANSPORTATION	GAMMA
F-PROCESS	0.18	0.18	0.18	0.18	MAFC-SI	DUST
I-BIOWAST	0.15	0.15	0.15	0.15	TRANSPORTATION	GAMMA
U-PROCESS	0.13	0.13	0.13	0.13	UHX-MD	DUST
C-TIMEPCS	.0001	0.043	5.09E-7	0.043	CW-SF	WELL
N-SSWASTE	0.030	0.030	0.030	0.030	UF-MD	DUST
F-COTRASH	0.027	0.027	0.027	0.027	MAFC-SI	DUST
L-WASTOIL	0.018	0.018	0.018	0.018	TRANSPORTATION	GAMMA
N-SSTRASH	0.009	0.009	0.009	0.009	UF-MD	DUST
C-SMOKDET	0.007	0.007	0.007	0.007	LMACW-SI	DUST
I-LQSCNVL	0.003	0.006	0.003	0.006	LURO-ON	WELL
F-NCTRASH	0.005	0.005	0.005	0.005	MAFC-SI	DUST

* Wastes are sorted from high to low CPG dose. BIOMED CPG doses were not estimated.

** Notes to Limiting Scenario:
TRANSPORTATION = Transportation of waste from generator site to disposal site.
MAFC-SI = Metro area with fuel cycle facility - suburban sanitary landfill with incineration.

Table continued on following page.

Table 7-3 (Continued)

CONTRIBUTION TO MAXIMUM CPG DOSE
BY WASTE AND REGION

CW-SF = Consumer product wastes - suburban sanitary landfill.
UHX-MD = Uranium hexafluoride facility - municipal dump.
UF-MD = Uranium foundry - municipal dump.
LMACW-SI = Large metropolitan area with consumer wastes - suburban sanitary landfill with incineration.
LURO-ON = Large university/medical center - onsite landfill with onsite incineration.

*** Notes to Limiting Pathway:

GAMMA = Direct gamma radiation to onsite worker.
DUST = Onsite worker dust inhalation.
WELL = Exposure to offsite resident from drinking contaminated well water.

could cause CPG doses in excess of 270 millirem per year (cobalt-60 and cesium-134 contribute the majority of the dose). Conversely, for eight wastes (including L-WASTOIL, N-SSTRASH, N-SSWASTE, I-LQSCNVL, F-COTRASH, F-NCTRASH, C-TIMEPCS, and C-SMOKDET), the highest contribution to CPG dose in any region from any scenario is less than 0.1 millirem per year. While BIOMED waste was excluded from the analysis of CPG scenarios, the maximum CPG dose from this waste is assumed to be less than 0.1 millirem per year.*

Economic Impacts of Alternative BRC Criteria

As described in Chapter 4, quantification of the costs and risks of alternative BRC standards requires specific assumptions regarding implementing the standard (i.e., the analysis requires a decision rule which specifies which wastes are regulated and unregulated in each region, at each level of the standard). Since the NRC will implement EPA's standard for commercial LLW, EPA must predict the method of implementation for purposes of estimating economic impacts.

Other things being equal, it is generally assumed that compliance with each standard is achieved at least cost. For alternative CPG dose limits, least-cost compliance means that deregulated disposal is permitted for a waste, provided that the CPG doses from all BRC scenarios, including all of

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* This assumption is consistent with maximum CPG dose contributions of I-LQSCNVL and I-BIOWAST, which are each less than 0.2 millirem per year. Thus, the BIOMED assumption holds as long as its average specific activity is a factor of 2 lower. Note that while the BIOMED rule is stated in terms of maximum specific activity, the CPG analysis is framed in terms of average specific activity for each waste. The consequences of using average activity are addressed in the sensitivity analysis.

the deregulated wastes, are less than the standard. In addition to least-cost compliance, three other implementation assumptions will be addressed, as follows: (1) whether population cost-effectiveness as well as CPG dose will be used as an EXPLICIT criterion by the NRC for permitting unregulated disposal, or whether population cost-effectiveness will be used only IMPLICITLY, through EPA's choice of a BRC standard (i.e., assuming that protecting the CPG at the same time adequately protects the general population); (2) whether the NRC will consider deregulation only on a NATIONAL basis (where, in effect, the worst hydrogeologic region determines whether a waste would qualify for unregulated disposal anywhere in the entire country regardless of regional hydrogeologic characteristics), or whether REGIONAL deregulation will be allowed, that is, a consideration of deregulation on a hydrogeologic region-by-region basis; and (3) whether partial waste streams will be deregulated (e.g., based on the activity of individual waste packages or on waste characteristics from a single waste generator). Current EPA analysis does not permit the third question to be assessed, although rough estimates of the potential economic impacts are presented in the sensitivity analysis later in this chapter.

The first two implementation issues result in four different implementation assumptions, labeled NATIONAL-EXPLICIT, NATIONAL-IMPLICIT, REGIONAL-EXPLICIT, and REGIONAL-IMPLICIT implementation. Tables 7-4, 7-5, 7-6, and 7-7 present the economic impacts for each of these four assumptions. Each table presents the BRC savings (versus current practice), additional health effects, and marginal cost-effectiveness of six alternative standards, ranging from 15 millirem per year down to zero. The second column of each table lists the maximum CPG dose actually predicted by EPA's risk assessment models. The fifth column lists the BRC "surrogates" which fail to meet the standard. Finally, for purposes of comparison, the top row in each table presents the costs and health effects for unregulated disposal of all 16 currently regulated BRC surrogates.

Table 7-4

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL LLW ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice * ($ Millions)	Additional Health Effects vs. Current Practice *	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	700	280	None	N.A.
15	12.00	490	270	P-COTRASH, B-COTRASH	51
4	2.58	400	53	I-COTRASH and Above	0.45
1	0.51	340	19	N-LOTRASH, I-ABSLIQD, and Above	1.5
0.1 **	0.04	270	0.5	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	4.3
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	87

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM and DOE waste are not included.

* Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregul[illegible]

N.A. = Not Applicable.

Table 7-5

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL LLW ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS *

BRC Criteria (Maximum CPG Dose in Mrem/Yr	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	700	280	None	N.A.
15	0.22	310	0.6	P-COTRASH, B-COTRASH I-COTRASH, I-BIOWAST, I-ABSLIQD, N-LOTRASH and N-LOWASTE	1.4
4	0.22	310	0.6	Same as Above	N.M
1	0.22	310	0.6	Same as Above	N.M.
0.1 ***	0.04	270	0.5	P-CONDRSN, F-PROCESS, U-PROCESS, and Above	14,000
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	87

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM and DOE waste are not included.

* Under Explicit implementation, BRC candidates are rejected if (1) the CPG standard is exceeded, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect. Different values would lead to different impacts.

Table continued on following page.

Table 7-5 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL LLW ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS *

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.
N.M. = Not Meaningful.

Table 7-6

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL LLW ASSUMING IMPLICIT IMPLEMENTATION ON A REGIONAL BASIS

BRC Criteria (Maximum CPG' Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice * ($ Millions)	Additional Health Effects vs. Current Practice *	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	700	280	None	N.A.
15	12.00	490	270	P-COTRASH, B-COTRASH	51
4	2.58	400	53	I-COTRASH and Above	0.45
1	0.51	340	19	N-LOTRASH, I-ABSLIQD, and Above	1.5
0.1 **	0.04	270	0.5	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	4.3
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and Biomed Waste	87

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM and DOE waste are not included.

* Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.

Table 7-7

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
LLW ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS *

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated): Humid Impermeable	Humid Permeable	Arid Permeable	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	700	280	None	None	None	N.A.
15	12.00	380	2.0	P-COTRASH, B-COTRASH	P-COTRASH, B-COTRASH, I-COTRASH, N-LOTRASH, I-ABSLIQD, N-LOWASTE, I-BIOWAST	P-COTRASH, B-COTRASH, I-COTRASH, N-LOTRASH, I-ABSLIQD, I-BIOWAST	1.2
4	2.58	340	1.5	I-COTRASH and Above	Same as Above	Same as Above	70.8
1	0.51	330	1.4	I-ABSLIQD, N-LOTRASH, and Above	Same as Above	Same as Above	135
0.1 ***	0.04	270	0.5	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	P-CONDRSN, F-PROCESS, U-PROCESS, and Above	N-LOWASTE, P-CONDRSN, F-PROCESS, U-PROCESS, and Above	72
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	All BRC Candidates, Consumer Waste, and BIOMED Waste	All BRC Candidates, Consumer Waste, and BIOMED Waste	87

Table continued on following page.

Table 7-7 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
LLW ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM and DOE waste are not included.

* Under Explicit implementation, BRC candidates are rejected if (1) the CPG standard is exceeded, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect. Different values would lead to different impacts.

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.

N.M. = Not Meaningful.

The marginal cost-effectiveness ratio, reported in the last column, compares any two adjacent standards; very low ratios imply that a lower (more stringent) standard would be preferred, based on population risk reduction alone. Assuming that EPA limits the BRC criteria to a level below 15 millirem per year (a criterion which rejects P-COTRASH and B-COTRASH), the economic choice* of a standard depends on the value placed on avoided health effects and the assumed NRC implementation. For example, under National-Implicit (Table 7-4), at a value of $5 million per avoided health effect, a BRC criterion of 0.1 millirem per year is preferred. However, this same value is consistent with a standard anywhere between 1 and 15 millirem per year under National-Explicit implementation since no additional wastes are regulated under this implementation scenario until a 0.1 millirem alternative is considered (Table 7-5). The economic impacts of Regional-Implicit (Table 7-6) and National-Implicit implementation are identical. The economic impacts associated with Regional- and National-Explicit implementation are also very similar.

EPA believes that the two most likely implementation assumptions on the NRC's part are the National-Explicit and the National-Implicit cases (impacts are shown in Tables 7-4 and 7-5) based on past experience with NRC. Significantly, these two implementation assumptions cover the range of economic impacts. Under these assumptions, the proposed 4 millirem standard is projected to save between $310 and $400 million versus current practice (for commercial waste only) and to cause from 0.55 to 53 additional health effects over 10,000 years. The economic impacts, with DOE waste included, will be discussed subsequently.

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* Of course, a variety of other important policy concerns are also considered by EPA.

Tables 7-8 and 7-9 illustrate the limiting wastes, CPG scenarios, exposure pathways, and radionuclides at each level of the BRC standard for the National-Implicit and National-Explicit implementations, respectively. As shown, direct gamma exposure from cobalt-60, cesium-134, and cesium-137 is the primary determinant of economic impact for standards between 1 and 15 millirem per year.

BRC Impacts, Including DOE Waste

Due to the lack of data sufficient to characterize the form and radionuclide content of DOE waste, the costs and risks for disposal of this waste could not be evaluated. However, since EPA expects its BRC standard to apply to DOE waste under the AEA, EPA has assumed that DOE costs and risks are equal to commercial waste costs and risks on a volume for volume basis, except that regulated disposal costs for DOE waste are adjusted downward to reflect a lower average transportation distance (since DOE disposal facilities are typically near the point of generation). EPA's assumptions are explained in more detail in Appendix G. To analyze the impacts of multiple standards under multiple implementation assumptions on a consistent basis, EPA's assumption is equivalent to assuming that each commercial waste stream has a "DOE analog" in each hydrogeologic region, the volume of which depends on the aggregate commercial and DOE volume in that region.

Using EPA's assumptions, the aggregate economic impacts of alternative standards were calculated, including both commercial and DOE waste. The results of these calculations are shown in Tables 7-10, 7-11, 7-12, and 7-13 for each of the four implementation assumptions discussed above (each table assumes that NRC and DOE implementation will be identical). Because of the reduced transportation costs for unregulated disposal of DOE waste, marginal cost-effectiveness ratios are reduced slightly, as compared to the impacts tables with commercial waste alone. Under the National-Explicit and

Table 7-8

LIMITING WASTES AND EXPOSURE SCENARIOS FOR COMPLIANCE WITH ALTERNATIVE BRC CRITERIA UNDER NATIONAL-IMPLICIT IMPLEMENTATION

BRC Criteria (Mrem/Yr)	Last BRC Surrogate Rejected	Dominant Scenario Exceeding Standard	Dominant Pathway Exceeding Standard	Dominant Radionuclide	Contribution To Dose
15	P-COTRASH, B-COTRASH	Transportation	Direct Gamma	Cs-134, Co-60 Cs-137	90%
4	I-COTRASH	Transportation	Direct Gamma	Cs-137, Co-60	88%
1	N-LOTRASH, I-ABSLIQD	Transportation	Direct Gamma	Co-60	94%
0.1	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS	UF-MD, LURO3, Transportation PWR-MD, MAFC-SLFI	DUST, Gamma, GW to well	U-238, U234, U-235, C-14 H-3, Co-60	Over 90%

NOTE: Transportation data from RAE86d. Other pathway data from PEI86b. Scenario and pathway acronyms are detailed in PEI86b.

Table 7-9

LIMITING WASTES AND EXPOSURE SCENARIOS FOR
COMPLIANCE WITH ALTERNATIVE BRC CRITERIA
UNDER NATIONAL-EXPLICIT IMPLEMENTATION

BRC Criteria (Mrem/Yr)	Last BRC Surrogate Rejected	Dominant Scenario Exceeding Standard	Dominant Pathway Exceeding Standard	Dominant Radionuclide	Contribution To Dose
15	P-COTRASH, B-COTRASH, I-COTRASH, I-BIOWAST, I-ABSLIQD, N-LOTRASH N-LOWASTE	Transportation	Direct Gamma	Cs-134, Co-60, Cs-137	90%
4	Same as Above	Same as Above	Same as Above	Same as Above	Same as Above
1	Same as Above	Same as Above	Same as Above	Same as Above	Same as Above
0.1	P-CONDRSH, F-PROCESS, U-PROCESS	UF-MD, PWR-MD, MAFC-SLFI	DUST, GW, Gamma	U-238, U-234, U-235, Co-60, H-3	Over 90%

NOTES: Transportation data from RAE86d. Other pathway data from PEI86b. Scenario and pathway acronyms are detailed in PEI86b.

Under Explicit implementation, BRC candidates are rejected if (1) the CPG standard is exceeded, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect.

Table 7-10

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS *

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	N.A.
15	12.00	780	510	P-COTRASH, B-COTRASH	44
4	2.58	620	96	I-COTRASH and Above	0.38
1	0.51	540	34	N-LOTRASH, I-ABSLIQD, and Above	1.4
0.1 ***	0.04	410	1.0	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	3.7
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

* DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. See Appendix G for further detail.

Table continued on following page.

Table 7-10 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.

N.M. = Not Meaningful.

Table 7-11

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS + *

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	N.A.
15	0.22	490	1.1	P-COTRASH, B-COTRASH, I-COTRASH, I-BIOWAST, I-ABSLIQD, N-LOTRASH, N-LOWASTE	1.1
4	0.22	490	1.1	Same as Above	N.M.
1	0.22	490	1.1	Same as Above	N.M.
0.1 ***	0.04	410	1.0	F-PROCESS, P-CONDRSN, U-PROCESS, and Above	12,000
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

+ DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. See Appendix G for further detail.

Table continued on following page.

Table 7-11 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS

* Under Explicit implementation, BRC candidates are rejected if (1) the CPG standard is exceeded, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect. Different values would lead to different impacts.

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.

N.M. = Not Meaningful.

Table 7-12

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A REGIONAL BASIS *

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	N.A.
15	12.00	780	510	P-COTRASH, B-COTRASH	44
4	2.58	620	96	I-COTRASH and Above	0.38
1	0.51	540	34	N-LOTRASH, I-ABSLIQD, and Above	1.4
0.1 ***	0.04	410	1.0	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	3.7
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

NOTE: Costs represent values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

* DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. See Appendix G for further detail.

Table continued on following page.

Table 7-12 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A REGIONAL BASIS

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.

N.M. = Not Meaningful.

Table 7-13

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS + *

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated) Humid Impermeable	Humid Permeable	Arid Permeable	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	None	None	N.A.
15	12.00	560	4.2	P-COTRASH, B-COTRASH	P-COTRASH, B-COTRASH, I-COTRASH, N-LOTRASH, I-ABSLIQD, N-LOWASTE, I-BIOWAST	P-COTRASH, B-COTRASH, I-COTRASH, N-LOTRASH, I-ABSLIQD, I-BIOWAST	2.1
4	2.58	530	3.6	I-COTRASH and Above	Same as Above	Same as Above	71
1	0.51	510	3.5	I-ABSLIQD, N-LOTRASH, and Above	Same as Above	Same as Above	140
0.1 ***	0.04	410	1.0	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	P-CONDRSN, F-PROCESS, U-PROCESS, and Above	N-LOWASTE, P-CONDRSN, F-PROCESS, U-PROCESS, and Above	40
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	All BRC Candidates, Consumer Waste, and BIOMED Waste	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

Table continued on following page.

Table 7-13 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

+ DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. See Appendix G for further detail.

* Under Explicit implementation, BRC candidates are rejected if (1) the CPG standard is exceeded, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect. Different values would lead to different impacts.

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (*i.e.*, *suitable for* deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.

N.M. = Not Meaningful.

National-Implicit implementation assumptions (the implementation cases EPA deems most likely), the proposed 4 millirem standard will result in a savings of between $490 and $620 million and will cause between 1.1 and 96 additional health effects over the next 10,000 years. These results assume that a total of 759,000 cubic meters of commercial LLW (including nine wastes) and about 535,000 cubic meters of DOE LLW will be disposed of in unregulated facilities over the next 20 years.

SENSITIVITY ANALYSIS

The purpose of a sensitivity analysis is to test the relative importance of key assumptions or parameters. If results change significantly with a change in the assumption or parameter being considered, then the importance of this variable should be emphasized. This section analyzes the sensitivity of the results to changes in several key assumptions that were made when calculating the economic impacts associated with alternative BRC standards. The key assumptions or parameters that will be tested include: 1) the possibility of segregating wastes into substreams for purposes of unregulated disposal, 2) the weightings which determine what proportion of BRC waste is disposed of in the five unregulated facilities, and 3) the CPG scenario definitions, specifically, analyzing the volume of waste assumed for each CPG scenario.

Substream Segregation

With the exception of the two LLW power reactor substreams, the BRC analysis does not account for the possibility that wastes could be segregated by activity, thereby allowing a low activity substream to meet the proposed 4 millirem BRC standard. The significance of waste segregation is that current estimates of the BRC savings would be understated, as would the additional health effects associated with the unregulated disposal of substreams.

The following substream sensitivity analysis will use P-COTRASH and B-COTRASH as an example since at least one independent study [AIF85] has estimated the proportion of these wastes that, if segregated, would meet a 1 millirem BRC alternative criteria. When interpreting the results from this sensitivity analysis, two caveats should be mentioned. First, if segregation is practiced, the CPG doses calculated in the LLW analysis will be understated, since an average regulated disposal facility will be smaller and will contain waste with a higher specific activity.* Second, waste segregation presumably is not costless. Therefore, the increase in BRC savings would be offset somewhat by the cost increase associated with segregating waste into substreams. Segregation costs are not included in the analysis below, however.

A study prepared for the Atomic Industrial Forum [AIF85] suggests that 90 percent of the volume for B-COTRASH and 65 percent of the volume for P-COTRASH would be able to meet a 1 millirem per year BRC standard. If these percentages of B- and P-COTRASH volumes can be segregated costlessly, deregulation of the substreams would increase BRC savings by $164 million, but three additional health effects would result.**

In the AIF study, the estimated volumes of P-COTRASH and B-COTRASH would meet a 1 millirem alternative standard, based on some very specific assumptions. These volumes available for BRC disposal are

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* Sensitivity results shown in the LLW analysis (Chapter 8) support the notion that CPG dose is related to specific activity (curies per cubic meter) and disposal facility size.

** The estimate overstates additional health effects, since it is based on average waste activity <u>before</u> segregation. Since the specific activity of the deregulated substream will be lower on average, additional health effects would likely be less than three.

based on limiting activities associated with disposing 435 cubic meters per year of B-COTRASH and 136 cubic meters per year of P-COTRASH at a sanitary landfill located in the southeast (i.e., humid permeable region). These assumptions are equal to a total disposal volume of 8,700 and 2,720 cubic meters over 20 years, respectively, compared to 32,413 and 12,500 cubic meters as assumed by EPA (BRC CPG Scenarios 2 and 1). Therefore, the percentages estimated by the AIF study may not be consistent with the results of the BRC analysis. An approximation, based on assumptions consistent with the BRC analysis, can be made to determine the percentage of B-COTRASH and P-COTRASH volume that would meet a 1 millirem alternative standard. The methodology used in estimating these percentages involves scaling down the average specific activity of the individual waste by the ratio of the 1 millirem standard to the maximum CPG doses calculated in the BRC analysis. This calculation provides the maximum waste specific activity that will meet the 1 millirem alternative. The percentage volume of a waste that meets a 1 millirem alternative then can be determined, using the distribution of specific activity by waste volume.

The volume distribution of specific activity for B-COTRASH and P-COTRASH is reproduced from DM86 in Table 7-14. The maximum CPG doses from the BRC analysis for B-COTRASH and P-COTRASH are 500 and 21.5 millirem, respectively. Using the above methodology, these CPG doses translate into a maximum specific activity to meet a 1 millirem standard of 3.94E-5 Ci/m^3 for B-COTRASH and 2.56E-3 Ci/m^3 for P-COTRASH. As seen in Table 7-14, 70 percent or less of B-COTRASH volume and 26 percent or less of P-COTRASH volume will meet a 1 millirem standard. Therefore, the maximum BRC savings would increase by $105 million (versus $165 million using AIF85 assumptions), with 70 percent of B-COTRASH and 26 percent of P-COTRASH deregulated. About two additional health effects would result, however. At EPA's proposed 4 millirem criteria, 49 percent

Table 7-14

DISTRIBUTION OF GROSS CONCENTRATION IN LWR COMPACTABLE TRASH WASTE STREAMS

Concentration Range (Ci/m^3)	Volume Percent	Average Concentration in Range (Ci/m^3)
P-COTRASH:		
0 - 9.16E-3	26	6.29E-3
9.61E-3 - 1.93E-2	23	1.56E-2
1.93E-2 - 7.70E-2	35	6.22E-2
7.70E-2 - 1.93E-1	12	1.27E-1
over 1.93E-1	4	3.16E-1
	Weighted average:	5.40E-2
B-COTRASH:		
0 - 6.83E-3	70	4.23E-3
6.83E-3 - 1.37E-2	13	1.22E-2
1.37E-2 - 5.45E-2	11	2.95E-2
5.45E-2 - 1.37E-1	4	9.48E-2
over 1.37E-1	2	4.07E-1
	Weighted average:	1.97E-2

SOURCE: Adopted from DM86, page A-58.

or less of P-COTRASH would meet the standard and, as with the 1 millirem alternative, 70 percent or less of B-COTRASH would meet 4 millirem per year. Total BRC savings would increase by a maximum of $126 million with 2.3 additional health effects resulting.

Unregulated Disposal Option Weightings

The unregulated disposal option weightings are used to reflect the proportion of waste volume that is disposed at each of the five representative unregulated disposal facilities. (Recall that the five unregulated disposal methods include a municipal dump, suburban sanitary landfill with and without incineration, and an urban sanitary landfill with and without incineration.) If unregulated disposal is permitted for any given waste, all five unregulated disposal methods might be used by different generators. Since the population and CPG risk analyses will have different estimates for the five alternative unregulated disposal practices, weighting unregulated facilities is necessary so total cost and total risk can be calculated for unregulated disposal. BRC scenario weightings are less important in estimating disposal costs, however. Our current database on unregulated disposal costs suggests that unit costs depend more on location in the country than on whether the disposal site is located in an urban, suburban, or rural area.* In neither case is the variation in unregulated disposal cost significant, relative to the much higher cost of regulated disposal practices. Therefore, unit costs are assumed not to vary by proximity to metropolitan areas. If the waste is incinerated, however, unit costs vary slightly -- by about $1.50 per cubic meter, according to the NSWMA86 survey. Since two of the BRC disposal options involve incineration, the scenario weightings are relevant (albeit to an almost insignificant degree) in calculating unregulated costs.

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* Unregulated disposal costs are based on a survey of tipping fees for landfills, transfer stations, and resource recovery plants, conducted by the National Solid Wastes Management Association [NSWMA86] in the fall of 1985. (See Appendix C for more details.)

The weights were chosen on a subjective basis, based on our general knowledge of the location of LLW generators and the types of facilities they are likely to use. Since cost estimates will not vary significantly across the unregulated disposal options, emphasis is placed on the variation in risk estimates. If risk estimates vary significantly by the type of BRC disposal option, the need for refining these subjective weightings is of greater importance.

Determining the sensitivity of the BRC results to changes in the scenario weightings involved a methodology which considered each BRC disposal scenario separately. That is, cost-effectiveness of the 18 wastes included in the BRC analysis was calculated for each of the five disposal scenarios. (BIOMED waste is not included, since a different facility type is used to model unregulated disposal of this waste, i.e., incineration at a large university or medical facility.) Therefore, the methodology is equivalent to an extreme weighting scenario that assumes a 100 percent weight for the disposal option considered and zero percent weight for the four other options. An upper and lower bound, therefore, can be placed on the results by using this methodology.

The sensitivity analysis suggests that, while the incremental costs associated with regulation do not vary much across the five unregulated disposal practices, the avoided health effects do vary significantly. For each hydrogeologic region and each unregulated disposal option, Appendix B reports the results from the sensitivity runs; incremental costs, avoided health effects, and cost-effectiveness ratios are presented for the 18 wastes considered in the BRC analysis and for the six NARM wastes analyzed in Chapter 6. In addition, the weighted average of these five options is presented as a reference in Appendix B.

The discussion below will focus on comparing the aggregate results for the total U.S. However, one counterintuitive result is apparent in the regional tables presented in Appendix B. That is, for some wastes, three of the unregulated disposal options actually result in lower health effects than the regulated alternative. These three options are: unregulated municipal dump and unregulated suburban sanitary landfills with and without incineration. This counterintuitive result generally occurs in the arid permeable region, although, for one option -- suburban sanitary landfill with incineration -- the humid impermeable region also has greater health effects associated with regulation.

EPA believes two modelling assumptions may account for this counterintuitive result. First, in estimating health effects associated with incineration of unregulated waste, a volatilization factor is assumed whereby 90 percent of H-3 nuclides and 75 percent of C-14 nuclides are lost up the smoke stack at the incineration facility. Since current practice for regulated disposal does not involve incineration, the inventory of nuclides in the regulated disposal scenario is significantly greater than in the unregulated disposal scenario, resulting in a greater number of health effects for regulated disposal.

A second modelling assumption that may explain the counterintuitive results found in the arid permeable region, even in the without incineration case, involves the differences assumed for the surface area for regulated and unregulated disposal sites. The surface area for unregulated disposal is smaller than for regulated disposal since it is assumed that, at an unregulated site, the waste is stacked in deeper columns to reduce land requirements. Given the smaller surface area, less leaching occurs at an unregulated site during rainfall. In the humid hydrogeologic regions, enough rainfall occurs over 10,000 years to wash out all the mobile nuclides (such as C-14) from both regulated and unregulated sites. Therefore, the slower leaching rate at an unregulated site does not become a factor in the risk model. However, in the arid permeable region, EPA hypothesizes that the lower amount of rainfall results in a smaller proportion of the mobile nuclides being washed out from the unregulated site. Therefore, health effects, which are directly correlated with nuclide inventories released into the environment, may actually be lower with unregulated disposal vis-a-vis regulated disposal. Further documentation of the risk modelling assumptions is presented in EPA87.

These counterintuitive results notwithstanding, the incremental costs associated with the five BRC disposal options are very similar, varying by less than $2 million <u>in aggregate</u> over the total U.S. for the 18 wastes included in BRC analysis. The total U.S. avoided health effects of these 18 wastes, on the other hand, range from 48 effects for disposal at an unregulated suburban sanitary landfill with incineration (SI) to 776 effects for an urban sanitary landfill without incineration (UF). As a result of this wide variation in avoided health effects, the aggregate cost-effectiveness ratios also vary significantly, ranging from about $2 million per avoided health effect for UF to $39 million for SI.*

To determine if the relative weights assigned to the five unregulated disposal scenarios could have a significant effect on the economic impacts associated with the proposed 4 millirem BRC criteria, attention should be focused on the five wastes that are assumed to be cost-effective to regulate. Although aggregate cost-effectiveness ratios for all 18 wastes vary significantly, the range in the cost-effectiveness ratios associated with the five wastes assumed to be cost-effective is relatively small. These five wastes include: I-COTRASH, I-BIOWAST, I-ABSLIQD, N-LOTRASH, and N-LOWASTE. In Table 7-2, these five wastes are ranked by their relative cost-effectiveness. N-LOWASTE, with the highest cost-effectiveness ratio of the five wastes, therefore, can be considered the limiting waste, that is, the last waste worth regulating. Using the weighted average of the five BRC disposal options, the cost-effectiveness of regulating N-LOWASTE is $3 million per avoided health effect. By comparison, under the extreme weighting of 100 percent SI, the maximum cost-effectiveness associated with regulating N-LOWASTE is $12 million per avoided health effect. Therefore, under less extreme weighting scenarios, the set of wastes considered to be cost-effective to regulate is not likely to change. For illustration purposes,

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* See Appendix B, especially Tables B-13 and B-17.

however, if a $5 million value per avoided health effect is assumed, then four of the five wastes would no longer be considered cost-effective to regulate (i.e., all but I-COTRASH), assuming SI is the only unregulated disposal option considered. (See Table B-13 in Appendix B.) BRC savings would increase by $83 million, but about 11 additional health effects would occur under National-Explicit implementation at the 4 millirem proposed standard.

At the proposed 4 millirem BRC standard, inspection of Table 7-2 shows that the next most cost-effective waste to regulate (excluding BIOMED as mentioned above and P-COTRASH since its CPG dose is too high to meet 4 millirem) is I-LQSCNVL. This waste is considered to be a limiting waste, since I-LQSCNVL is next in line for regulation but was determined not to be cost-effective under the National-Explicit implementation assumption. Using weighted averages, the cost-effectiveness of regulating I-LQSCNVL is $45 million per avoided health effect. Under the extreme weighting of 100 percent UF, however, the cost-effectiveness of regulating I-LQSCNVL is as low as $17 million per avoided health effect.

The next most cost-effective waste to regulate is C-TIMEPCS, with a cost-effectiveness ratio of $23 million for UF disposal. Cost-effectiveness ratios are extremely large for other wastes; C-SMOKDET is the next most cost-effective waste to regulate, with a $375 million ratio, assuming UF disposal. Therefore, if the extreme weighting scenario of 100 percent UF is assumed and the value placed on an avoided health effect is greater than $23 million, I-LQSCNVL and C-TIMEPCS would be considered cost-effective to regulate. Under National-Explicit implementation, BRC savings at the 4 millirem standard would decrease by $456 million since the regulated disposal of C-TIMEPCS is very expensive due to collection costs. This would avoid 20 health effects, however. If only I-LQSCNVL is considered cost-effective to regulate, then BRC savings would be reduced by $25 million and health effects would be reduced by less than two.

In summary, the results of the sensitivity analysis suggest that, while the incremental costs associated with regulation do not vary much across the five unregulated disposal practices, the avoided health effects do vary significantly. Consequently, cost-effectiveness ratios can vary significantly as well. However, the economic impacts at the proposed 4 millirem BRC standard will not change under National-Explicit implementation if the valuation per avoided health effect exceeds $12 million but is less than $17 million, assuming an extreme weighting scheme of either 100 percent SI or 100 percent UF, the two limiting disposal options. For illustration purposes, however, a $3 million to $5 million valuation per avoided health effect would increase BRC savings by $83 million and result in 11 additional health effects, assuming SI is the only unregulated option considered. If a valuation of $23 million to $374 million is used, BRC savings would decrease by $456 million with 20 less health effects occurring, assuming UF is the only unregulated disposal option considered.

CPG Scenario Definition

The following sensitivity analysis evaluates the importance of the volume assumptions which were made in defining the 18 CPG disposal scenarios described in Chapter 3. These BRC disposal scenarios were constructed to estimate the maximum CPG dose from unregulated disposal by estimating the maximum LLW volume likely to be disposed in a single unregulated disposal facility. Clearly, disposal volumes would vary and the actual "worst case" disposal facility could have either more or less LLW. Therefore, the analysis below evaluates the change in the economic impacts at the proposed 4 millirem standard resulting from increasing or decreasing the assumed waste volume by a factor or two.

Again, under the National-Implicit implementation assumption, N-LOWASTE and I-ABSLIQD, among others, would meet the 4 millirem BRC standard. If waste volumes are increased by a factor of two, however, N-LOWASTE will no longer meet the standard, although I-ABSLIQD would continue to meet a 4 millirem per year limit. Net BRC savings at the proposed 4 millirem standard would fall by $35 million, but about 22 health effects would be avoided.

Under the National-Explicit implementation assumption, N-LOWASTE is considered cost-effective to regulate. Consequently, at the 4 millirem standard, BRC savings would not be affected by doubling waste volumes since population risk cost-effectiveness, rather than CPG dose, is the controlling factor. For the same reason, decreasing waste volume assumptions by a factor of two would not affect the economic impacts associated with the 4 millirem standard under National-Explicit implementation.

Decreasing CPG scenario volumes by a factor of two will not affect the economic impacts at the 4 millirem standard under the National-Implicit implementation assumption, either. Under National-Implicit implementation, I-COTRASH, with a maximum CPG dose of 12 millirem per year, will not meet the proposed standard. With a CPG dose of this magnitude, decreasing volumes by a factor of two will not be sufficient to allow I-COTRASH to meet the 4 millirem standard. Larger reductions in volume assumptions may be sufficient, however. If I-COTRASH could meet a 4 millirem standard, BRC savings would increase by $98 million, but 218 additional health effects would occur. High volume decreases would be necessary for P- and B-COTRASH to meet the 4 millirem standard, given that unregulated disposal would result in CPG doses for these two wastes of 270 and 500 millirem per year, respectively (due to transportation).

SUMMARY OF ECONOMIC IMPACTS FOR BRC STANDARDS

Table 7-15 presents the combined aggregate economic impacts, including commercial and DOE LLW, under the proposed BRC standards.

Table 7-15

AGGREGATE ECONOMIC IMPACTS OF 4 MREM STANDARD
BY IMPLEMENTATION ASSUMPTION

	BRC Savings* ($ Millions)			Additional Health Effects*		
Implementation Assumption	LLW	DOE **	TOTAL	LLW	DOE **	TOTAL
NATIONAL IMPLICIT	400	220	620	53	43	96
NATIONAL EXPLICIT ***	310	180	490	0.55	0.51	1.1
REGIONAL IMPLICIT	400	220	620	53	43	96
REGIONAL EXPLICIT ***	340	190	530	1.5	2.1	3.6

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects, and are not discounted.

* BRC savings and health effects are measured relative to current practice. Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except for P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed rule [NRC81a]) are unregulated.

** DOE impacts are calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting DOE regulated disposal costs to reflect a lower transport distance. See Appendix G for more detailed discussion. NRC and DOE implementation are also assumed to be the same in this table.

*** Under Explicit implementation, BRC candidates are rejected if (1) the CPG standard is exceeded, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect. Different values would lead to different impacts.

Under National-Explicit and National-Implicit implementation, total net savings (versus current practice) will range from $490 to $620 million, including commercial and DOE LLW. From one to 96 additional health effects might be expected. The other implementation scenarios have been included for comparison. The BRC savings of $620 million and the 96 additional health effects for Regional-Implicit implementation are identical to the economic impacts associated with National-Implicit implementation. The impacts for Regional-Explicit implementation fall within the overall range of possible impacts with BRC savings of $530 million and 3.6 additional health effects occurring.

INTRODUCTION

Presented in this chapter are the results of the analysis of alternative standards for LLW disposal. As with the analysis of alternative BRC standards, the methodology used to evaluate alternative LLW standards relies on a quantification of costs, population health effects, and CPG risks. As explained in Chapter 3, costs are expressed in present value 1985 dollars, discounted at a 10 percent real rate over the 20-year assumed disposal period; population health effects are expressed as the cumulative, undiscounted statistical total of fatal cancers and genetic effects over 10,000 years resulting from the 20-year volume of LLW. Unlike the CPG risk analysis for the BRC standard, the contributions of individual waste streams to the CPG risk from LLW disposal depend on the volume and mix of other low-level wastes present at the site. Hence, a precise analysis of the economically "optimal" disposal practice that would meet each alternative level of the standard was not possible; rather, the analysis concentrated on the determination of aggregate differences among disposal options, focusing on those options most likely to be used. Although the "optimal" disposal practice is not known with certainty due to limitations on the number of combinations that could be considered, the costs and health effects associated with the approximations presented in this analysis are not believed to differ significantly from those of the least-cost optimum.

BRC Wastes Excluded

As mentioned in Chapter 7, the analysis of regulated disposal of LLW excludes wastes that, on average, are expected to meet EPA's proposed

4 millirem BRC standard under the National-Explicit implementation assumption.* Nine currently regulated wastes are excluded from the analyses, including four fuel cycle wastes (F-COTRASH, F-NCTRASH, F-PROCESS, and U-PROCESS), two source and special nuclear material wastes (N-SSTRASH, N-SSWASTE), two commercial power reactor substreams (P-CONDRSN, L-WASTOIL), and an institutional waste (I-LQSCNVL). In addition, BIOMED waste, the two consumer wastes, and four of the six discrete NARM wastes considered in Chapter 6 are expected to remain unregulated and are not included here. Since two of the NARM wastes, R-RASOURC and R-RAIXRSN, will be regulated using TSCA authority and co-disposed with LLW, these wastes are included in the LLW analysis of alternative standards. The analysis in this chapter assumes NARM will be regulated, as would an AEA LLW under the proposed 25 millirem standard (i.e., solidified and disposed of in ISD trenches, as for Class C waste).

Calculation of DOE Impacts

The base case analysis excludes LLW generated at DOE facilities, since the limited availability of data does not allow for the separate evaluation of health risks and costs associated with the disposal of DOE waste. However, EPA expects that the LLW standard will apply to DOE waste. To approximate the potential economic impact of the LLW standard on DOE waste, EPA has assumed that DOE waste is analogous in character to commercial LLW. Using EPA's assumption, the combined economic impacts associated with alternative standards are calculated for commercial and DOE waste. In this calculation, treatment of DOE waste under current practice is assumed to be consistent with shallow land disposal, with waste in the "as generated" waste form. A more detailed description of the DOE impacts

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* The National-Explicit implementation assumption is environmentally the most conservative case since the smallest volume of waste is unregulated at 4 millirem and, in addition, results in the least amount of BRC savings.

calculation is presented in Appendix G, with the basis for EPA's assumptions.

Definition of 10 CFR 61 Disposal

Since a determination of the degree to which EPA's proposed standard and the NRC's existing performance standards are congruent is a primary objective of this analysis, it is important to characterize the set of disposal option/waste stream combinations that closely matches the NRC's 10 CFR 61 standard. To the extent that EPA's proposed standard is not congruent with 10 CFR 61, the differential impact of such a standard on the commercial sector could be significant, as is evident in the economic impacts tables presented later in this chapter. The economic impact of EPA's proposed standard on DOE waste disposal will also be calculated based on EPA assumptions discussed in Appendix G.

Based on the discussion in Chapter 5, three of EPA's 25 LLW, as well as two of the NARM wastes, were treated as Class C waste under the NRC's classification system, as assumed in EPA87. Under 10 CFR 61, these wastes would thus require solidification and disposal using the "improved" shallow land disposal method. The Class C wastes -- N-ISOPROD, L-DECONRS, N-SOURCES, R-RASOURC, R-RAIXRSN -- account for 0.9 percent of the total volume for commercial LLW and NARM (excluding DOE waste and wastes expected to meet the proposed 4 millirem BRC standard). Four wastes were deemed by EPA87 to be Class B waste -- L-IXRESIN, L-FSLUDGE, N-TRITIUM, and N-TARGETS. Under 10 CFR 61, these wastes would be solidified and disposed of using the shallow land disposal method. Class B waste accounts for 10.8 percent of total volume of commercial LLW and NARM. The remaining 11 LLW wastes were treated as

Class A waste, accounting for 88 percent of the volume. Under 10 CFR 61, Class A waste can be disposed of in the as generated waste form using the shallow land disposal method. Figure 8-1 illustrates the distribution of waste volume by hydrogeologic region and NRC classification. The allocation of States to Compacts and Compacts to hydrogeologic regions is discussed in Appendix A. The allocation of States to Compacts is necessary since waste volumes are projected on a State-by-State basis. The allocation of Compacts to hydrogeologic regions is significant since the analyses assume the same hydrogeologic characteristics are present across an entire Compact. As a result of these allocations, the volume of waste generated in a given hydrogeologic region can be estimated. Since the risk model estimates unit health effects by hydrogeologic region for each waste, total health effects can be calculated by multiplying these regional waste volumes by regional unit health effects.

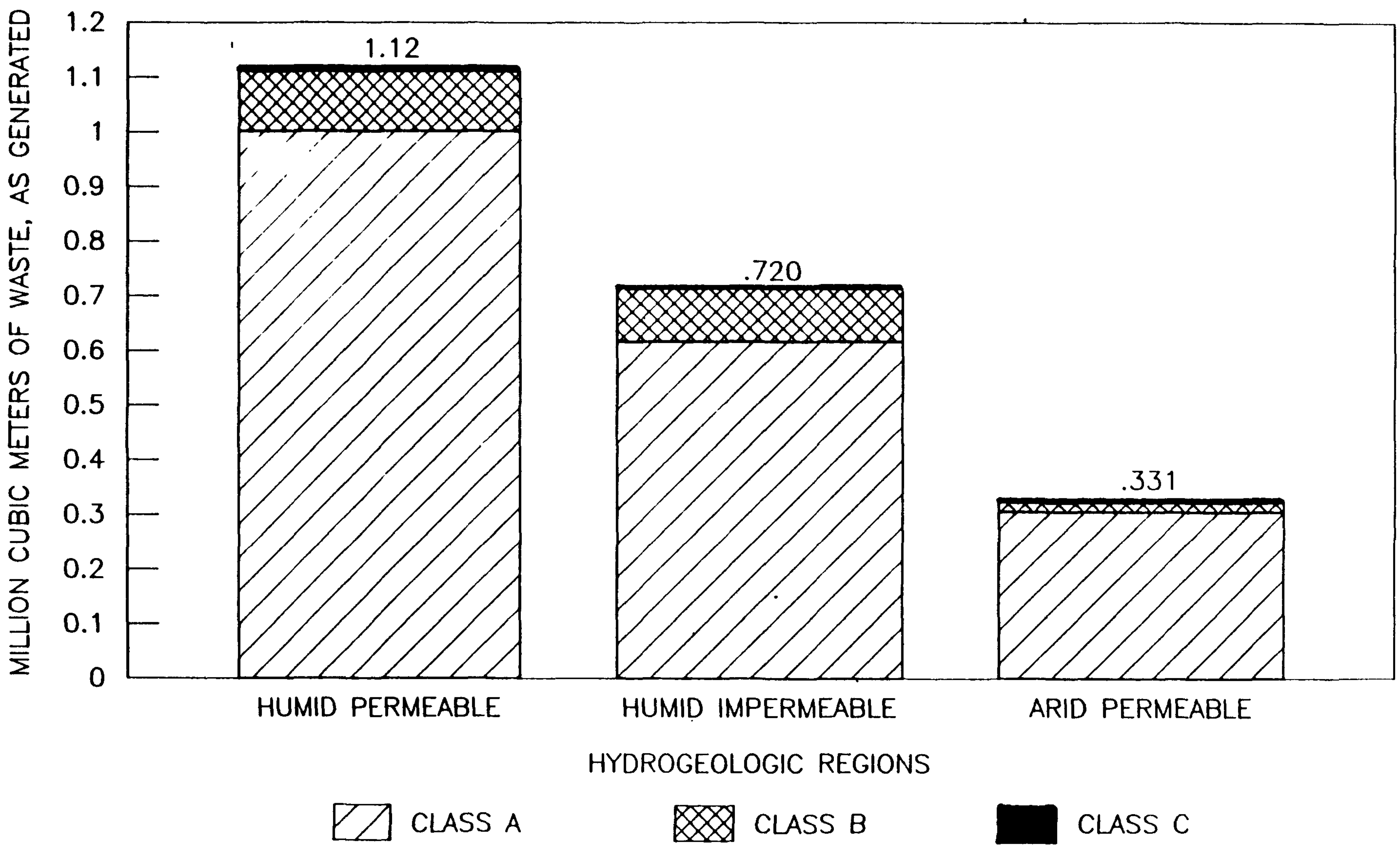
Disposal Practices Evaluated

As discussed in Chapter 3, nine regulated disposal practices have been considered for the LLW analysis -- regulated sanitary landfill (SLF), shallow land disposal (SLD), improved shallow land disposal (ISD), intermediate depth disposal (IDD), earth mounded concrete bunker (EMCB), concrete canisters (CC), deep geologic disposal (DGD), hydrofracture (HF), and deep well injection (DWI). The last two options can be used for slurried or liquid wastes only. In addition, four disposal "suboptions" relating to the waste form are considered -- packaged as generated (AG); solidified (S); incinerated, then solidified (I/S); and packaged in a high integrity container (HIC). The analysis assumes that a given disposal site may represent a combination of the above options and suboptions for each of the three NRC waste classes. In theory, 108 combinations of disposal options are possible (9 options x 4 suboptions x 3 waste classes). However, only one "option" is technically practical for HF and DWI, and only one option has been engineered to a degree sufficient for cost and risk analyses for CC and EMCB. These limitations still leave 64 potential disposal practices. Obviously, an analysis that considers all 64

Figure 8-1

WASTE VOLUME BY REGION AND CLASS

COMMERCIAL LLW-BRC+NARM; 1985-2004



possibilities would be time-consuming and expensive. Moreover, a good understanding of the effect that disposal option and waste form have on costs and health effects can be achieved by analyzing a much smaller set of disposal options. Table 8-1 summarizes the 17 disposal practices, representing a reasonable range of disposal possibilities, that are analyzed in this chapter.

Organization

This chapter is divided into three parts. In the first section, the regulated disposal costs, population health effects, and CPG risks are summarized, excluding the nine LLW wastes expected to meet the BRC standard (including the two LLW power reactor substreams) and DOE wastes. The second section then presents the evaluation of alternative LLW standards, as defined in Chapter 4. In addition to estimating the economic impacts of alternative standards associated with the disposal of commercial LLW and NARM, an approximation of the aggregate impacts when DOE waste is included in the analysis also is presented in this section. The third section discusses the sensitivity of the results with respect to assumptions regarding NRC implementation, the exclusion of NARM, discounted health effects, and the distribution of waste volumes across Compacts. Finally, changes in the assumptions used in estimating CPG, such as disposal site size, waste mix, the inclusion of BRC wastes, and the exclusion of greater-than-Class C wastes, also are evaluated.

RESULTS FROM THE ANALYSIS OF REGULATED DISPOSAL COSTS AND HEALTH EFFECTS FOR COMMERCIAL LLW AND NARM

As mentioned above, analyzing the impact of alternative LLW standards necessitates removing BRC waste since this volume of waste will not be co-disposed with other LLW. Hence, the waste remaining for regulated disposal is then both reduced in volume and increased in average activity. The remaining 18 commercial LLW wastes considered in the analysis below

Table 8-1

DISPOSAL PRACTICES FOR LLW DISPOSAL

Mnemoic	Burial Option	Packaging/Processing Suboption
1. SLF	Sanitary Landfill	As Generated
2. SLD	Shallow Land Disposal	As Generated
3. SLD1	Shallow Land Disposal	A: As Generated B: Solidified C: Solidified
4. SLD2	Shallow Land Disposal	A: Incinerated/As Generated B: Incinerated/Solidified C: Incinerated/Solidified *
5. SLD/ISD	A: Shallow Land Disposal B: Shallow Land Disposal C: Improved Shallow Land	A: As Generated B: As Generated C: As Generated
6. SLD/ISD2	A: Shallow Land Disposal B: Shallow Land Disposal C: Improved Shallow Land	A: High Integrity Container (HIC) B: High Integrity Container (HIC) C: High Integrity Container (HIC)
7. SLD/ISD3	A: Shallow Land Disposal B: Shallow Land Disposal C: Improved Shallow Land	A: As Generated B: High Integrity Container (HIC) C: Solidified
8. SLD/ISD4	A: Shallow Land Disposal B: Improved Shallow Land C: Improved Shallow Land	A: As Generated B: As Generated C: As Generated
9. SLD/ISD5	A: Shallow Land Disposal B: Shallow Land Disposal C: Improved Shallow Land	A: Incinerated/As Generated B: Incinerated/Solidified C: Incinerated/Solidified *
10. 10CFR61	A: Shallow Land Disposal B: Shallow Land Disposal C: Improved Shallow Land	A: As Generated B: Solidified C: Solidified
11. ISD	Improved Shallow Land Disposal	A: As Generated B: Solidified C: Solidified
12. IDD	Intermediate Depth Disposal	A: As Generated B: Solidified C: Solidified

Table continued on following page.

Table 8-1 (Continued)

DISPOSAL PRACTICES FOR LLW DISPOSAL

Mnemoic	Burial Option	Packaging/Processing Suboption
13. DWI	Deep Well Injection	As Generated
14. HF	Hydrofracture	As Generated
15. EMCB	A: Earth Mound B: Concrete Bunker C: Concrete Bunker	A: Solidified B: Solidified C: Solidified
16. CC	Concrete Canister	Solidified
17. DGD	Deep Geologic Disposal Existing Mine	Solidified

NOTE: A, B, and C refer to waste class under NRC 10 CFR 61 definition. For purposes of analysis, NARM is considered to be a Class C waste.

* Incinerated waste form used where possible; otherwise the indicated form was used, with the exception of NARM wastes whose form was "as is" if not incinerated.

September 1987

will comprise about 2.2 million cubic meters of the total amount of LLW estimated to be generated over the next 20 years; the two NARM wastes that constitute the bulk of that which EPA is proposing to regulate will make up about 6,600 cubic meters of waste over the same 20-year period.* The regional distribution of LLW involves 720,000 cubic meters being generated in the humid impermeable region, 1,120,000 cubic meters being generated in the humid permeable region, and 330,000 cubic meters being generated in the arid permeable region. Figure 8-2 illustrates the distribution of this waste by Compact.** Two of the Compacts, the Southeast and Northeast, will generate 48 percent of the waste.

In total, the 2.2 million cubic meters of commercial LLW and NARM are projected to contain about 13 million curies of activity.*** Five wastes account for more than 88 percent of the activity -- L-NFRCOMP, L-IXRESIN, N-TRITIUM, L-FSLUDGE, and N-ISOPROD. Nine wastes account for less than one percent of the activity. Figure 8-3 presents the distribution of activity by waste stream and radionuclide. Although one nuclide, Fe-55, accounts for 31 percent of the curies, it produces very few

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* The 6,600 cubic meters for NARM assumes an as generated volume of 0.445 cubic meters for R-RASOURC, which reflects the small volume of the bare sources. Based on limitations on the maximum activity per drum, R-RASOURC is projected to have a 20-year as disposed volume of 1,297 cubic meters. See Appendix C for a derivation of this volume.

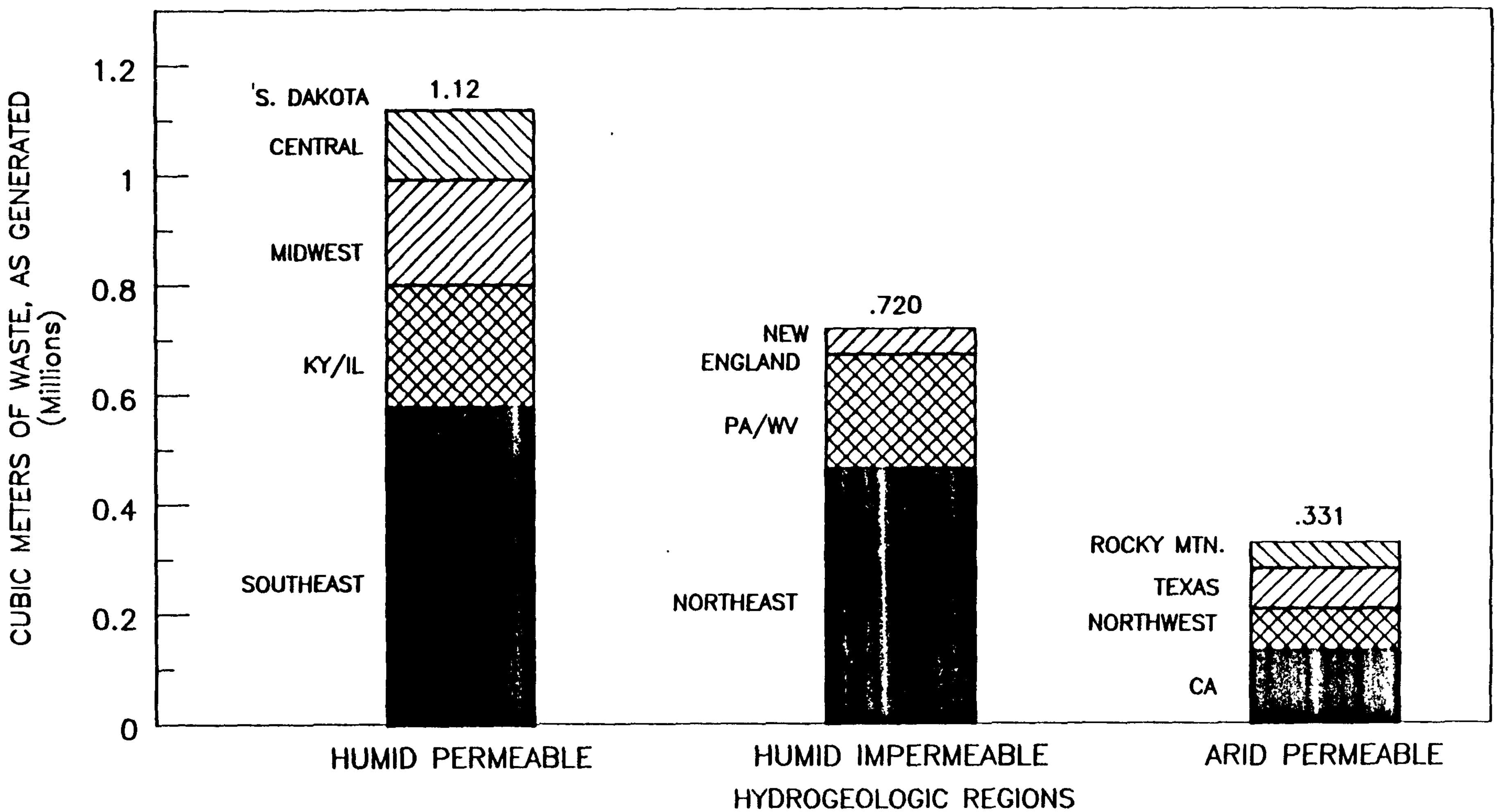
** As noted above and in Chapter 5, estimation of economic impacts requires that disposal volumes be assigned to hydrogeologic regions. For purposes of analysis, this involved two steps: assigning States to Compacts, and assigning Compacts to regions. In assigning States to Compacts, some judgment by EPA was required, since the current disposition of all States has not been decided. Some Compacts have not been ratified. In addition, some States have not signed any existing Compact agreements. The assignment of Compacts to hydrogeologic regions also involved some judgment by EPA. A sensitivity analysis evaluates the effect of reallocating some of the Compacts to different hydrogeologic regions, however.

** Measures of activity refer to the 40 long-lived nuclides included in EPA's risk assessment.

Figure 8-2

WASTE VOLUME BY REGION AND COMPACT

COMMERCIAL LLW-BRC+NARM;1985-2004



STATES IN EACH COMPACT:

SOUTHEAST: AL, FL, GA, MS, NC, SC, TN, VA
NORTHWEST: AK, HI, ID, MT, OR, UT, WA, WY
ROCKY MOUNTAIN: AZ, CO, NV, NM, UT, WY
MIDWEST: IA, OH, MI, MN, MO, IN, WI

NORTHEAST: CT, DE, DC, MA, MD, NJ, NY, RI
CENTRAL: AR, IA, KS, LA, MN, MO, NE, ND, OK
NEW ENGLAND: ME, VT, NH

Note: See Appendix A for allocation of states to co[illegible]ts

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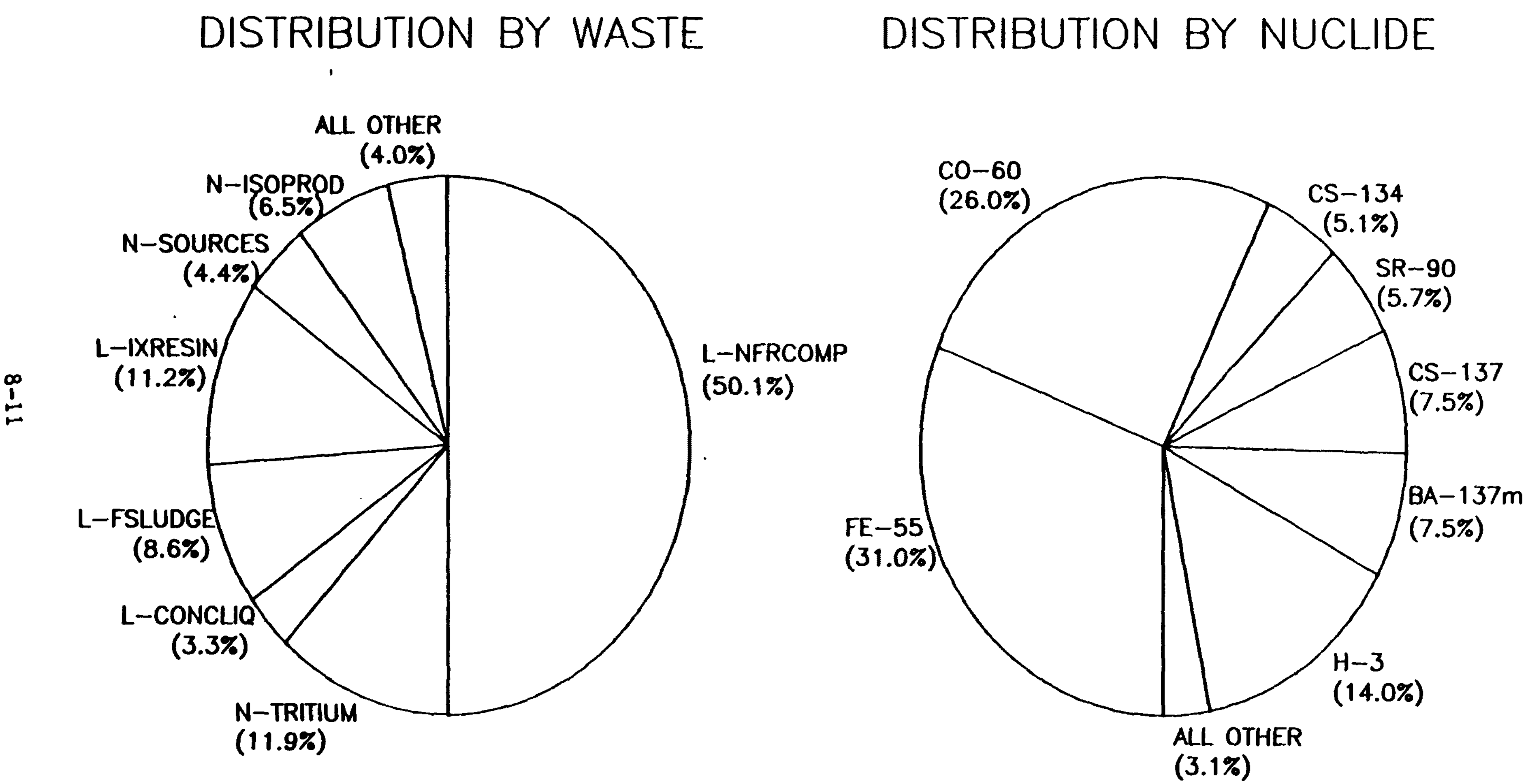
Figure 8-3

DISTRIBUTION OF TOTAL WASTE ACTIVITY



Includes 40 nuclides included in EPA risk assessment, for commercial LLW and NARM generated in 1985-2004. Excludes wastes expected to meet the BRC standard.

of the health effects since Fe-55 is relatively immobile and has a half-life of only 2.6 years. Conversely, six "significant" nuclides -- tritium (H-3), carbon-14 (C-14), iodine-129 (I-129), cesium-137 (Cs-137), cobalt-60 (Co-60), and radium-226 (Ra-226) -- comprise 47.5 percent of the curies (these nuclides are responsible for the majority of population health effects and CPG risk). However, C-14, I-129, and Ra-226 contain less than 0.1 percent of the activity. These nuclides nevertheless account for a significant portion of population health effects and CPG risk since C-14, I-129, and Ra-226 are highly mobile nuclides with long half-lives.

The following discussion focuses on characterizing the absolute costs and health risks associated with the 17 disposal practices considered in the analysis. The absolute measures associated with each disposal method then are used to calculate the incremental costs and avoided population health effects relative to the base case (defined as current practice, i.e., 10 CFR 61 disposal for commercial LLW). The marginal cost-effectiveness associated with moving from one disposal practice to another then is calculated for purposes of determining the set of economically "efficient" disposal methods (in terms of least-cost compliance or with respect to the cost-effectiveness of avoiding population health effects). From this set of disposal methods, the most efficient disposal method that will meet a given LLW alternative standard is determined.

Results of Costs Analysis

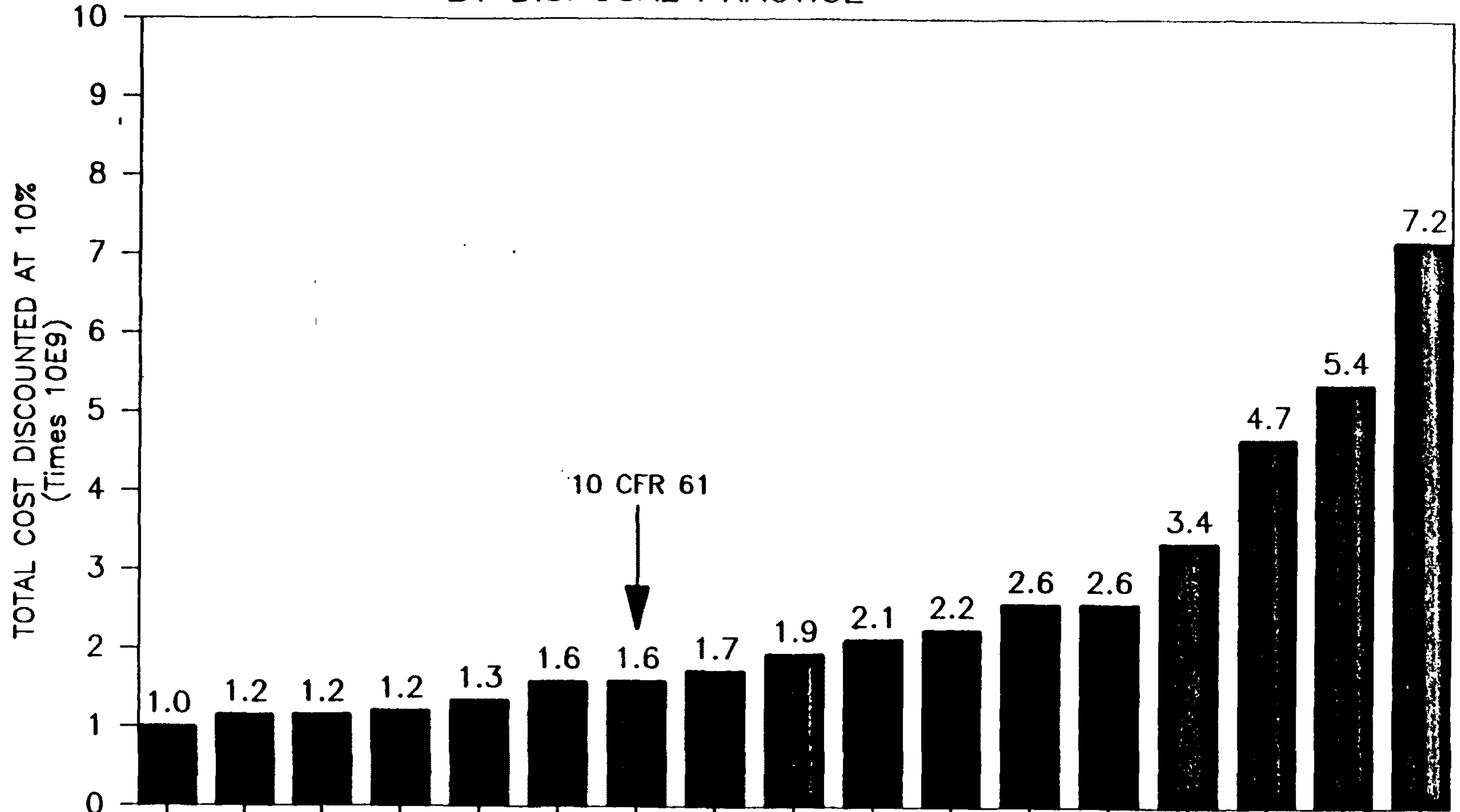
For the 17 disposal methods considered, the disposal of commercial LLW and NARM could cost from $1 billion, for waste disposed of at a regulated sanitary landfill in the as generated waste form, to over $8 billion, for deep geologic disposal in a shale repository containing the solidified waste. Figure 8-4 presents the variation in disposal costs among all 17 disposal methods.

These disposal costs include four components: packaging, processing, transportation, and disposal technology. Figure 8-5 illustrates the relative

Figure 8–4

VARIATION IN TOTAL DISPOSAL COST

BY DISPOSAL PRACTICE



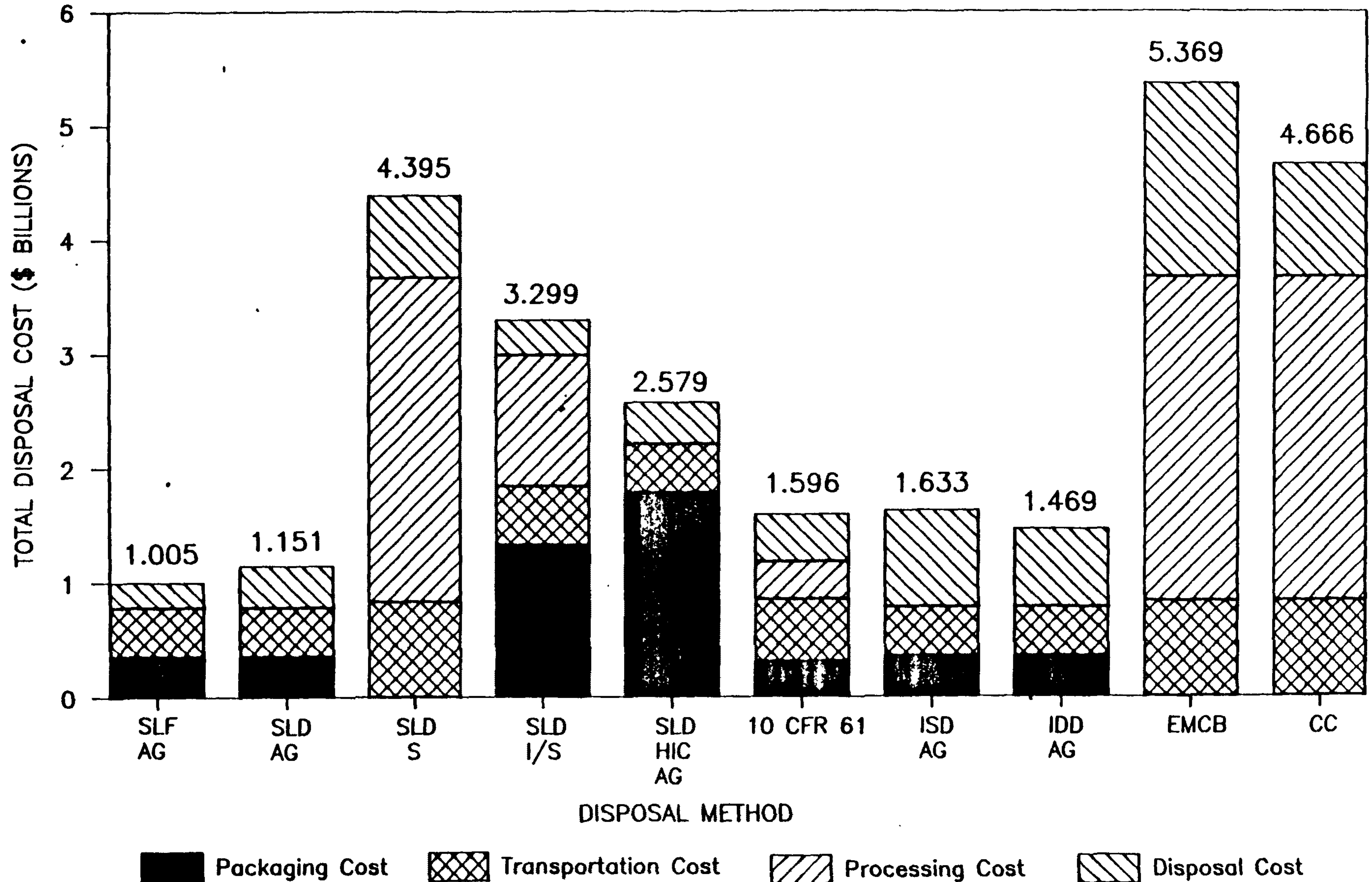
Disposal Option:	Class A	SLF	SLD	SLD	SLD	SLD	SLD	SLD	HF	IDD	ISD	DWI	SLD	SLD	SLD	CC	EM	DGD
	Class B	SLF	SLD	SLD	ISD	SLD	SLD	SLD	HF	IDD	ISD	DWI	SLD	SLD	SLD	CC	CB	DGD
	Class C, NARM	SLF	SLD	ISD	ISD	ISD	SLD	ISD	HF	IDD	ISD	DWI	SLD	ISD	ISD	CC	CB	DGD
Waste Form:	Class A	AG	AG	AG	AG	AG	AG	AG	AG	AG	AG	AG	I/AG	I/AG	HIC	S	S	S
	Class B	AG	AG	AG	AG	HIC	S	S	AG	S	S	AG	I/S	I/S	HIC	S	S	S
	Class C, NARM	AG	AG	AG	AG	S	S	S	AG	S	S	AG	I/S	I/S	HIC	S	S	S

September 1987

Figure 8-5

COST COMPONENTS

BY DISPOSAL METHOD



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importance of each cost component for 10 disposal methods, assuming all classes of waste are treated the same. Packaging costs are included in processing costs if the waste is solidified. Using shallow land disposal, as generated (SLD, AG) for comparison, note that packaging, transportation, and disposal technology costs account for roughly equal proportions of total cost. Relative to this option, solidification (included in processing costs) accounts for the bulk of the cost difference among disposal options.

Since unit costs for transportation and packaging vary by waste,* and considering the differences in waste volume, the contribution to total cost by waste varies significantly. For 10 CFR 61 disposal, seven wastes account for 77 percent of total cost -- L-NCTRASH, L-CONCLIQ, B-COTRASH, L-FSLUDGE, I-COTRASH, P-COTRASH, and L-IXRESIN. Figure 8-6 illustrates the relative contribution of these wastes to the total cost of 10 CFR 61 disposal.

Results of Population Health Effects Analysis

Having characterized the costs associated with the 17 disposal practices considered in the analysis of alternative LLW standards, the discussion now turns to characterization of health effects. Disposal of the 20-year volume of commercial LLW and NARM could result in population health effects ranging from about seven effects for disposal of solidified waste in concrete canisters (CCs) up to 187 health effects for disposal of waste as generated in a regulated sanitary landfill (SLF, AG). Figure 8-7 illustrates the variation in total population health effects among disposal methods for all 17 methods. Most of the risk reduction benefit of more stringent disposal is gained during the first 1,000 years, due to longer site integrity (i.e., time to cap failure) and the slower transport of nuclides resulting from solidification. Figure 8-8 demonstrates the variation in population risk over time for selected disposal practices.

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* Transportation and packaging costs vary by waste due, in part, to the variation in activity among wastes. See Appendix C for a more detailed discussion of these cost components.

Figure 8-6

CONTRIBUTION TO TOTAL COST BY WASTE

10 CFR 61

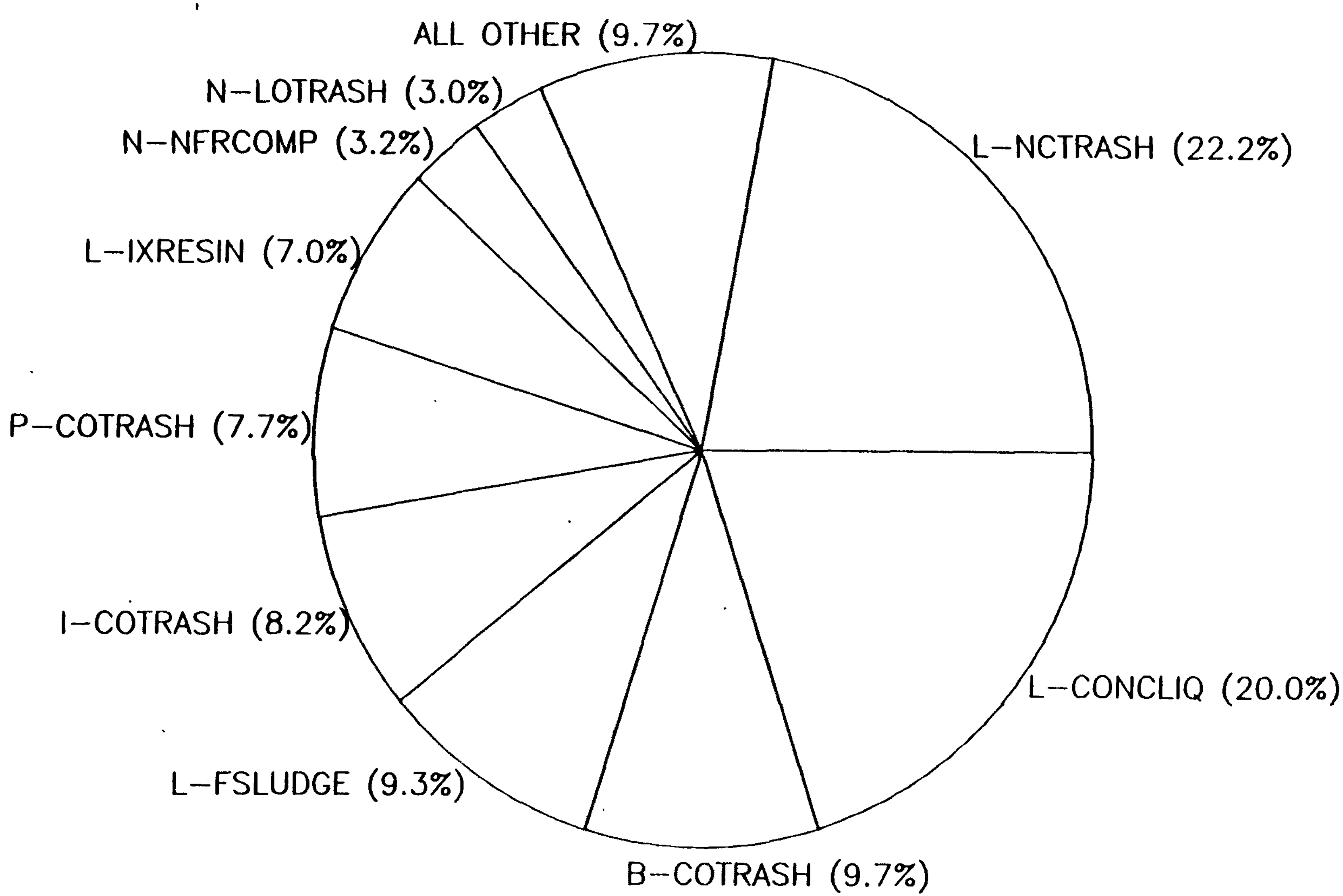
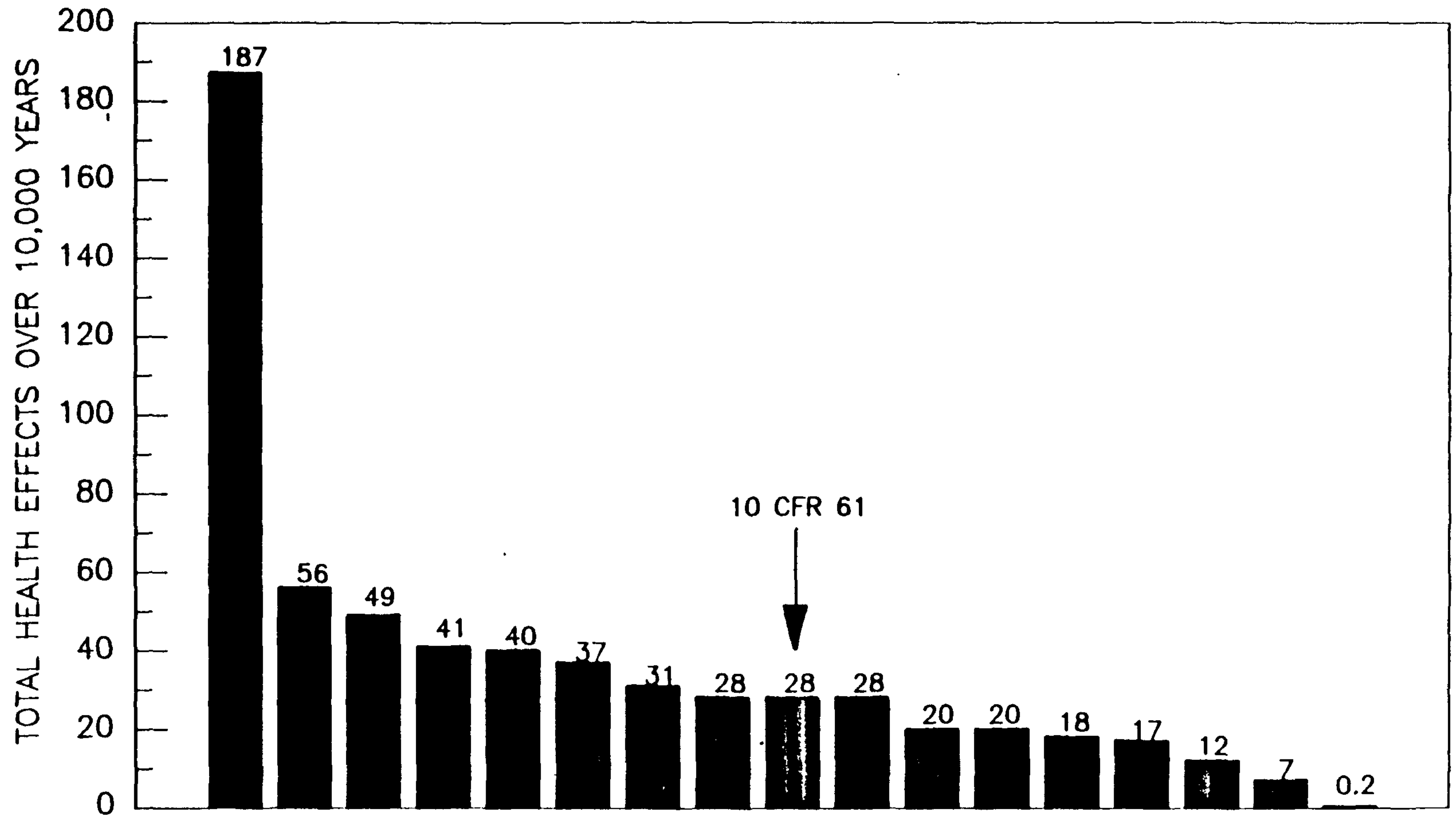


Figure 8-7

VARIATION IN POPULATION HEALTH EFFECTS
BY DISPOSAL PRACTICE

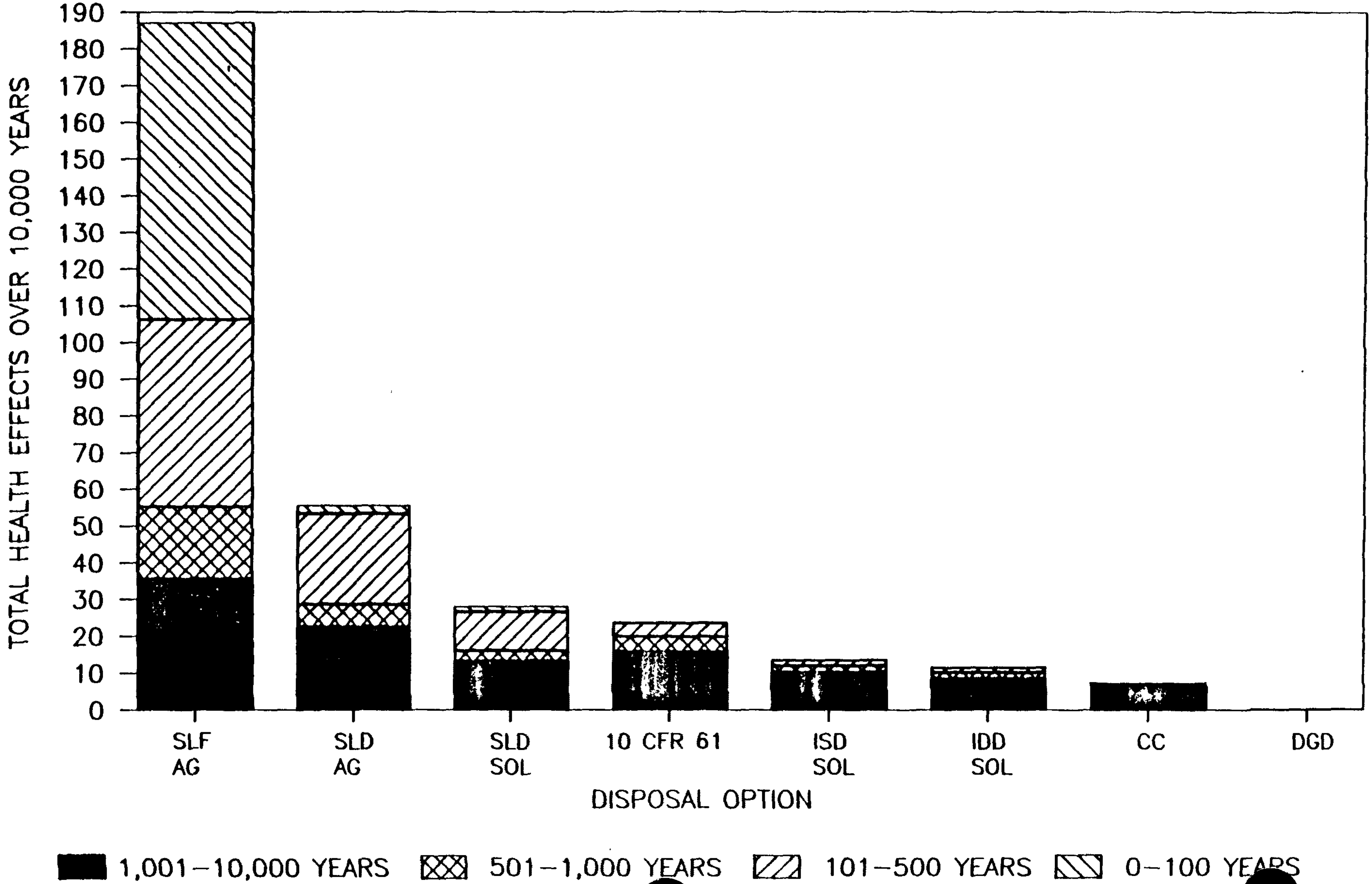


Disposal Option:	Class A	SLF	SLD	SLD	SLD	SLD	SLD	SLD	SLD	SLD	DWI	ISD	HF	IDD	SLD	EM	CC	DGD
	Class B	SLF	SLD	SLD	SLD	SLD	ISD	SLD	SLD	SLD	DWI	ISD	HF	IDD	SLD	CB	CC	DGD
	Class C, NARM	SLF	SLD	ISD	ISD	ISD	ISD	SLD	SLD	ISD	DWI	ISD	HF	IDD	ISD	CB	CC	DGD
Waste Form:	Class A	AG	AG	HIC	AG	AG	AG	I/AG	AG	AG	AG	AG	AG	AG	I/AG	S	S	S
	Class B	AG	AG	HIC	AG	HIC	AG	I/S	S	S	AG	S	AG	S	I/S	S	S	S
	Class C, NARM	AG	AG	HIC	AG	S	AG	I/S	S	S	AG	S	AG	S	I/S	S	S	S

Figure 8-8

VARIATION IN POPULATION HEALTH EFFECTS

BY TIME AND DISPOSAL OPTION



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Disposal consistent with 10 CFR 61 regulations is expected to result in about 28 health effects over 10,000 years. Of this total, fatal cancers account for about 25 health effects or 89 percent of the total. As with other disposal options, the contribution to total risk varies strongly by waste for 10 CFR 61 disposal, as demonstrated in Table 8-2. Class A waste comprises over 15 health effects, which is not surprising since this waste class represents 88 percent of the total volume. Class B waste, on the other hand, represents only 10.8 percent of waste volume but accounts for almost half of the total health effects. Class C and NARM waste contribute an insignificant amount of the total, due to the more stringent treatment of this waste.* For 10 CFR 61 disposal, six wastes account for 70 percent of the population health effects: I-COTRASH, N-TRITIUM, L-IXRESIN, L-CONCLIQ, L-NFRCOMP, and N-LOTRASH. Note that the dominant contributors to cost and population health effects are not the same. Figure 8-9 shows the contribution to total health effects by waste for 10 CFR 61 disposal.

The regional contribution to total health effects also is demonstrated in Table 8-2. Under 10 CFR 61 disposal, the regional contribution of health effects is roughly proportional to the regional volumes. The humid permeable region represents 52 percent of the total commercial and NARM volume and 47.6 percent of the health effects; the humid impermeable region represents 33 percent of total U.S. volume and 38.5 percent of the health effects; the arid permeable region represents 15 percent of volume and 13.9 percent of health effects under 10 CFR 61 disposal. This proportionality of volumes to health effects should not be construed to suggest that hydrogeology does not play a role in estimating health effects, however. Due to a higher percentage volume of lower activity waste in the humid permeable region, the role of hydrogeology is masked somewhat. Under 10 CFR 61 disposal, if the same distribution of waste volume is assumed in each hydrogeologic region, twice as many health effects would occur in the

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* For conventional shallow land disposal as generated, these wastes account for 39 percent of the population health effects, however.

Table 8-2

CONTRIBUTION TO TOTAL POPULATION HEALTH EFFECTS
BY CLASS OF WASTE AND HYDROGEOLOGIC REGION
FOR 10 CFR 61 DISPOSAL

Total Health Effects

Waste Class	Humid Permeable Region	Humid Impermeable Region	Arid Permeable Region	U.S. Total
Class A	8.6	3.9	3.2	15
Class B	4.7	7.3	0.72	13
Class C	0.0084	0.0011	0.0012	0.0107
NARM	0.16	0.0006	0.0069	0.16
TOTAL	13	11	4	28

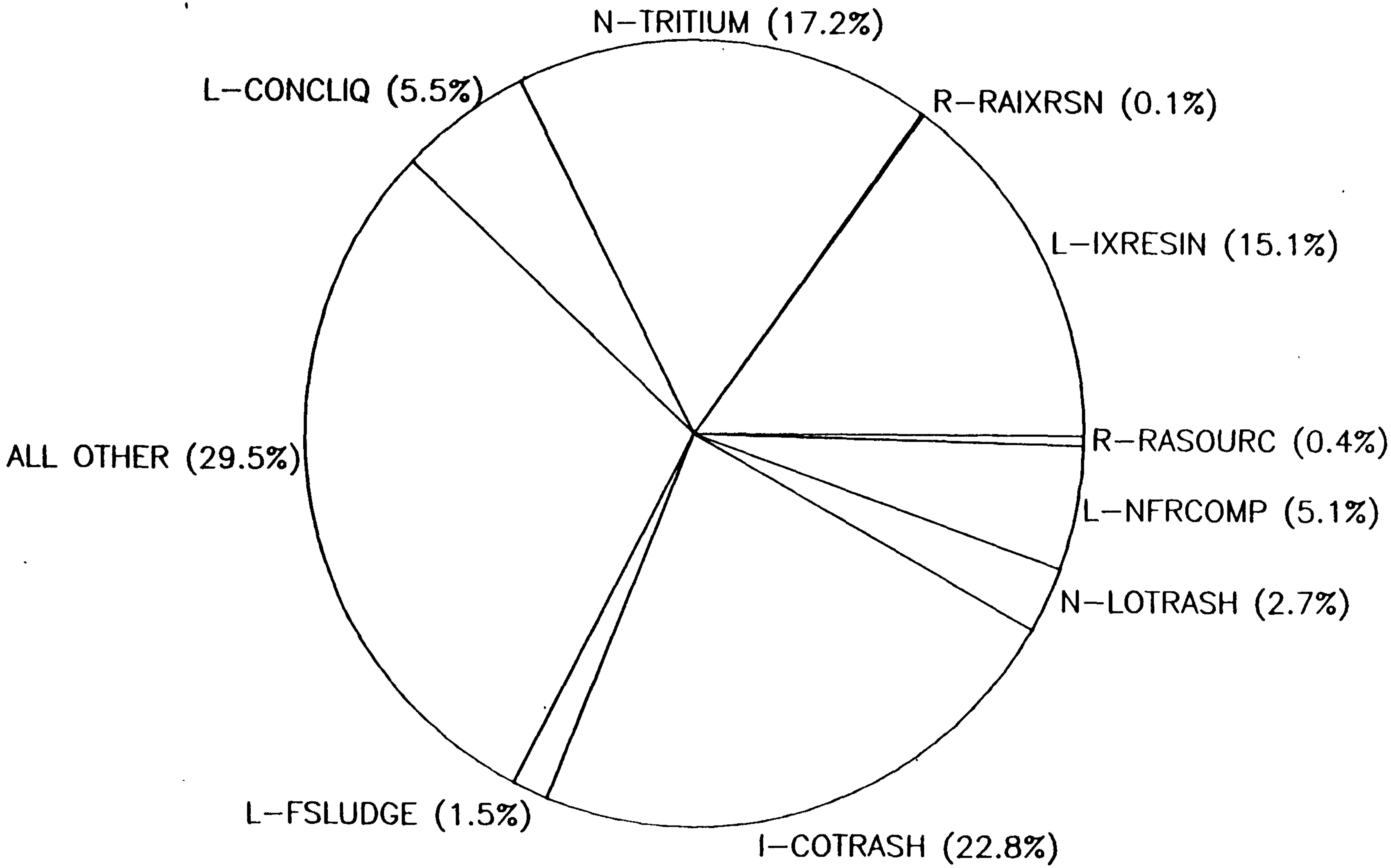
NOTE: Health effects include fatal cancers and genetic effects over 10,000 years and are not discounted. Includes commercial LLW and NARM only, excluding DOE waste and wastes expected to meet the 4 mrem BRC standard. See Appendix F for a summary of the contribution to total population health effects, by class of waste and hydrogeologic region, for all 17 disposal methods.

September 1987

Figure 8-9

CONTRIBUTION TO TOTAL POPULATION HEALTH EFFECTS BY WASTE

10 CFR 61



humid permeable region as in the other two regions; an equal number of health effects would occur in the arid permeable and humid impermeable region.

Results of the CPG Dose Analysis

The final area of analysis that is relevant to the evaluation of economic impacts for alternative LLW standards involves the CPG risk results.* Unlike the population health effects analysis, CPG risk depends on the waste mix and site volume, as well as disposal option and waste form. Our analysis employs standard assumptions for mix and volume (i.e., U.S. average mix for commercial LLW and NARM and a 250,000 cubic meter disposal site) and evaluates the 17 disposal practices.

The modelling results indicate that CPG risks depend strongly on hydrogeologic region. Table 8-3 summarizes this information. The highest CPG doses for all disposal scenarios occurred in the humid permeable region. CPG dose ranges from 82 millirem per year in the humid permeable region (Class A -- SLD, AG; Class B -- SLD, HIC; Class C and NARM -- ISD, S) to essentially zero in the arid permeable region (concrete canister, solidified). Disposal consistent with 10 CFR 61 results in an annual CPG dose of 9.2 millirem per year in the humid permeable region, 0.03 millirem in the humid impermeable, and 0.0009 millirem in the arid permeable region. These results highlight the importance of hydrogeology in meeting the LLW standard. If humid impermeable sites can be found in the generally humid permeable region, for example, compliance with EPA's LLW standard could be accomplished through resiting, rather than employing a more stringent disposal option. In the sensitivity analysis section of this chapter, economic impacts are estimated under the assumption that the hydrogeologic characteristics of the humid impermeable region might be found in the humid

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* Similar to the BRC analysis in Chapter 7, this discussion considers CPG dose only. However, since dose and risk are related by a constant factor [MEY86a], the discussion applies to CPG dose as well.

Table 8-3

MAXIMUM CPG DOSES FOR 17 LLW DISPOSAL PRACTICES
BY HYDROGEOLOGIC REGION

	Burial Option			Packaging/Processing Suboption			Maximum CPG Dose By Region (millirem per year)			
Mnemonic	Class A	Class B	Class C	Class A	Class B	Class C	Humid Impermeable	Humid Permeable	Arid Permeable	Maximum U.S.
SLD/ISD3	SLD	SLD	ISD	As Is	HIC	SOL	0.12	82	0.0039	82
SLF	SLF	SLF	SLF	As Is	As Is	As Is	0.77	62	0.41	62
SLD/ISD4	SLD	ISD	ISD	As Is	As Is	As Is	0.048	44	0.0014	44
SLD/ISD2	SLD	SLD	ISD	HIC	HIC	HIC	0.13	40	0.0019	40
SLD/ISD	SLD	SLD	ISD	As Is	As Is	As Is	0.12	35	0.0022	35
SLD	SLD	SLD	SLD	As Is	As Is	As Is	0.13	35	0.0022	35
SLD/ISD5	SLD	SLD	SLD	Incin/As Is*	Incin/SOL*	Incin/SOL*	0.025	13	0.0003	13
SLD2	SLD	SLD	ISD	Incin/As Is*	Incin/SOL*	Incin/SOL*	0.030	13	0.0003	13
10 CFR 61	SLD	SLD	ISD	As Is	SOL	SOL	0.030	9.2	0.0009	9.2
SLD1	SLD	SLD	SLD	As Is	SOL	SOL	0.030	9.1	0.0009	9.1
DWI	DWI	DWI	DWI	As Is	As Is	As Is	7.3	7.3	7.3	7.3
ISD	ISD	ISD	ISD	As Is	SOL	SOL	0.012	5.1	4.4E-05	5.1
IDD	IDD	IDD	IDD	As Is	SOL	SOL	0.0093	5.0	3.7E-05	5.0
EMCB	EM	CB	CB	GR (SOL)	SOL	SOL	0.0019	2.0	3.1E-06	2.0
CC	CC	CC	CC	SOL	SOL	SOL	0.0014	1.3	0.0	1.3
HF	HF	HF	HF	As Is	As Is	As Is	1.70E-04	1.70E-04	1.7E-04	0.0
DGD	DGD	DGD	DGD	SOL	SOL	SOL	0.0	0.0	0.0	0.0

NOTE: CPG doses are based on RAE86c and RAE86e. CPG doses reflect the U.S. average waste mix and the reference site volume equal to 250,000 cubic meters of waste as generated, except HF and DWI. All estimates are based on commercial LLW and NARM waste streams excluding seven BRC wastes. Disposal practices are sorted from high to low U.S. maximum CPG dose.

permeable region. Given the uncertainty of the availability of such sites, however, base case economic impacts are calculated under the conservative assumption that more favorable site characteristics are not available in the humid permeable region.

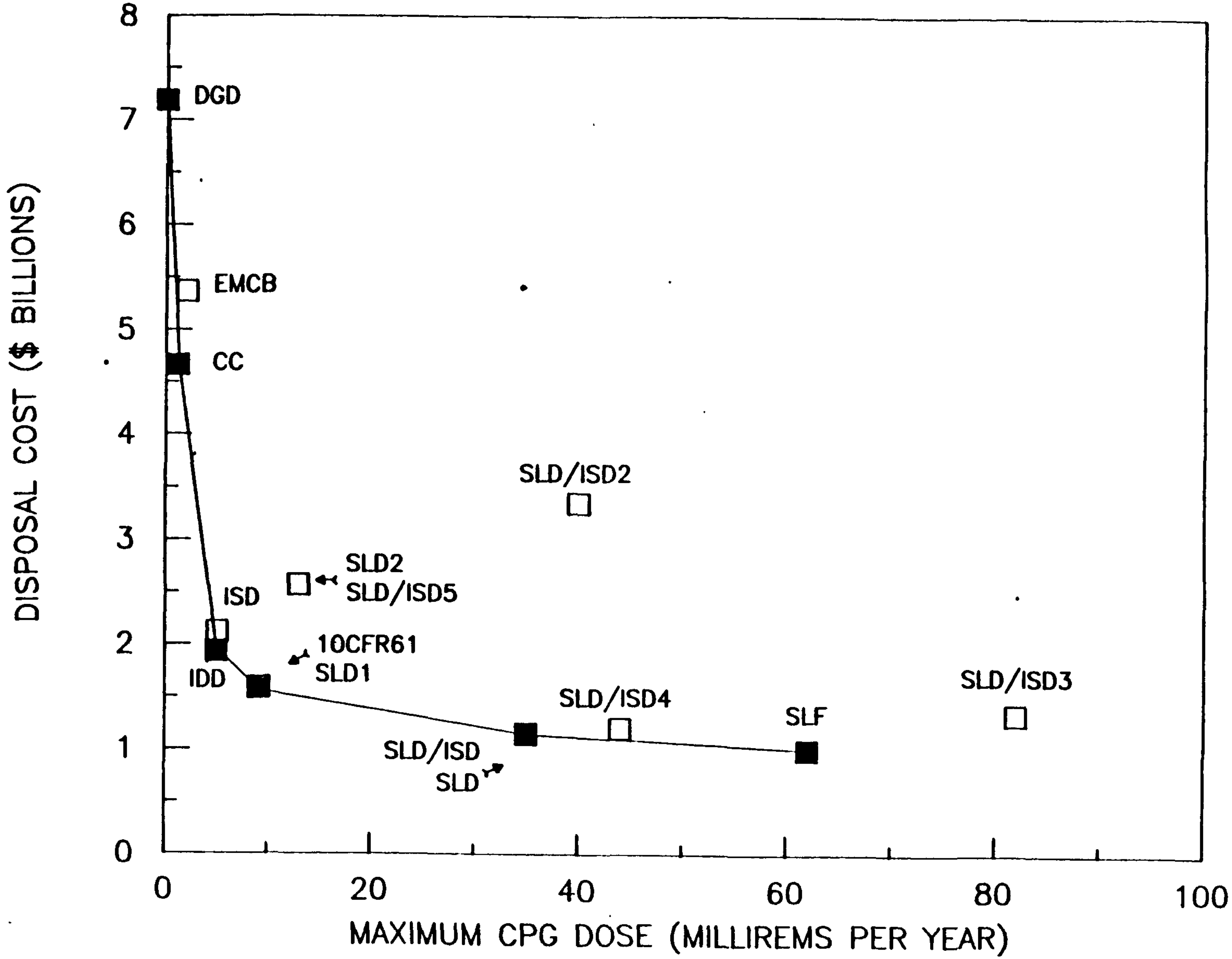
In general, disposal practices with higher costs are expected to lead to lower CPG doses. However, the risk modelling did not always confirm this expectation. The clearly unattractive disposal practices (i.e., for which another practice has both lower cost and lower CPG dose) vary by region. However, four disposal practices produced unexpected (i.e., more expensive but less protective) results in all three regions: the two practices using high integrity containers (HICs), earth mounded concrete bunkers, and improved shallow land disposal. (See Figure 8-10.) The explanation of these counterintuitive results and EPA's risk modelling assumptions are described in EPA87.

Figure 8-10 presents a plot of total disposal costs and CPG doses for 15 of the 17 disposal methods considered in the analysis. (Hydrofracture and deep well injection are excluded since only a subset of the wastes considered in the LLW analysis were included for these two technologies when running the computer model that estimates CPG risk. Recall that these two technologies apply only to the disposal of liquid wastes.) The curve drawn in the figure highlights the set of least-cost disposal options that would meet alternative CPG dose limits. Least-cost disposal options are relevant since, under the implicit implementation assumption (i.e., where population risk cost-effectiveness is not a consideration), compliance with EPA's proposed CPG dose standard presumably will be accomplished by a commercial disposal facility at the lowest possible cost. In Figure 8-10, the "least-cost compliance curve" indicates that 10 CFR 61 disposal (current practice) is almost identical in cost and risk to the least-cost option that would meet the proposed 25 millirem standard.

Figure 8-10

MAXIMUM CPG DOSE VERSUS DISPOSAL COST

BY DISPOSAL OPTION



ECONOMIC IMPACT OF ALTERNATIVE STANDARDS

Interpretation of Cost-Effectiveness Ratios

In general, more costly disposal options are expected to result in fewer health effects. The cost-effectiveness ratio provides a relative measure of the value of more costly disposal and is defined as the ratio of incremental costs to avoided health effects. In our analysis, incremental costs and avoided health effects are calculated by comparing any two disposal options (A and B); consequently, a mathematical formulation of this is:

$$\text{Cost-Effectiveness Ratio} = \frac{\text{Cost (A)} - \text{Cost (B)}}{\text{H.E. (B)} - \text{H.E. (A)}} = \text{Cost/Avoided H.E.}$$

In this analysis, the average cost-effectiveness is calculated by comparing the costs and risks of any particular option to the base case of 10 CFR 61 disposal. Therefore, average cost-effectiveness measures the value of the disposal option under consideration relative to the base case. By comparison, the marginal cost-effectiveness measures the value of a given disposal option relative to another disposal option (i.e., not necessarily the base case). The marginal cost-effectiveness is also used in the economic evaluation of alternative standards to compare each standard with higher or lower alternatives.

The base case implementation scenario used in the LLW analysis of alternative standards assumes NRC will implement the standard on a national, rather than regional, basis, without explicit consideration of the population risk cost-effectiveness (i.e., National-Implicit implementation). Another consideration in estimating the economic impacts associated with alternative standards concerns whether current disposal practice would be relaxed in the event that a higher standard is chosen. The analysis considers five discrete alternative standards -- 125 millirem per year, 75 millirem, 25 millirem, 10 millirem, and 4 millirem. At higher standards, a less stringent disposal option (in comparison to current practice) would be sufficient to meet the standard. Since EPA is proposing a 25 millirem standard, our analysis does not necessarily imply that less costly disposal will be used to meet a higher millirem standard. However, since these less costly disposal options are true economic alternatives to the status quo, the opportunity that society forgoes by choosing to employ more stringent disposal technology is represented by the incremental cost and avoided health effects associated with the less stringent disposal. Thus, in estimating economic impacts, the least-cost method of compliance is assumed for all alternatives, including those which are less restrictive than current practice.

Table 8-4 presents the economic impacts associated with the disposal of commercial and NARM waste under the National-Implicit implementation (the base case implementation assumption). Incremental costs and avoided health effects are measured relative to current practice, i.e., 10 CFR 61 disposal. Costs, in 1985 dollars, are incurred annually from 1985 to 2004 and discounted to 1985 at a 10 percent rate. Health effects, statistical fatal cancers and genetic effects, occur over 10,000 years, beginning in 2008. As mentioned previously, costs and health effects exclude all unregulated wastes (including nine commercial wastes expected to meet the BRC standard) and DOE waste.

The regulated disposal practices that meet each alternative standard at least cost are also shown in Table 8-4. Given the uncertainty associated with applying to actual disposal sites the results from the CPG risk model (which is based on a characterization of a "generic" disposal site), EPA has increased the predicted maximum CPG dose by a factor of two for purposes of determining whether a given disposal method would meet an alternative LLW standard, an environmentally conservative assumption.* This factor of

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* This factor was not used in the BRC analysis since environmentally conservative assumptions were already built into the analysis through the specification of "worst case" BRC disposal scenarios.

Table 8-4

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS

LLW Standard Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose Doubled ** (Mrem/Yr)	Incremental Cost vs. Current Practice * ($ Millions)	Avoided Health Effects vs. Current Practice *	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect)	Required Disposal Practice
125	62	124	(590)	(160)		Shallow Landfill, As Is
					1.1	
75	35	70	(450)	(28)		Shallow Land Disposal, As Is
25*	9.2	18.4	0	0	16	10 CFR 61 Disposal
25	9.1	18.2	(9.1)	(0.12)		Shallow Land Dispos[illegible] Class A: As Is; Class B, C, & NAR[illegible] Solidified
					33	
10	5	10	340	10		Intermediate Depth Disposal (A: As Is; B, C, & NARM SOL)
					250	
4	1.3	2.6	3,100	21		Concrete Canister

NOTE: Costs represent present values at a 10 percent discount rate (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Costs and health effects are for commercial LLW and NARM waste only, excluding DOE wastes and wastes expected to meet the BRC standard.

* Current practice is assumed to be consistent with 10 CFR 61 disposal for all commercial LLW. Current practice for NARM waste is ISD solidified.

** An environmentally conservative assumption which refle[illegible]A concerns over whether or not an actual disposal s[illegible]ll meet an alternative standard given the uncertainty surrounding t[illegible]eric modelling used in estimating the maximum CPG dose.

two is not inconsistent with the results of the sensitivity analysis presented later in this chapter, which explores the effect of changing some modelling parameters such as site size, waste mix, the exclusion of NARM, and the inclusion of BRC wastes.

At EPA's proposed 25 millirem annual exposure standard, the economic impacts associated with the least-cost option are fairly small -- $9 million in savings with little impact on health effects. From a practical standpoint, it is not within the resolving power of our analysis to distinguish between the least-cost option at a 25 millirem annual exposure standard and 10 CFR 61 disposal. Moreover, a deviation from current practice is probably unlikely at a 25 millirem annual exposure standard. Therefore, the economic impacts on commercial and NARM waste generators would be nonexistent by definition (compared to current practice) at the proposed 25 millirem standard.*

The last column of Table 8-4 shows the marginal cost-effectiveness associated with moving from a higher to a lower standard. For example, moving from a 100 millirem standard to a 50 millirem standard would require shallow land disposal, as generated (SLD, AG) rather than a regulated sanitary landfill, as generated (SLF, AG). The marginal cost-effectiveness from a 100 to 50 millirem annual exposure standard is about $1.1 million per avoided health effect. The marginal cost-effectiveness associated with moving from a 50 to a 25 millirem annual exposure standard is $16 million per avoided health effect. The marginal cost-effectiveness ratio increases significantly as successively more stringent standards are considered.

In addition to estimating the economic impacts of alternative standards associated with the disposal of commercial LLW and NARM, an approximation

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* Recall that the cost and avoided health effects associated with regulating R-RAIXRSN and R-RASOURC were already captured in the estimates of NARM impacts in Chapter 6. In this chapter, ISD solidified is defined as current practice for NARM, to avoid double-counting impacts.

of the aggregate economic impacts including DOE waste is presented as well. The costs and risks of DOE waste disposal have not been specifically modeled, due to the limited availability of data. Rather, using EPA assumptions, the costs and risks for DOE waste were calculated by adjusting estimates derived from commercial LLW by the relative volume of DOE waste and commercial waste. EPA's calculation procedure (explained in detail in Appendix G) requires several important assumptions, such as: (1) DOE waste can be described by the same set of waste stream characteristics as commercial; (2) the concentration and distribution of radionuclides is the same for each waste; (3) although aggregate volumes differ, the distribution of waste volume is the same within each hydrogeologic region; (4) DOE will have the same percentage of BRC waste as commercial; and (5) the unit costs of disposal are assumed to be the same for DOE and commercial, with the exception of transportation costs. Since most DOE waste is expected to be disposed of onsite, a 10-mile transportation distance is assumed rather than the 650-mile distance assumed for commercial. This translates into about a 96 percent savings in transportation costs. Current disposal practice for DOE waste is assumed to differ from commercial. Under current practice, DOE waste is disposed of at a shallow land disposal site with waste in the as generated waste form.

Since current practice for DOE waste assumes a less stringent disposal option than what would meet a 25 millirem annual exposure standard, the economic impacts are more significant when DOE is included in the analysis. Table 8-5 presents the economic impacts for alternative standards associated with the disposal of commercial, NARM, and DOE waste. Assuming least-cost compliance, a 25 millirem annual exposure standard would cost an additional $140 million, but would avoid three additional health effects. The marginal cost-effectiveness of moving from a 50 to a 25 millirem standard in the aggregate is $19 million per avoided health effect (in comparison to $16

Table 8-5

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS,
INCLUDING DOE WASTE

LLW Standard Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose Doubled ** (Mrem/Yr)	Incremental Cost vs. Current Practice * ($ Millions)	Avoided Health Effects vs. Current Practice *	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect)	Required Disposal Practice
125	62	124	(680)	(160)		Sanitary Landfill, As Is
					1.7	
75	35	70	(450)	(28)		Shallow Land Disposal, As Is
25*	9.2	18.4	155	3.4	19	10 CFR 61 Disposal
25	9.1	18.2	140	3.2		Shallow Land Disposal; Class A: As Is; Class B, C, & NARM Solidified
					41	
10	5	10	700	17		Intermediate Depth Disposal (A: As Is; B, C, & NARM: SOL)
					220	
4	1.3	2.6	5,000	36		Concrete Canister

Table continued on following page.

Table 8-5 (Continued)

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS,
INCLUDING DOE WASTE

NOTE: Costs represent present values at a 10 percent discount rate (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Costs and health effects are for commercial LLW and NARM waste only, excluding wastes expected to meet the BRC standard. Impacts for DOE waste are calculated using EPA assumptions, whereby commercial LLW costs and risks are scaled by the ratio of commercial and DOE LLW regional volumes, after adjusting costs to reflect a lower average DOE transport distance. See Appendix G for further details.

* Current practice is assumed to be consistent with 10 CFR 61 disposal, for all commercial LLW, improved shallow land disposal (solidified) for NARM waste, and shallow land disposal (as generated) for all DOE waste.

** An environmentally conservative assumption which reflects EPA concerns over whether or not an actual disposal site will meet an alternative standard given the uncertainty surrounding the generic modelling used in estimating the maximum CPG dose.

million for commercial and NARM only). If the impact on DOE were to be considered in isolation, the marginal cost-effectiveness of moving from a 50 to a 25 millirem annual exposure standard would be on the order of $47 million per avoided health effect.

SENSITIVITY ANALYSIS

A great number of important assumptions are embedded in the preceding analysis of alternative standards. This section discusses the sensitivity of the results to five of the key assumptions that were made. First, an analysis of the economic impacts under different NRC implementation assumptions is performed. Regional implementation and the explicit consideration of population risk cost-effectiveness is evaluated. Second, the sensitivity of the above results to the exclusion of NARM waste is analyzed. Third, the sensitivity of the results to discounting health effects will be discussed. Fourth, the variation in CPG dose is analyzed under different risk model assumptions relating to disposal site size, waste mix, and the inclusion of BRC waste. Fifth, reassignment of compacts to different hydrogeologic regions is analyzed, and, finally, waste segmentation is considered qualitatively.

NRC Implementation Assumption

The implementation assumption that has been used in this analysis to calculate the incremental impacts of alternative standards on the commercial sector is actually two separate assumptions. The first assumption is that the same disposal technology will be used throughout the nation, regardless of hydrogeological region. This assumption is based on past NRC regulations as evidenced by 10 CFR 61 and is referred to as the National case. The National case contrasts with the case in which the disposal technology used to meet a given standard is allowed to vary by hydrogeologic region (recall the previous discussion of the large differences in CPG for any given method in the different hydrogeologic regions). Implementation done on a region-specific basis will be termed here the Regional case. Since CPG doses are relatively low in two of the three hydrogeological regions (thus, potentially allowing a less costly disposal option to be used to meet the 25 millirem standard in those two regions), considerable cost savings could be realized if NRC implements EPA's standard on a regional basis. However, the number of health effects would increase.

The second assumption used to construct the base case for this analysis is that the least-cost disposal option will be utilized, rather than the most cost-effective option that meets each CPG dose standard. These are termed the Implicit and Explicit assumptions, respectively. Under the Implicit implementation assumption, the economic impacts are estimated for the disposal technology that meets an alternative standard at the lowest possible cost. Under the Explicit implementation assumption, the economic impacts are estimated for the disposal technology that meets an alternative standard at the lowest cost per avoided health effect, relative to the base case disposal technology (10 CFR 61).

The significance of this second assumption can be emphasized by comparing the set of economically efficient disposal options that result under the Implicit assumption and under the Explicit assumption. Since a different set of disposal options may result depending on which implementation assumption is used, the economic impacts associated with the alternative LLW standards can differ.

The methodology used in determining the set of economically efficient disposal options (with respect to avoiding population health effects) is worth highlighting since this underlies the construction of the economic impact tables presented in this chapter. The following discussion focuses on the determination of the set of economically efficient disposal options that result under the Explicit implementation assumption. An analogous methodology was employed to determine the set of efficient options lying on the "least-cost compliance curve" (plotted in Figure 8-10). As discussed above, the least-cost compliance curve was used to determine the disposal option that would meet an alternative standard at least cost (under the Implicit implementation assumption).

The marginal cost-effectiveness was used in determining the set of economically efficient disposal options, regardless of the valuation placed on an avoided health effect. Recall that the marginal cost-effectiveness measures the value of a given disposal option relative to another disposal option. Starting at the lowest cost option (SLF, AG), and considering which is the most efficient of the remaining set of higher cost options, one would choose the option that has the smallest marginal cost-effectiveness. That is, the "efficient" option has the smallest cost per avoided health effect associated with moving from a lower to higher cost option.

Figure 8-11 plots the "efficient path," representing the six economically efficient disposal options out of the 15 disposal options considered.* The marginal cost-effectiveness is represented on the graph by the slope of the line drawn between the options on the efficient path. All options on the interior of the efficient path are considered "dominated" options; that is, an economically more efficient option is available.

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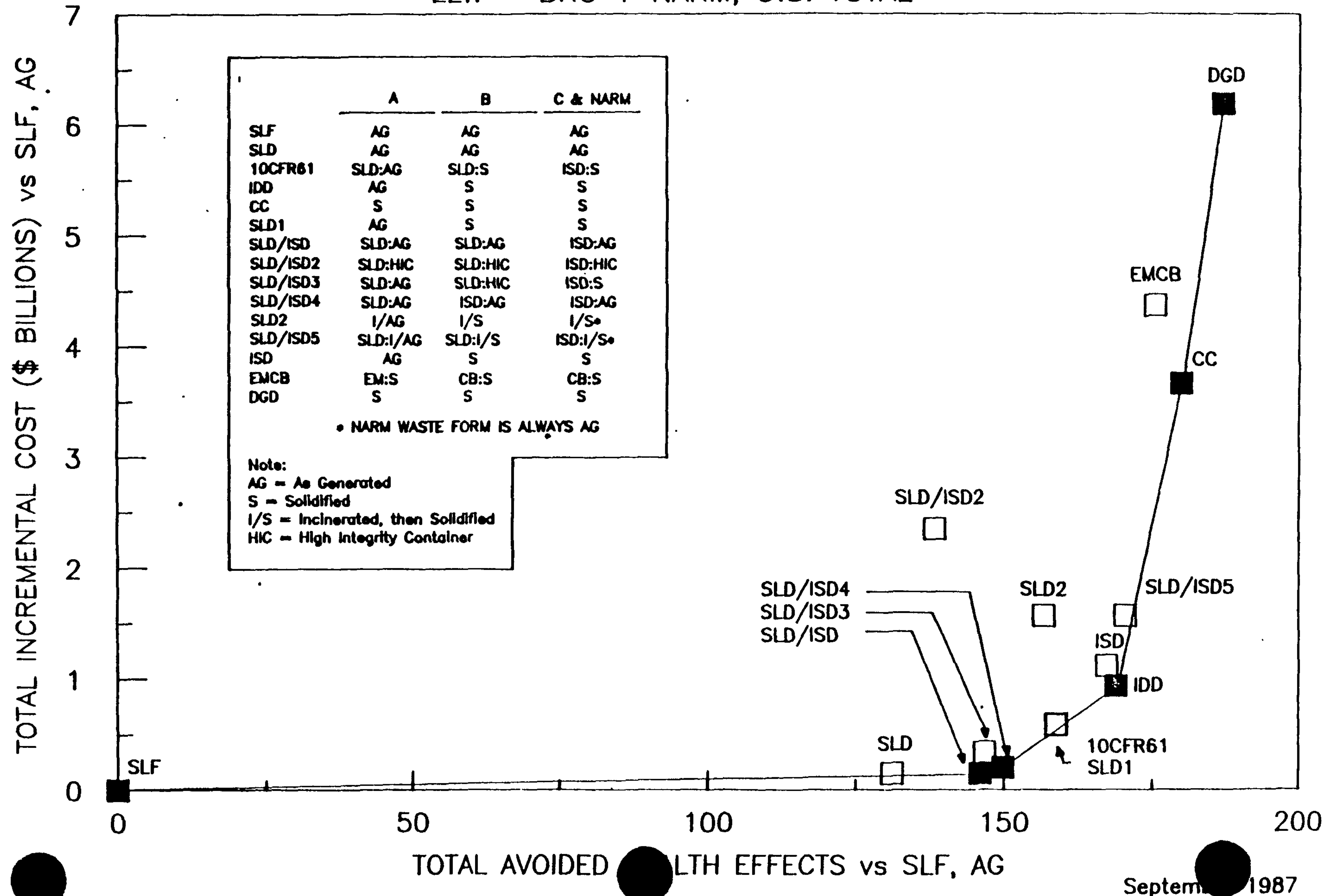
* Although the analysis produced sufficient information to characterize the costs and population health effects associated with hydrofracture (HF) and deep well injection (DWI), these two disposal technologies were excluded from the figure to allow for a comparison to the disposal methods found on the "least-cost compliance curve" presented in Figure 8-10. Recall that HF and DWI were excluded from Figure 8-10 since only a subset of the wastes considered in the LLW analysis were included for these two technologies when running the computer model that estimates CPG risk. Significantly, if hydrofracture is included in the analysis presented in Figure 8-11, which plots incremental costs against avoided health effects, this disposal technology would lie on the "efficient path."

Figure 8–11

COST-EFFECTIVENESS OF DISPOSAL

LLW – BRC + NARM; U.S. TOTAL



	A	B	C & NARM
SLF	AG	AG	AG
SLD	AG	AG	AG
10CFR61	SLD:AG	SLD:S	ISD:S
IDD	AG	S	S
CC	S	S	S
SLD1	AG	S	S
SLD/ISD	SLD:AG	SLD:AG	ISD:AG
SLD/ISD2	SLD:HIC	SLD:HIC	ISD:HIC
SLD/ISD3	SLD:AG	SLD:HIC	ISD:S
SLD/ISD4	SLD:AG	ISD:AG	ISD:AG
SLD2	I/AG	I/S	I/S•
SLD/ISD5	SLD:I/AG	SLD:I/S	ISD:I/S•
ISD	AG	S	S
EMCB	EM:S	CB:S	CB:S
DGD	S	S	S

• NARM WASTE FORM IS ALWAYS AG

Note:
AG = As Generated
S = Solidified
I/S = Incinerated, then Solidified
HIC = High Integrity Container

Septem 1987

In some cases, a disposal option is both more costly and results in more health effects than another option. This seemingly counterintuitive result was encountered for several disposal options in at least one region for at least one waste. In aggregate, EMCB, ISD, and the use of a HIC were options where, in all regions, a clearly more desirable alternative exists (i.e., a lower cost option results in fewer health effects).*

Of the six options that are considered efficient with respect to avoiding population health effects, the question addressing which of these options is the most cost-effective depends on the valuation placed on an avoided health effect. The more costly method is warranted if the value per avoided health effect is greater than the marginal cost-effectiveness associated with moving to the higher cost option. However, the above measure of cost-effectiveness, which evaluates the cost associated with avoiding population health effects, is not the sole criterion guiding EPA's choice of a standard. EPA's decision also reflects the value of avoiding radiological exposure to the CPG. Table 8-6 demonstrates how closely these two criteria (population risk and CPG risk) are correlated with one another in determining the economically preferred disposal option. The table compares the set of economically efficient disposal options, on the basis of population risk cost-effectiveness, to the set of disposal options on the least-cost compliance curve. This comparison highlights the importance of the implementation assumption, since a different set of disposal options may result depending on whether both cost-effectiveness and CPG dose are considered in implementing EPA's LLW standard.

One final observation will be made regarding the cost-effectiveness of alternative disposal options across individual waste streams. For options that are not dominated, the cost-effectiveness ratio varies by eight to nine orders of magnitude across the 17 commercial LLW and two NARM wastes. This implies that, if each individual waste could be treated differently at a

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* For a discussion of EPA's risk modelling assumptions, see EPA87.

Table 8-6

DISPOSAL OPTIONS ON THE EFFICIENT FRONTIER AND LEAST-COST COMPLIANCE CURVE*

"Efficient Path"

Disposal Option: Class A	Disposal Option: Class B	Disposal Option: Class C & NARM	Waste Form: Class A	Waste Form: Class B	Waste Form: Class C & NARM
SLF	SLF	SLF	AG	AG	AG
SLD	SLD	ISD	AG	AG	AG
SLD	ISD	ISD	AG	AG	AG
IDD	IDD	IDD	AG	S	S
CC	CC	CC	S	S	S
DGD	DGD	DGD	S	S	S

Least-Cost Compliance

Disposal Option: Class A	Disposal Option: Class B	Disposal Option: Class C & NARM	Waste Form: Class A	Waste Form: Class B	Waste Form: Class C & NARM
SLF	SLF	SLF	AG	AG	AG
SLD	SLD	SLD	AG	AG	AG
SLD	SLD	SLD	AG	S	S
IDD	IDD	IDD	AG	S	S
CC	CC	CC	S	S	S
DGD	DGD	DGD	S	S	S

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* Hydrofracture (HF) and deep well injection (DWI) are excluded since only a subset of the wastes considered in the LLW analysis were included for these two technologies when running the computer model which estimates CPG risk. Recall that the HF and DWI technologies are appropriate for the disposal of liquid wastes only.

particular disposal site (rather than each NRC class of waste being treated differently, as assumed in the LLW analysis), the "optimal" disposal option would involve a very different mix of disposal options vis-a-vis current practice (i.e., 10 CFR 61 disposal).

Tables 8-7, 8-8, and 8-9 show the economic impacts for commercial LLW and NARM under Regional-Implicit, National-Explicit, and Regional-Explicit implementation, respectively (compare to Table 8-4). Under Regional-Implicit implementation, Table 8-7, a savings of $300 million will be realized compared to current practice at a 25 millirem standard. However, 149 additional health effects would result. Figure 8-12 plots the marginal cost-effectiveness between the alternative implementation assumptions. This figure is constructed by plotting the avoided health effects and incremental costs associated with a 25 millirem standard for the four alternative implementation assumptions. The marginal cost-effectiveness, or value per avoided health effect, is represented by the slope of the line drawn between these data points. If the value per avoided health effect exceeds $2 million, then National-Implicit implementation would be more cost-effective than Regional-Implicit implementation. This ratio is within the $0.4 to $7 million range suggested for evaluating the sensitivity of results when analyzing EPA regulatory programs [EPA83]. (As noted earlier, however, EPA's choice of a standard depends on other policy considerations as well.)

This result, where National implementation seems to be preferred to Regional implementation, occurs since CPG dose and population risk are poorly correlated across different disposal practices. That is, the least-cost option (chosen on the basis of CPG only) is not the most cost-effective method (based on both CPG risk and population health effects reduction) in the two regions where less stringent disposal practices are able to meet the LLW standard. Regional-Explicit implementation (Table 8-9), therefore would be expected a priori to be the most economically efficient implementation scenario, since CPG risk and cost-effectiveness are

Table 8-7

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING IMPLICIT IMPLEMENTATION ON A REGIONAL BASIS

LLW Standard Maximum CPG Dose (MREM/Year)	Predicted Maximum CPG Dose (MREM/Year)	Predicted Maximum CPG Dose Doubled ** (MREM/Yr)	Incremental Cost vs. Current Practice * ($ Millions)	Avoided Health Effects vs. Current Practice *	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect)	Required Disposal Practice by Region: Humid Impermeable	Humid Permeable	Arid Permeable
125	62	124	(590)	(160)		Sanitary Landfill, As Is	Sanitary Landfill, As Is	Sanitary Landfill As Is
					9.1			
75	35	70	(520)	(151)		Sanitary Landfill, As Is	Shallow Land Disposal, As Is	Sanitary Landfil As Is
					110			
25	9.1	18.2	(300)	(149)		Sanitary Landfill, As Is	Shallow Land Disposal; (Class A: As Is; Class B, C, & NARM: SOL)	Sanitary Landfil As Is
					120			
10	5	10	(120)	(147)		Sanitary Landfill, As Is	Intermediate Depth Disposal (A:As Is; B,C, & NARM:SOL)	Sanitary Landfil As Is
					220			
4	1.3	2.6	1,300	(140)		Sanitary Landfill, As Is	Concrete Canister	Sanitary Landfil As Is

NOTE: Costs represent present values at a 10 percent discount rate (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Costs and health effects are for commercial LLW and NARM waste only, excluding DOE wastes and wastes expected to meet the BRC standard.

* Current practice is assumed to be consistent with 10 CFR 61 disposal for all commercial LLW. Current practice for NARM waste is ISD solidified.

** An environmentally conservative assumption which reflects EPA concerns over whether or not an actual disposal site will meet an alternative standard given the uncertainty surrounding the generic modelling used in estimating the maximum CPG dose.

Table 8-8

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS[+]

LLW Standard Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose Doubled ** (Mrem/Yr)	Incremental Cost vs. Current Practice * ($ Millions)	Avoided Health Effects vs. Current Practice *	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect)	Required Disposal Practice
125	35	70	(440)	(13)	N.M.(***)	Class A & B:SLD, As Is; Class C & NARM:ISD, As Is
75	35	70	(440)	(13)	35	Class A & B:SLD, As Is; Class C & NARM:ISD, As Is
25	9.1	18.2	(9.1)	(0.12)	33	Shallow Land Disposal; Class A: As Is, Class B, C, & NARM:SOL
10	5	10	340	10	250	Intermediate Depth Disposal (A:As Is; B, C & NARM:SOL)
4	1.3	2.6	3,100	21		Concrete Canister

Table continued on following page.

Table 8-8 (Continued)

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS

NOTE: Costs represent present values at a 10 percent discount rate (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Costs and health effects are for commercial LLW and NARM waste only, excluding DOE wastes and wastes expected to meet the BRC standard.

+ Under Explicit implementation, a value per avoided health effect of $5 million is used to determine the most cost-effective practice which meets each alternative.

* Current practice is assumed to be consistent with 10 CFR 61 disposal for all commercial LLW. Current practice for NARM waste is ISD solidified.

** An environmentally conservative assumption which reflects EPA concerns over whether or not an actual disposal site will meet an alternative standard given the uncertainty surrounding the generic modelling used in estimating the maximum CPG dose.

*** NM means not meaningful since the disposal practice for the 50 and 100 millirem alternatives is the same.

Table 8-9

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS+

LLW Standard Maximum CPG Dose (MREM/Year)	Predicted Maximum CPG Dose (MREM/Year)	Predicted Maximum CPG Dose Doubled ** (MREM/Yr)	Incremental Cost Vs. Current Practice * ($ Millions)	Avoided Health Effects vs. Current Practice *	Marginal Cost-Effectiveness ($Millions Per Avoided Health Effect)	Required Disposal Practice by Region: Humid Impermeable	Humid Permeable	Arid Permeable
125	62	124	(540)	(22)		Class A & B:SLD, As Is Class C & NARM:ISD, As Is	Sanitary Landfill, As Is	Sanitary Landfill, As Is
					9.1			
75	35	70	(470)	(14)		Class A & B:SLD, As Is Class C & NARM:ISD, As Is	Shallow Land Disposal, As Is	Sanitary Landfill, As Is
					110			
25	9.1	18.2	(250)	(12)		Class A & B:SLD, As Is Class C & NARM:ISD, As Is	Shallow Land Disposal; (Class A: As Is; Class B, C & NARM: SOL)	Sanitary Landfill, As Is
					120			
10	5	10	(74)	(10)		Class A & B:SLD, As Is Class C & NARM:ISD, As Is	Intermediate Depth Disposal (A: As Is B,C & NARM:SOL)	Sanitary Landfill, As Is
					220			
4	1.3	2.6	1,400	(3.7)		Class A & B:SLD, As Is Class C & NARM:ISD, As Is	Concrete Canister	Sanitary Landfill, As Is

Table continued on following page.

Table 8-9 (Continued)

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS

NOTE: Costs represent present values at a 10 percent discount rate (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Costs and health effects are for commercial LLW and NARM waste only, excluding DOE waste and wastes expected to meet the BRC standard.

+ Under Explicit implementation, a value per avoided health effect of $5 million is used to determine the most cost-effective practice which meets each alternative.

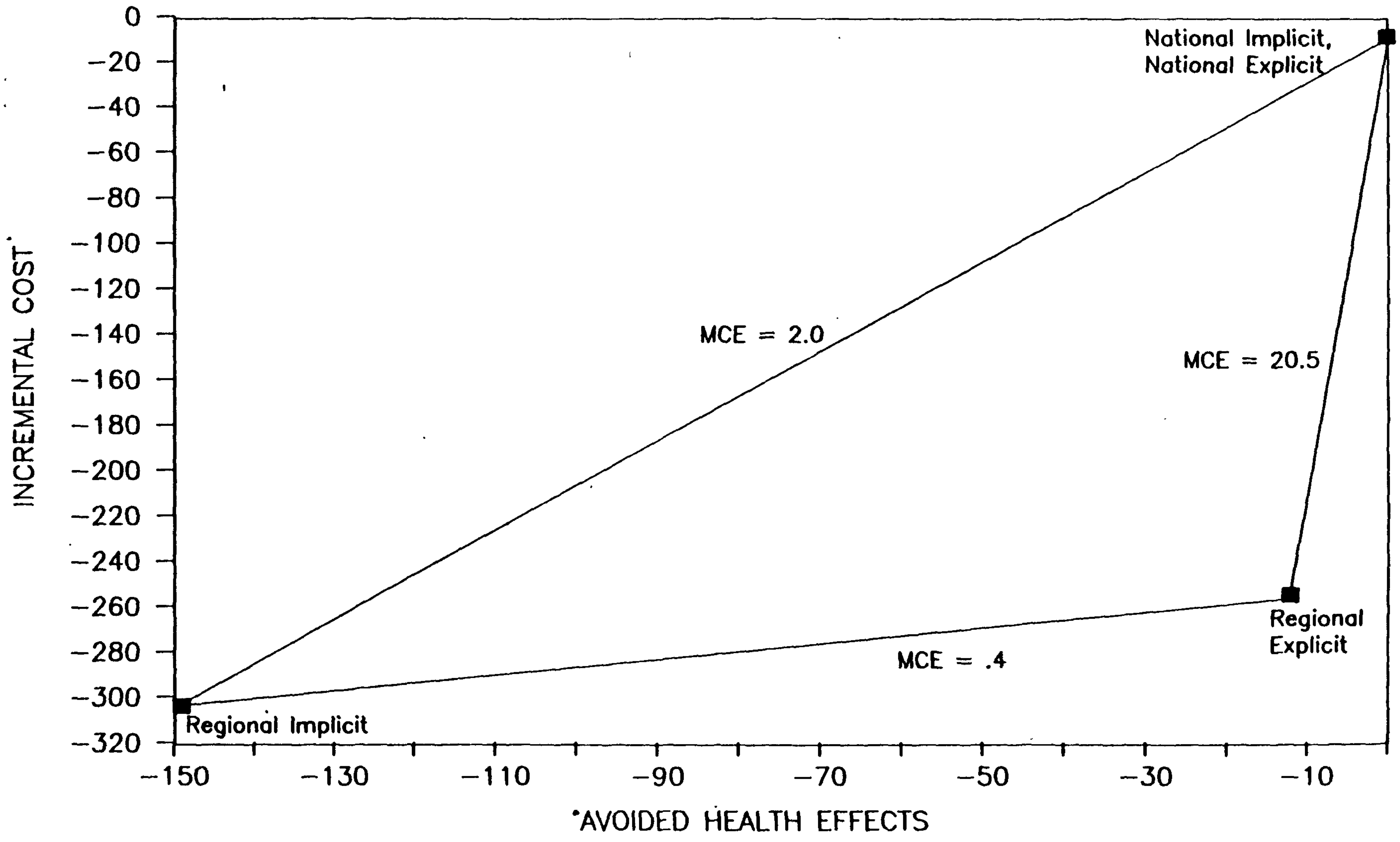
* Current practice is assumed to be consistent with 10 CFR 61 disposal for all commercial LLW. Current practice for NARM waste is ISD solidified.

** An environmentally conservative assumption which reflects EPA concerns over whether or not an actual disposal site will meet an alternative standard given the uncertainty surrounding the generic modelling used in estimating the maximum CPG dose.

Figure 8–12

ALTERNATIVE IMPLEMENTATION ASSUMPTIONS

FOR A 25 MREM STANDARD



NOTES: Cost and health effects measured relative to current practice and include commercial LLW and NARM.
MCE = Marginal Cost–Effectiveness ratio in $million, per avoided health effect.

September 1987

considered independently in each hydrogeologic region.* Under Regional-Explicit implementation, the economy would realize a $250 million savings in comparison to current practice, but would incur 12 additional health effects at the proposed 25 millirem standard. However, the marginal cost-effectiveness of moving from Regional-Implicit implementation to Regional-Explicit implementation is only $0.4 million per avoided health effect (see Figure 8-12).

Note that National-Implicit (Table 8-4) and National-Explicit (Table 8-8) implementations have the same economic impacts at a 25 millirem standard and lower. This occurs since the most cost-effective disposal options that meet these alternative standards also happen to be the least-cost disposal options. Therefore, at a 25 millirem standard, and under a National implementation assumption, the additional consideration of population risk cost-effectiveness does not affect the base case results.

One final observation involves the marginal cost-effectiveness of moving from one alternative to another under the different implementation assumptions. Since some of the benefit of avoiding population risk in the humid impermeable region is either accomplished at the higher levels of the alternative standards (as in the case of the Regional-Explicit implementation) or simply not considered (as in the case of the Regional-Implicit implementation), the marginal cost-effectiveness of moving from the 50 to the 25 millirem alternative is significantly greater than under the base case implementation assumption. The marginal cost-effectiveness between the 50 and 25 millirem alternatives is $110 million per avoided health effect under either Regional implementation vis-a-vis $16 million

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* For illustration purposes only, a $5 million value per avoided health effect is used in estimating the economic impacts under an explicit implementation assumption (Tables 8-8 and 8-9). This figure is not meant to suggest a valuation applied by EPA. The economic impacts may be significantly different, however, under different assumptions regarding the value per avoided health effect.

under National-Implicit implementation. Therefore, the economic analysis suggests that the relative cost of moving from a 50 to 25 million standard increases significantly if the NRC implements on a Regional rather than a National basis.

Exclusion of NARM

Since R-RASOURC and R-RAIXRSN will be regulated using TSCA authority and will be co-disposed with AEA wastes, these two NARM wastes have been included in the base case analysis. As a sensitivity, however, the impacts associated with excluding NARM from the LLW analysis are presented in Table 8-10 for commercial LLW under National-Implicit implementation. Since NARM volume is small relative to commercial LLW volume, the incremental costs do not change significantly. Avoided health effects, on the other hand, change substantially, since much of the health risk reduction is associated with more stringent treatment of NARM. For example, NARM is responsible for 38 percent of the health effects associated with SLD, as generated disposal technology, in comparison to less than one percent of the health effects for 10 CFR 61 disposal. Thus, the exclusion of NARM has the most significant impact on avoided health effects at higher standards, where the as generated waste form is used for disposal. The solidification of NARM appears to be an effective means of eliminating most of the health effects associated with its disposal. By excluding NARM from the analysis, the benefit associated with solidifying this waste is not captured, as reflected in the marginal cost-effectiveness associated with moving from the 50 millirem to the 25 millirem per year alternative. Without NARM, the marginal cost-effectiveness per commercial LLW increases from $16 million to $69 million per avoided health effect between the 50 and 25 millirem per year alternatives.

Discounting Health Effects

While costs, which occur over the 20-year disposal period, are

Table 8-10

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS, EXCLUDING NARM WASTE

LLW Standard Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose Doubled (Mrem/Yr)	Incremental Cost vs. Current Practice * ($ Millions)	Avoided Health Effects vs. Current Practice *	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect)	Required Disposal Practice
125	62	124	(570)	(98)		Sanitary Landfill, As Is
					1.6	
75	35	70	(430)	(6.3)		Shallow Land Dispos[e] As Is
					67	
25	9.1	18.2	(5.6)	(0.01)		Shallow Land Dispos[e] (Class A: As Is; Class B, C, & NARM: SOL)
					35	
10	5	10	350	10		Intermediate Depth Disposal (A:As Is B, C, & NARM:SOL)
					250	
4	1.3	2.6	3,100	21		Concrete Canister

NOTE: Costs represent present values at a 10 percent discount rate (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Costs and health effects are for commercial LLW only, excluding NARM, DOE waste, and wastes expected to meet the BRC standard.

* Current practice is assumed to be consistent with 10 CFR 61 disposal for all commercial LLW. Current practice for NARM waste is ISD solidified.

discounted at a 10 percent real rate in the base case analysis, health effects, which occur over the 10,000-year exposure period, are not discounted at all. Therefore, a sensitivity analysis was performed to determine the effect of discounting avoided health effects (i.e., benefits). The results from Appendix E are reproduced in Table 8-11. The methodology used in calculating the economic impacts under different discount rate assumptions is discussed in the appendix. Since health effects occur over such a long period, the effect of using any positive discount rate can be extreme. For example, the base case of 160 additional health effects (versus current practice) predicted at the 100 millirem per year alternative is reduced to 22 additional health effects when discounted at a two percent rate. The marginal cost-effectiveness ratios increase one to two orders of magnitude at a two percent discount rate and increase by one to three orders of magnitude at a five percent rate. Changes in the marginal cost-effectiveness ratio are especially large at standards below 50 millirem.

Variation in CPG Dose

Several additional risk model runs were performed to explore the sensitivity of the CPG results to modelling parameters such as site size, waste mix, the exclusion of NARM, and the inclusion of BRC. Since some uncertainty concerning these parameters exists, a sensitivity analysis was performed to estimate the relative importance of each parameter. But, more importantly, these parameters are more a function of the economics of LLW disposal (vis-a-vis the technical or scientific parameters used in the model such as leach rates, annual rainfall, etc.). Therefore, a sensitivity analysis was performed to estimate the effect of decisions that influence the economics of disposal, such as the formation of compacts, which may result in a different site size and waste mix, or the type of NRC implementation, which could affect the set of wastes that meet the 4 millirem BRC criterion. The sensitivity results are summarized by hydrogeologic region in Table 8-12 for 10 CFR 61 disposal.

Table 8-11

IMPACTS OF ALTERNATIVE LLW STANDARDS
AT DIFFERENT RATES OF DISCOUNT
UNDER NATIONAL-IMPLICIT IMPLEMENTATION

LLW Standard (Maximum CPG Dose in mrem per year)	Predicted Maximum CPG Dose	Predicted Maximum CPG Dose Doubled	Present Value Incremental Cost ($ Millions)			Present Value Avoided Health Effects			Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect)		
			Discount Rate			Discount Rate			Discount Rate		
			10%	5%	2%	0%	5%	2%	10%/0%	5%/5%	2%/2%
125	62	124	(590)	(860)	(1,100)	(160)	(5.1)	(22)			
									1.1	42	13
75	35	70	(450)	(650)	(860)	(28)	(0.0501)	(0.36)			
									16	13,000	2,400
25	9.1	18.2	(9.1)	(13)	(17)	(0.12)	(0.001)	(0.0036)			
									35	10,000	2,700
10	5	10	340	504	660	10	0.051	0.25			
									250	71,000	17,000
4	1.3	2.6	3,070	4,500	5,900	21	0.107	0.56			

NOTES:

(1) Incremental Costs and Avoided Health Effects are measured relative to current practice (10 CFR 61 for commercial waste; ISD Solidified for NARM).

(2) Costs (in 1985 dollars) are incurred annually from 1985 to 2004. Health effects (fatal cancers and genetic effects) occur over 10,000 years, beginning in 2008.

(3) Costs and health effects are discounted to 1985 at the rate indicated above each column. The procedure used to discount health effects is approximate and assumes a linear occurrence of health effects within the four discrete time intervals for which health effects were quantified.

(4) Costs and health effects include commercial LLW and two NARM wastes, and exclude BRC and DOE waste. The average annual waste volume is 108,750 cubic meters as generated.

(5) Compliance with the standard assumes that the same disposal technology is used everywhere, as determined by the CPG dose in the worst hydrogeologic region.

Table 8-12

SENSITIVITY ANALYSIS OF CPG DOSE ESTIMATES
BY REGION FOR 10 CFR 61 DISPOSAL

Case	Maximum CPG Dose (millirem/year) Humid Permeable	Humid Impermeable	Arid Permeabl
1. Base Analysis*	9.2	0.030	0.00092
2. LLW + NARM; 373,000 Cubic Meter Site	8.6	0.034	0.00068
3. LLW + NARM; 250,000 Cubic Meter Site	7.0	0.023	0.00068
4. LLW + NARM; 170,000 Cubic Meter Site	5.7	0.015	0.00055
5. LLW; 366,000 Cubic Meter Site	8.6	0.033	0.00084
6. LLW; 250,000 Cubic Meter Site	7.0	0.023	0.00068
7. LLW; 170,000 Cubic Meter Site	5.7	0.015	0.00055
8. LLW-BRC+NARM-Class D (240,000 Site)	9.1	0.030	0.00092
9. 500,000 Cubic Meter Site	13.0	0.060	0.00130
10. 100,000 Cubic Meter Site	5.6	0.012	0.00560
11. Regional Compact Waste Mix	9.7 (Southeast)	0.031 (Northeast)	0.00010 (Rocky Mountain)
12. Regional Compact Mix and Volume	15.0 (Southeast) (590K Site)	0.058 (Northeast) (470K Site)	Not Analyzed
13. 10,000-Year Horizon	9.2	0.030	0.01700

* Assumes U.S. average waste mix; 250,000 cubic meters of waste; LLW-BRC+NARM; 1,000-year horizon. Normal exposure pathways only. Cases 2 through 13 are variations the Base Analysis; the particular assumption that deviates from the Base Analysis assumptions is noted in each case.

Site size has the most significant impact on CPG dose. The base case site size was assumed to be 250,000 cubic meters. If site size is increased to 500,000 cubic meters, the maximum CPG dose would increase by 41 percent, or from 9.2 to 13 millirems per year in the humid permeable region.

Another parameter, waste mix, has a much smaller effect on CPG dose. The base case assumes the U.S. average waste mix is disposed of at the site. If a representative regional Compact waste mix is disposed of at the site, maximum CPG dose would increase by about five percent, or from 9.2 to 9.7 millirems per year in the humid permeable region. If the regional Compact mix and entire Compact volume is assumed to be disposed of at a site, the maximum CPG dose could increase by 63 percent, or from 9.2 to 15 millirems in the humid permeable region. The 15 millirem CPG dose estimate is based on disposal at one site of the entire 590,000 cubic meters of waste generated in the Southeast Compact. Significantly, even with these variations, 10 CFR 61 still meets the proposed 25 millirem standard in the humid permeable region (the region with the highest estimates of CPG dose).

In the hypothetical case where a zero BRC standard is promulgated, the nine commercial wastes expected to meet the proposed 4 millirem standard would be disposed at a regulated facility. In this case, the maximum CPG dose would decrease by seven percent, or from 9.2 to 8.6 millirems per year in the humid permeable region. Since the nine BRC wastes are characterized by high volumes and low radionuclide concentrations, the inclusion of these wastes at a regulated facility tends to dilute the overall radionuclide concentration at the site (the average site volume increases from 250,000 cubic meters to 373,000 cubic meters, but little activity is added).

Excluding NARM from the site appears to have an insignificant effect on CPG dose. For example, compare Case 3 in Table 8-12 to Case 6. These two cases differ only in that Case 3 includes NARM whereas Case 6 does not. Nevertheless, Cases 3 and 6 have identical predicted maximum CPG doses in all three hydrogeologic regions.

Finally, the base case assumes a 1,000-year time horizon (vis-a-vis the 10,000-year time horizon used in estimating population health effects). Alternatively, assuming a 10,000-year horizon, no change in the CPG dose occurs in the humid permeable and humid impermeable regions. In the arid permeable region, however, a more than 18-fold increase occurs. This result is still rather inconsequential, since the base case CPG in the arid permeable region is 0.00092 millirems per year.

Compact Assignment to Hydrogeologic Region

Two sensitivity analyses on the assignment of Compacts to hydrogeologic regions were also performed. Case 1 involved reassigning the volumes for the PA/WV Compact (259,548 cubic meters) from the humid impermeable region to the humid permeable region. Case 2 involved reassigning volumes as in Case 1 and, in addition, reassigning volumes for the Central Compact (153,807 cubic meters) from the humid permeable region to the arid permeable region.*

The results for Cases 1 and 2 are presented in Tables 8-13 and 8-14, respectively, for three alternative implementation assumptions. (The fourth, National-Explicit, is not reported, due to its close similarity to National-Implicit implementation.) The results for the two cases do not vary significantly; therefore, the following discussion will focus on comparing the base case results to results for Case 1. This observation also suggests that reallocating the Central Compact volumes to the arid permeable region would have little effect on the base case results as well.

Since unit costs do not vary across hydrogeologic region, shifting the PA/WV Compact volume from the humid impermeable to the humid permeable

* These scenarios were chosen by EPA to reflect current areas of large uncertainty in Compact siting.

Table 8-13

IMPACTS OF ALTERNATIVE LLW STANDARDS
UNDER DIFFERENT IMPLEMENTATION ASSUMPTIONS
COMPACT REASSIGNMENT CASE 1

LLW Standard (Maximum CPG Dose in mrem per year)	Maximum Lifetime Risk	Present Value Incremental Cost ($ Millions) Implementation Assumption: National Implicit	Regional Implicit	Regional Explicit	Present Value Avoided Health Effects Implementation Assumption: National Implicit	Regional Implicit	Regional Explicit	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) Implementation Assumption: National Implicit	Regional Implicit	Regional Explicit
125	3.50E-3	($590)	($590)	($560)	(120)	(120)	(23)			
								$1.4	$8.7	$8.7
75	2.10E-3	($450)	($502)	($470)	(23)	(110)	(12)			
								$19	$90	$90
25	7.00E-04	($9.1)	($220)	($190)	(0.11)	(110)	(9.3)			
								$38	$97	$97
10	2.80E-4	$340	($6.3)	$29	9.1	(108)	(7.04)			
								$230	$206	$206
4	1.12E-4	$3,070	$1,700	$1,700	21	(100)	1.05			

NOTES:

(1) Incremental Costs and Avoided Health Effects are measured relative to current practice (10 CFR 61 for commercial waste; ISD Solidified for NARM).

(2) Costs (in 1985 dollars) are incurred annually from 1985 to 2004. Health effects (fatal cancers and genetic effects) occur over 10,000 years, beginning in 2008.

(3) Costs are discounted to 1985 at a 10 percent rate. Health effects are not discounted.

(4) Costs and health effects include commercial LLW and two NARM wastes, and exclude BRC and DOE waste. The average annual waste volume is [illegible]08,750 cubic meters as generated.

[illegible] lumes for the PA/WV Compact were reassigned from the humid [illegible]meable region to the humid permeable region.

([illegible] ximum risk is equal to maximum dose times a factor of 2.8E[illegible] (MEY86a).

Table 8-14

IMPACTS OF ALTERNATIVE LLW STANDARDS
UNDER DIFFERENT IMPLEMENTATION ASSUMPTIONS
COMPACT REASSIGNMENT CASE 2

LLW Standard (Maximum CPG Dose in mrem per year)	Maximum Lifetime Risk	Present Value Incremental Cost ($ Millions) — Implementation Assumption: National Implicit	Regional Implicit	Regional Explicit	Present Value Avoided Health Effects — Implementation Assumption: National Implicit	Regional Implicit	Regional Explicit	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) — Implementation Assumption: National Implicit	Regional Implicit	Regional Explicit
125	3.50E-3	($590)	($590)	($560)	(120)	(120)	(22)			
								$1.5	$8.8	$8.8
75	2.10E-3	($450)	($510)	($480)	(23)	(110)	(13)			
								$19	$88	$88
25	7.00E-04	($9.1)	($250)	($220)	(0.11)	(110)	(9.8)			
								$38	$94	$94
10	2.80E-4	$340	($58)	($23)	9.3	(109)	(7.8)			
								$230	$208	$208
4	1.12E-4	$3,070	$1,400	$1,500	21	(102)	(0.54)			

NOTES:

(1) Incremental Costs and Avoided Health Effects are measured relative to current practice (10 CFR 61 for commercial waste; ISD Solidified for NARM).
(2) Costs (in 1985 dollars) are incurred annually from 1985 to 2004. Health effects (fatal cancers and genetic effects) occur over 10,000 years, beginning in 2008.
(3) Costs are discounted to 1985 at a 10 percent rate. Health effects are not discounted.
(4) Costs and health effects include commercial LLW and two NARM wastes, and exclude BRC and DOE waste. The average annual waste volume is 108,750 cubic meters as generated.
(5) Volumes for the PA/WV Compact were reassigned from the humid impermeable region to the humid permeable region; volumes for the Central Compact were reassigned from the humid permeable region to the arid permeable region.
(6) Maximum risk is equal to maximum dose times a factor of 2.8E-05 [MEY86a].

region will not affect total costs under a National implementation assumption. Under Regional implementation, however, costs generally increase since, in the humid permeable region, a more stringent disposal practice is required to meet the alternative standards. Since the unit health risks are greater in the humid permeable region, avoided health effects generally increase for Case 1. The net effect on marginal cost-effectiveness is mixed, however. A comparison of the marginal cost-effectiveness ratios associated with the base case and Case 1 indicates that the ratios change from 10 percent to 30 percent. In particular, the marginal cost-effectiveness under a National implementation assumption increases from $16 million to $19 million when moving from a 50 to a 25 millirem standard, or about a 20 percent increase when the PA/WV Compact is assigned to the humid permeable region.

Segmentation of Wastes

Similar to substream segregation in the BRC analysis, segmentation of waste substreams is an issue in the LLW analysis. Since the distribution of specific activity for a waste can vary by a couple of orders of magnitude, substreams of a particular waste may qualify for NRC classification different from the aggregate waste stream. As a result, if segmentation is practiced, the type of disposal treatment could differ across the substreams for a given waste. For example, L-NCTRASH, a Class A waste, is an aggregation of two NRC substreams -- P-NCTRASH, also a Class A waste, and B-NCTRASH, a Class B waste. Since L-NCTRASH is characterized by a significant volume, Class B treatment of the substream B-NCTRASH (which involves solidification of the waste) would increase costs by $287 million under 10 CFR 61 disposal. Total health effects associated with 10 CFR 61 would not vary significantly, in this example, since L-NCTRASH accounts for less than one health effect.

This example demonstrates that segmentation of the waste can have a significant effect on the results. However, if B-NCTRASH is treated as

Class B waste under current practice, incremental costs and avoided health effects at the 25 millirem standard will not be affected, since current practice was demonstrated to be in compliance with this standard. Since absolute costs for 10 CFR 61 disposal are understated, however, marginal cost-effectiveness ratios associated with moving from a 50 millirem alternative to the 25 millirem standard will increase from $16 to $26 million per avoided health effect.

In addition to the BRC criterion, the LLW standard, and the regulation of certain NARM wastes, EPA is proposing two other limits which affect LLW in this action. These limits include contamination limits expressed as an annual CPG dose limit for groundwater, graded by aquifer class, and a pre-disposal waste management limit of 25 millirem per year. Finally, EPA is also proposing that the implementation of the LLW and BRC standards be phased in over time, with application to commercial sites taking effect for any site seeking a new or renewed license, and application to DOE sites taking effect as of January 1, 1993.

A detailed quantitative analysis with respect to the three provisions described above has not been undertaken since EPA believes that the economic impact of these provisions will be small (except perhaps for the groundwater standard, depending on the option chosen). The purpose of this chapter is to describe in qualitative terms what the economic impacts would include if they were quantified and the reasons EPA believes the impacts will probably be small. Each of the three provisions will be treated individually in the following discussions.

PROPOSED GROUNDWATER STANDARDS

EPA is proposing two separate options for the groundwater protection limits for the disposal of low-level radioactive waste. Under either option, the limits depend on the type of aquifer affected, as follows:

Aquifer Class	Proposed Groundwater Limit
OPTION I:	
Class I	No Degradation (i.e., 0 millirem)
Class II --	
High Yield (above 10,000 gpd)	4 millirem per year
Low Yield (above 10,000 gpd)	Less than 25 millirem per year (covered by LLW standard)
Class III	Less than 25 millirem per year (covered by LLW standard)
OPTION II:	
Class I	No Degradation (i.e., 0 millirem)
Class II and Class III	4 millirem per year

As with other EPA groundwater protection strategies, the purpose of a graded limit is to protect aquifers to a degree commensurate with their value and potential use. Class I aquifers include essential community water supplies (sole source aquifers) and, in particular, pure sources of groundwater. Class III aquifers include groundwaters that generally are not drinkable due to natural causes (e.g., saline water) or prior manmade contamination. Class II aquifers, which include the great majority of all aquifers, include all groundwaters that are not Class I or Class III. Class II aquifers are further subdivided under Option I according to their potential yield. An aquifer yield threshold of 10,000 gallons per day is used to differentiate low and high yield aquifers. This threshold is chosen, in part, to reflect the average daily consumption of 25 people (at 200 gallons per day per person, for a total consumption of 5,000 gallons) and a design factor of two to account for the difference between the actual yield of the aquifer and human consumption (which varies on a daily basis).

The 4 millirem per year dose limit, which is proposed under Option I for high yield Class II aquifers and under Option II for both Class II and Class III aquifers, is numerically equal to the National Interim Primary Drinking Water Standard - Maximum Contaminant Level (MCL) for manmade radionuclides, which is also 4 millirem per year (whole-body dose equivalent). This interim MCL [EPA76] was promulgated on July 9, 1976 (41 FR 28404) at 40 CFR 141.15 and 141.16, with additional interim MCLs of 5 picocuries per liter for radium-226 and -228, and 15 picocuries per liter for gross alpha particle activity (excluding uranium and radon). Under the interim standards, compliance monitoring is only required for surface water systems serving more than 100,000 people.

The LLW groundwater standards proposed in this action are designed to direct siting of LLW disposal facilities away from the most valuable groundwaters (Class I) and to ensure that no community has to treat its water supply to remove radionuclides due to a LLW disposal facility.

Impact on LLW Disposal

The proposed groundwater protection standards affect the economic analysis of LLW disposal only to the extent that they alter the costs and benefits of LLW disposal specifically as a result of meeting the groundwater standard. These incremental costs and benefits would accrue in addition to those already quantified in Chapter 8 for the proposed 25 millirem per year LLW standard. Thus, under Option I, the groundwater standards would have no additional economic impact on sites located above Class III or Class II low yield aquifers, since the groundwater CPG dose would already be limited to less than 25 millirem per year by the LLW standard (which covers all pathways, including groundwater). However, under Option II, the incremental economic impact of the groundwater standards could be much greater since the groundwater pathway often determines the maximum CPG dose with respect to the LLW standard (i.e., Option II is tantamount to an LLW standard of 4 millirem per year).

Incremental Impact of Option I Groundwater Limits

The proposed groundwater standards under Option I could raise the costs of disposal site selection if a site must be relocated away from a Class I or Class II high yield aquifer. If an alternative site cannot be found (or is very expensive to locate or purchase), the proposed groundwater standards under Option I could require instead a more expensive disposal technology to limit the groundwater CPG dose to 4 millirem per year or lower.

As explained further in EEI84b, normal siting costs are estimated to equal approximately $263,000 to $530,000 per site for a single disposal facility; similar costs would be incurred for any of the shallow land disposal options (i.e., SLD, ISD, and IDD). These siting cost estimates include the costs especially designated in EEI84b as costs of site selection ($263,000), and additional costs for legal services and site study that are likely to begin before a decision to reject a site from further consideration is reached. For purposes of illustrating potential resiting costs, the estimated legal costs of $175,000 incurred during the first year of facility construction and about one-half of the first year costs estimated for preparation of the Environmental Impact Statement ($91,000) are added to normal site selection costs ($263,000), to derive the upper-bound estimate of resiting cost ($530,000). These costs are included since EEI84b assumes that all activities will begin in parallel in the first year.

Most of the site selection cost reflects the expense of the detailed hydrogeologic assessments that are needed to characterize the surrounding aquifer system. If resiting were used to meet the groundwater limit, EPA estimates that siting costs could increase by as much as a factor of nine, depending on how many "tries" it takes to locate an acceptable site. This factor is based on a preliminary study conducted for EPA that concludes that for the entire U.S., only 10 percent of all aquifers can be considered low yield (less than 10,000 gallons per day). Thus, the probability of randomly choosing a site above a low yield aquifer (an acceptable site) is also about one in 10. The probability of choosing an acceptable site on a random basis would, of course, also depend on the prudence of potential sites above Class I or Class III aquifers, or above no aquifer at all. In any event, a 10 percent probability of locating an acceptable site implies that, on average, 10 tries would be required per site, for an incremental siting cost of nine times the cost per try (since the LLW analysis already accounts for siting costs at the site eventually chosen). Since at least some prior knowledge of aquifer type is likely to be available, the probability of a successful "try" is probably higher than 10 percent. However, it is also likely that at least two sites will be investigated in parallel, so that at least one "reject" will occur.

Under these assumptions, resiting could add from one to nine times normal siting costs ($263,000 to $530,000 per try), or from $263,000 to $4.77 million per site (i.e., 1 x $263,000 to 9 x $530,000).

In contrast to resiting, the incremental cost of using more expensive disposal technology to meet the groundwater standards (compared to the cost of 10 CFR 61 disposal, which is required by the 25 millirem disposal standard under a National Implicit implementation assumption) could range up to $341 million per site (the incremental cost of concrete canister disposal). Thus, it is easy to see that the cost of compliance with the groundwater standards depends strongly on whether resiting (to areas controlled only by the 25 millirem overall LLW disposal standard) is necessary. The need for resiting depends on the distribution of aquifer types at otherwise acceptable site locations. If all of the otherwise acceptable sites are located above aquifers covered by the 4 millirem limit, the more expensive disposal technology could be required.

In general, for either arid permeable or humid impermeable sites, any disposal technology that is at least as good as current practice is likely to meet the proposed groundwater limits, even for Class II aquifers. For these regions, the groundwater standards may not have any economic impact at all (assuming compliance is judged on a regional or site-specific basis). A more difficult question is whether suitable sites in humid permeable regions can be located with only a few attempts, given other political and engineering constraints on site selection. In these sites, the groundwater CPG dose can exceed 4 millirem per year, even when 10 CFR 61 disposal is used to meet the 25 millirem LLW standard. If resiting in humid permeable regions is not feasible, a more expensive technology may be necessary to meet the groundwater standard; in this case, the economic impact of the groundwater limits could be substantial. Of course, implementation of EPA's standards by the NRC and DOE could also affect the economic impact of the groundwater standards. For example, if a more expensive technology were needed to meet groundwater requirements in humid permeable regions and the NRC and DOE required the same minimum technology everywhere in the country, as under a National-Implicit implementation assumption, the economic impact could range up to $5 billion. If only the sites in humid permeable regions were affected and disposal practice was allowed to relax in the other two regions (Regional implementation), the incremental cost would be $2.1 billion; if current disposal practice is not allowed to relax, the incremental cost would be $2.5 billion.

EPA does not currently possess the detailed hydrogeologic characterization of the distribution of aquifers nationwide that is necessary to evaluate quantitatively the likelihood that more expensive technology (rather than resiting) would be necessary to meet the groundwater standards. However, for purposes of estimating economic impacts, EPA assumes that resiting will be possible, at least within the humid permeable regions where it is more likely to be necessary. To estimate the potential magnitude of the proposed groundwater standard impacts, EPA has assumed that resiting will be necessary between one and nine times per site. If these assumptions are correct, for 15 ultimate sites nationwide (nine commercial and six DOE sites, at $263,000 to $4.77 million per site), the total maximum incremental cost (over the LLW standard) of the proposed groundwater protection standards would be $3.9 million to $72 million. Note that since the potential benefit (health effects reduction) of resiting away from Class I or Class II high yield aquifers could not be assessed quantitatively, the cost-effectiveness of the groundwater standard under Option I could also not be determined.

Incremental Impact of Option II Groundwater Limits

The analysis of the potential aspects of the groundwater standards under Options I and II are similar, except that while more expensive disposal technology may not be needed under Option I, it is almost certainly required under Option II. Since the groundwater pathway controls the CPG dose in the humid permeable region, a 4 millirem groundwater standard would require more expensive disposal technology (e.g., concrete canisters). Relative to 10 CFR 61 disposal practice, the incremental cost could range from $2.1 to $5 billion (for commercial and DOE sites), depending on whether the limit is implemented on a Regional or National basis.

Impact on BRC Disposal

Unlike LLW disposal, it is possible to show that the economic assessment of alternative BRC criteria is unlikely to be affected by the proposed groundwater protection standards, at least for the proposed level of the BRC criterion of 4 millirem per year. Except for the relatively rare Class I aquifers, the proposed groundwater standards under both Option I and Option II are equal to or above the 4 millirem per year MCL and the proposed BRC criterion. Furthermore, the contribution of the groundwater pathway to the estimated CPG dose from unregulated disposal is always less than 4 millirem (in the worst hydrogeologic region, even for higher BRC alternatives, including 15 millirem per year). For BRC criteria of 4 millirem and above, the controlling CPG dose pathway is direct gamma radiation to onsite workers or transportation workers. The CPG dose from the groundwater pathway is less than 1 millirem per year at the proposed 4 millirem per year BRC criterion.

PROPOSED PREDISPOSAL MANAGEMENT STANDARD

EPA is proposing a 25 millirem per year CPG dose limit for low-level radioactive waste management operations prior to disposal. This standard applies to the cumulative dose from all exposure pathways measured at the boundary of facilities managed by DOE or licensed by the NRC.

Predisposal management is the preparation of the waste for disposal and includes packaging, compaction, incineration, and solidification processes, either current or future. These activities could be carried out, for example, at LLW generator sites (power plants, industrial sites, hospitals and medical centers, DOE sites), at or adjacent to LLW disposal facilities during operation, or at future regional facilities designed to serve a State or an entire Compact.

Several existing EPA regulations already limit the CPG dose from certain exposure pathways and certain LLW facilities to 25 millirem per year or less. The existence of these regulations is a principal reason why EPA believes that the additional impact of the proposed predisposal management standard is likely to be small. The Radionuclide Emissions Standards for Hazardous Air Pollutants [EPA73], which were promulgated under the Clean Air Act and are codified in 40 CFR 61, Subparts H (DOE facilities) and I (NRC licensed facilities), limit radiation exposures from air emissions of radionuclides to 25 millirem per year at the facility boundary (excluding radon-220 and -222 and their decay products). This standard would apply to airborne emissions at LLW facilities both before and after disposal. The Uranium Fuel Cycle Standard, which was promulgated under the Atomic Energy Act in 1977 and is codified at 40 CFR 190, is also a 25 millirem annual dose limit and covers all pathways from facilities in the Uranium Fuel Cycle, including uranium milling facilities, uranium hexafluoride conversion facilities, enrichment facilities, fuel fabrication plants, commercial nuclear power plants, and commercial fuel reprocessing plants. This standard does cover waste processing facilities onsite at the fuel cycle facilities. However, the Fuel Cycle Standard does not cover mines, transportation of radioactive waste, or offsite waste processing facilities. The latter category would be covered under EPA's proposed Predisposal Management standard. Hence, the exposures most obviously affected by the Predisposal Management standard include those from spills and direct radiation at LLW surface storage or volume reduction facilities (e.g., biomedical waste incinerators), or regional storage, transfer, or treatment facilities. Certain DOE facilities could also be affected; however, specific facility types have not been identified.

Impacts on LLW Predisposal Management

Although EPA has not performed the quantitative cost or risk assessments that would be necessary to assess the economic impacts of the proposed Predisposal Management standard, such assessments would first require identification of potential exposure pathways that are not already limited by existing regulations or standards. Since the proposed standard represents a limit on the cumulative dose from all pathways, the contribution of the air pathway, even though limited by the Clean Air Act emissions standards, would need to be quantified, including exposure resulting from surface spillage, followed by air entrainment and offsite transport.

Permanent emplacement of waste at facilities covered by either 40 CFR 190 or this Predisposal Management standard is not contemplated. Therefore, groundwater releases resulting from normal waste leaching processes (such as occur at disposal sites) are unlikely, although they could conceivably result from spillage during operations. Similarly, it is theoretically possible that offsite contamination could occur as a result of spillage and surface runoff during a rainstorm (or flood). Finally, if waste treatment or storage vessels are located close to the boundary of the site, external direct gamma radiation could also cause exposure to individuals at the site boundary in excess of 25 millirem per year.

In summary, the additional costs of meeting the proposed 25 millirem Predisposal Management standard would probably result from actions to control spillage (e.g., by the use of good housekeeping practices and proper design of handling equipment) or to limit direct gamma radiation (e.g., by placing storage bins away from the facility boundary). Conceptually, reduction of air emissions could also be used to meet the predisposal standard, if such reduction proved to be a less expensive means of meeting the standard. The costs of specific measures that may be necessary to meet the proposed Predisposal Management standard have not been quantified, but due to the small additional measures that are envisioned to be required, these costs can be expected to be minimal.

PROPOSED EFFECTIVE DATE OF THE STANDARDS

EPA is proposing that its Post- and Predisposal Management standards be applied at commercial facilities as soon as such facilities seek new or renewed licenses. Application of these standards is proposed to commence three years after promulgation (January 1, 1993) for new or present DOE facilities if they are to continue operation.

Deferral of the effective date of these standards has both cost and benefit implications. First, until the standards take effect, some disposal practices may continue to exceed the standards (this is most likely for DOE facilities, which currently employ a disposal technology which may exceed a 25 millirem per year CPG dose in humid permeable hydrogeologic regions). The second impact is that short-term costs (in excess of the costs already included in the cost-effectiveness analysis of alternative LLW standards) are avoided. The cost analysis presented in Chapter 8 implicitly assumes that disposal site operators and engineers will design and build a new facility that complies with the standard. No costs are considered "sunk" costs (i.e., costs that are already incurred), such as the capital costs at an existing site; sunk costs would not be included in the assessment of the incremental costs of the standard. On the other hand, transitional costs (e.g., the lost value of the remaining capacity at existing sites) are reduced by delaying the effective date, as are unusual costs that reflect current conditions that will change by 1993 (e.g., transportation of the waste as much as 2,000 miles, for generators located far away from the three disposal facilities now accepting waste, and disposal tariffs under LLWPA85, for generators located outside of Compacts that host one of the three operating commercial sites). Were it possible to quantify both the short-term costs (avoided by deferral of the effective date) and the interim short-term risks, it would be possible to construct a cost-effectiveness ratio that compared immediate implementation to the proposed deferred implementation. However, based on the foregoing qualitative discussion, this ratio appears likely to be large (high transitional costs, low incremental risks).

As part of its regulatory analysis, EPA considers the economic impact of its regulations on small businesses and, in particular, whether small businesses would be substantially or disproportionately affected. To support EPA's analysis, the overall objective of this chapter is to evaluate the distribution of costs among various groups resulting from the implementation of EPA's proposed standards.

The incremental costs borne by commercial enterprises resulting from the implementation of EPA's standards package -- which includes a 25 millirem LLW standard, a 4 millirem BRC limit, a 2 nanocurie per gram and 0.05 millicurie NARM limit, a zero to 25 or zero to 4 millirem groundwater limit (depending on groundwater option), and a 25 millirem predisposal limit -- are expected to be either very small or negative (i.e., a net savings).* Accordingly, this analysis will address the distributional impacts associated with EPA's proposed standards package in a qualitative manner only.

The discussion will focus first on the overall impacts expected from the implementation of each component of the standards package. Next, the types of industries expected to bear these impacts will be identified. Finally, the distribution of the impacts among the parties will be specified to the extent possible, with particular consideration given to whether additional costs will be imposed upon small businesses.

* As discussed in Chapter 9, the impact on commercial LLW disposal of groundwater Option II could be significant since it might require more expensive disposal technology.

IMPACTS OF THE STANDARDS PACKAGE

The LLW Disposal Standard

The proposed 25 millirem per year LLW disposal standard is not expected to change current disposal practice (i.e., 10 CFR 61 disposal) in the commercial sector. As a result, the economic impacts associated with implementing this standard are zero for commercial LLW disposal. However, current practice at DOE waste sites, as defined by EPA, involves shallow land disposal which will not always meet (i.e., in all regions) the proposed 25 millirem LLW standard. However, the additional cost borne by DOE sites is not a distributional issue since this incremental cost will ultimately be borne by taxpayers and, therefore, will be widely distributed. Furthermore, the overall impact on DOE waste disposal is expected to result in a net savings to society as a result of the savings associated with the BRC criterion.

The BRC Criterion

The proposed 4 millirem BRC criterion is expected to produce substantial savings for the economy -- approximately $400 million for commercial LLW disposal and $220 million for DOE LLW disposal under National Implicit implementation, or $310 million for commercial and $180 million for DOE under National Explicit implementation. The estimated savings of $220 or $180 million for DOE waste are based on EPA assumptions explained in Appendix G. As discussed below, the BRC criterion will produce substantial revenue increases for some businesses, but may also result in revenue losses for others.

The NARM Limit

The combined 2 nanocurie per gram (specific activity) and 0.05 millicurie per package (total activity) NARM limit will result in an additional cost to society ranging from zero to $23 million, depending on base case as explained in Chapter 6. Current disposal practice for NARM waste, which is somewhat difficult to define given the different regulatory treatment by the states, is assumed to range from unregulated disposal to disposal in an Improved Shallow Land Disposal (ISD) site in the solidified waste form for both R-RASOURC and R-RAIXRSN. All other NARM waste is assumed to be disposed at an unregulated disposal site. Since the unregulated disposal of R-RASOURC and R-RAIXRSN will not meet the NARM limit, generators of these wastes could bear the additional cost of regulated disposal if they had otherwise planned on unregulated disposal. These generators would include municipal water systems using filters to remove radium or uranium from water (for R-RAIXRSN), and laboratories, hospitals, and academic institutions currently possessing radium sources (R-RASOURC).

The Groundwater Standards

As discussed in Chapter 9, the proposed groundwater standards will have no additional economic impact on sites located above Class III aquifers or Class II low yield aquifers under Option I, since the groundwater CPG dose would already be limited to less than 25 millirem per year under the LLW standard. However, under Option I, additional costs associated with either resiting or more expensive disposal could result if an otherwise acceptable site is above a Class I aquifer (where no degradation is permitted) or a Class II high yield aquifer (which is subject to a 4 millirem per year limit). Under Option II, additional costs are likely to be significant (ranging from $2.1 billion to $5 billion, depending on implementation) since the groundwater standards (4 millirem or below under this option) would constitute effectively a lower LLW standard, since groundwater is often the controlling pathway. In Chapter 9, the analysis demonstrates that resiting costs are small (ranging from $3.9 million to $72 million) relative to the additional costs associated with an alternative way to meet the groundwater standard -- i.e., using a more expensive disposal technology to meet the groundwater standard. The groundwater standards under both Option I and Option II are expected to have little or no impact on the generators of BRC waste since all of the groundwater standards are equal to or above the 4 millirem proposed BRC criterion, with the exception of the relatively rare Class I aquifers. In any event, generators of commercial LLW would bear the additional impacts; these generators include electric utilities (with nuclear power plants), institutional, industrial, and fuel cycle generators or commercial LLW, and DOE LLW generators.

The Predisposal Management Standard

Finally, as mentioned in Chapter 9, EPA expects that the 25 millirem predisposal management standard will result in little additional cost since several existing EPA regulations already limit the CPG dose from certain exposure pathways and certain LLW facilities [CAA67, DOT83, EPA73, EPA76, EPA77, SDWA74]. The additional costs of meeting this standard would probably result from actions to control spillage (e.g., by the use of good housekeeping practices and proper design of handling equipment) or to limit direct gamma radiation (e.g., by placing storage bins away from the facility boundary).

IDENTIFICATION OF INDUSTRIES BEARING THE IMPACTS

Social Versus Out-of-Pocket Costs

The previous discussion summarized the incremental societal costs associated with the standards package. As explained in Chapter 3, these costs are based on estimates of the before-tax cash costs paid by the generator. Cash costs are based either on engineering estimates (e.g., for disposal or processing) or on market rates, and are used as a proxy for the cost of real resources (capital, labor, etc.) used in the disposal of the waste. Throughout the EIA, and in this chapter, only incremental costs are considered as impacts, i.e., only those additional costs which are attributable to this standards package. These estimates of social (real resource) cost may diverge from disposal costs paid by generators for a variety of reasons.

One reason for this difference between social cost and prices paid involves the distortion of societal costs by the introduction of taxes into the analysis. In the case of inter-Compact waste shipments, where a substantial surcharge will be imposed under the LLWPA Amendments, actual disposal costs paid by the waste generator will exceed those estimated in this EIA. As discussed in Chapter 8, the segregation of waste into lower activity substreams could result in additional BRC savings to some generators. As disposal costs rise, the role of volume reduction may become more significant. Volume reduction is important in estimating the distributional impact since wealth would be transferred from disposal site operators and waste transporters (which would lose volume) to the LLW processing business. Finally, determining who will bear the costs or savings (i.e., the actual price paid by a given firm) depends on how much can be passed through from seller to buyer. This pass-through of the BRC savings or the additional costs associated with the other components of the standards package is a function of the demand and supply elasticities in a given industry.

In summary, the out-of-pocket expenses (or savings) for those industries that are affected by EPA's proposed standards package may not necessarily be equivalent to the societal costs presented above. Assuming this divergence is small, however, the following discussion identifies the industries that will be affected by the proposed standards package.

Industries That Benefit Financially

The most significant impact will be on those industries currently generating wastes that are expected to meet the BRC criterion. Under either National Implicit or National Explicit implementation, fuel cycle wastes will meet the 4 millirem BRC criterion, resulting in a $106 million savings for the fuel fabrication industry and a $7 million savings for the two firms engaged in uranium hexafluoride conversion. Industrial facilities outside the nuclear fuel cycle which generate source and special nuclear material (N-SSTRASH and N-SSWASTE), generally those facilities that process and fabricate depleted uranium and manufacture chemicals or products containing uranium, will also realize a $146 million savings. Electric utilities operating pressurized water reactors using ion-exchange resins in their secondary condensate polishing systems (P-CONDRSN) or light water reactors generating low activity waste oils (L-WASTOIL) will collectively realize a $35 million savings. Institutional facilities (e.g., hospitals) using liquid scintillation vials (I-LQSCNVL) will save $25 million. Generators of consumer wastes will not be affected by the proposed standards package. Under National Implicit implementation, two additional institutional wastes will also meet the 4 millirem BRC criterion (I-BIOWAST and I-ABSLIQD), resulting in a $27 million savings for the institutional facilities generating this waste, e.g., universities and medical schools engaged in research. In addition, two low activity industrial wastes (N-LOTRASH and N-LOWASTE) will meet the BRC criterion, resulting in a $56 million savings to firms generating this waste, e.g., pharmaceutical companies, independent testing laboratories, and analytical laboratories.

Another industry for which business volume should increase due to the proposed BRC criterion is unregulated waste disposal facilities.* In comparison to the overall volume of solid waste handled by these facilities, this business volume increase is not expected to be significant.

As mentioned earlier, although not considered to be a distributional issue, EPA believes that, except for the potential impact of the groundwater limits under Option II, the net impact on DOE waste disposal is expected to be positive since the BRC savings are expected to more than offset the additional costs associated with complying with the 25 millirem LLW standard.

Other industries that potentially benefit from the implementation of EPA's standards package are owners of waste processing and storage

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* Unregulated with respect to radiation hazards.

facilities. If, due to surcharges, disposal costs are higher than the estimates used in this study, the business volume of facilities engaged in either volume reduction or interim storage should increase. This increase would be offset by the potential loss of business at existing processing facilities due to implementation of the BRC criterion which, by allowing unregulated disposal, would reduce the volume of waste that must be processed.

Industries That Lose Financially

Industries that bear additional costs or lose revenues due to implementation of the standards package include, as a result of the NARM limit, municipalities engaged in the use of ion-exchange media for purposes of removing radium or uranium from groundwater supplies, as well as current holders of radium sources. The incremental cost of disposing R-RAIXRSN in a regulated fashion is $20 million. This negative impact is not expected to significantly affect small businesses in the local community since the additional cost is likely to be spread widely through a tax or water fee increase. The incremental cost of the NARM limit with respect to R-RASOURC is at most $3.3 million. This cost represents an average incremental cost per source on the order of $530, although some sources could cost as much as $2,000 to dispose, as noted in Chapter 6. Since no single generator is assumed to hold a large number of sources, this cost is not believed to have an important impact. As noted earlier, the NARM limit impacts could be much smaller (perhaps zero), depending on the choice of base (i.e., what current practice really is).

Current transporters of LLW could lose $160 million in total revenues (1985 present value over 20 years) as a result of the BRC criterion, since roughly 25 percent of LLW volume could meet the 4 millirem criterion. This revenue loss (which is equal to $18.8 million per year) represents less than 3.6 percent on average of the total revenues of companies involved in LLW transport. LLW transport is dominated by a few relatively large companies, some of which are involved in other phases of LLW disposal and other business activity. 1985 revenues for four such companies -- Tri-State Transit Co., Chemical Waste Management (Chem-Nuclear), Pacific Nuclear Systems, and American Ecology (U.S. Ecology) -- were $521 million. The total revenue loss to the industry of $18.8 million represents 3.6 percent of the revenues for these four companies ($521 million).

As noted earlier, impacts due to the LLW standard are not assumed to present distributional issues since only DOE would bear additional costs. However, the groundwater limits could require significant costs if a more costly disposal technology is required (more likely under Option II, as explained in Chapter 9). While a quantitative analysis was not performed, it is likely that many generators would be able to pass these costs on to customers (this is especially true for electric utilities). In addition, small business are very unlikely to be large generators of radioactive wastes; hence, impacts on small businesses are unlikely to be large. For utilities, some institutional generators, and some industrial generators, BRC savings could partially affect cost increases.

Summary

In summary, businesses that may benefit (by reducing cost or raising revenue) from implementing the EPA standards package include waste generators and unregulated disposal site operators, largely as a result of the BRC criterion. Businesses that may bear additional costs or lose revenue are limited to current transporters of LLW, municipalities using ion-exchange resins as a media to remove radium from the community water supply, and current holders of NARM sources. However, these impacts are unlikely to be material. Finally, significant costs could arise if Option II were chosen as the groundwater standard. These costs are unlikely to pose distributional issues and would be offset by BRC savings.

This appendix documents the assumptions used to estimate the as generated volumes for each waste considered in this analysis, for the period between 1985 and 2004, inclusive. Volume projections for each hydrogeologic region and for the U.S. in total were presented in Chapters 5 and 6 for 37 different wastes. For the purpose of describing the volume projection assumptions, these wastes have been grouped as follows:

A. Twenty-five low-level wastes as defined by EPA, including power reactor, fuel cycle, institutional, and industrial wastes;

B. Two LLW substreams (L-WASTOIL and P-CONDRSN);

C. Two consumer wastes (C-TIMEPCS and C-SMOKDET);

D. Six NARM wastes;

E. BIOMED waste (already deregulated by the NRC); and

F. DOE low-level waste.

In general, the volume estimation procedure captures as much location-specific and waste-specific information as was available regarding the current rates of waste generation and the source of the waste. Volumes were assigned to three hydrogeologic regions which reflect different soil permeabilities (permeable, impermeable) and meteorological conditions (humid, arid). The overall volume estimation methodology includes five steps:

1. Estimation of the current (1985) rate of waste generation.

2. Projection of the total U.S. waste volume over the 1985 to 2004 period, incorporating explicit assumptions about the average growth in waste generation rates (using current generation rate as a base).

3. Allocation of U.S. waste volumes to individual States based on historical State-by-State waste generation, U.S. population, or waste-specific information, depending on the waste.

4. Aggregation of State-by-State volumes to Compact volumes, based on the composition of Compacts ratified in LLWPA85, or on EPA assumptions (for States not yet belonging to ratified Compacts).

5. Assignment of each Compact to a hydrogeologic region based on EPA assumptions regarding the hydrogeology typical of States within each Compact. This fifth step is necessary in order to project total health effects, since health effects differ among the three hydrogeologic regions included in EPA's risk assessment.

In the following paragraphs, each of these steps is described in more detail for each of the six waste groups listed above.

TWENTY-FIVE LOW-LEVEL WASTES

In general, most of the assumptions used to develop volume estimates for these wastes were derived from DM86, DM84, or DM81, and from compilations of actual LLW generation for the years 1978, 1982, and 1983 [CRCPD83, CRCPD84, NUS80]. Detailed assumptions for each of the five steps in the general methodology are listed below.

Step 1: Estimate current generation rates: DM86 lists generation rates for each of 148 wastes as defined by the NRC. Sixty-eight of the NRC wastes were aggregated to form the 25 LLW streams analyzed by EPA. The remaining 80 NRC wastes, which include D&D waste and other special waste categories, have been excluded from the analysis, as explained in Chapter 3. The correspondence between the 25 EPA and the 68 NRC low-level wastes was listed in Table 3-1 (for the first 25 EPA wastes listed). For three EPA wastes, a large number of NRC wastes were aggregated. The correspondence between these three EPA wastes and their NRC waste counterparts is shown in Table A-1. For each of the 68 NRC wastes, waste volumes were first projected by State and then aggregated to the EPA waste categories. In two cases, the generation rate listed in DM86 was not used in the analysis:

- For the 11 NRC source wastes, the waste volume as generated was assumed to be equal to the volume of a drum (one 55 gallon drum per source), and a total generation of 140 sources per year was assumed, based on both DM86 data and EPA assumptions. Since the volume of a drum is 0.208 cubic meters, the annual generation rate is 29.12 cubic meters per year, in aggregate over the 11 wastes.

- For P-FSLUDGE, DM86 implied a near zero volume generation rate (no rate was actually listed in DM86). Since a quantitative estimate was desired, the earlier estimate from DM81 was used in the analysis (0.002 cubic meters per MW(e) year).

The generation rate for all power reactor wastes and for fuel cycle wastes as listed in DM86 depends on the capacity of nuclear power plants operating in a given year, and on the type of reactor. DM86 distinguishes five reactor types for the purpose of waste generation rate estimates. Assumptions regarding the location, capacity, type, and on- and off-line dates for each nuclear power reactor were derived from Appendix E of DM84, which uses a similar methodology to derive volume estimates.

The NRC generation rates for each of the 68 NRC wastes are listed in Table A-2. The assumptions regarding nuclear power plant on-line dates and reactor type are listed in Table A-3.

Step 2: Project 20-year volumes: Estimation of waste generation growth is included implicitly for fuel cycle and power reactor wastes since the generation rate depends on the number and mix of reactors operating in a given year. Thus, the aggregate growth rate for these wastes is determined by the reactor on-line dates listed in Table A-3. As noted in Chapter 5, Table A-3 includes fairly optimistic assumptions regarding the operation of plants now under construction, since the future operation of a number of nuclear power plants under construction has been questioned by utility rate commissions, and a few reactors have been cancelled. With respect to other LLW (institutional and industrial wastes), a zero generation rate was assumed for most wastes since the generation is tied to specific activities at specific manufacturing sites, or relates to institutional wastes for which volume reduction (including less generation) is being practiced or which have been partially deregulated by the BIOMED rule. The analysis includes 11 exceptions to this "no growth" assumption, including institutional trash and absorbed liquids, industrial low and high activity wastes and trash, and special source waste and trash. For these wastes, the historical rate of increase for industrial wastes between 1982 and 1983 (about three percent) was assumed to continue through 2004.*

Thus, in order to calculate total waste volume over 20 years for wastes with no growth, the generation rate listed in Table A-2 was simply multiplied by 20. For wastes growing at three percent per year, a factor of about 27.7 was used (which reflects the compound growth in generation rate of three percent per year).** To simplify actual calculations, all

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* At the time of this analysis, data on actual waste generation in years after 1983 were not available.

** Algebraically, $27.7 = \sum_{n=1}^{19} (1.03)^n$

annual generation rates (except power reactor and fuel cycle wastes) were multiplied by 20; wastes growing at three percent per year were then multiplied by 1.383 (i.e., 27.7 divided by 20). This factor (1.383) appears in the row labeled "growth factor" in Table A-2; the factor equals one for wastes for which a zero growth rate is assumed.

Step 3: Allocate U.S. volume projections to States: State-by-State allocation of waste generation was determined by the location of the nuclear power plants for all power reactor wastes (the State is indicated in Table A-3). Generation of fuel cycle wastes was allocated to the States in which the fuel cycle processing plants reside, in proportion to fuel cycle plant capacity (listed in EEI84b).

Generation of institutional wastes was allocated to States based on historical waste generation, as listed in NUS80, CRCPD83, and CRCPD84. Since waste generation within a State is often small, the allocation for each State was determined by a weighted sum of waste generated in that State over the three years for which data were available at the time of the analysis (1978, 1982, and 1983), divided by the total U.S. generation (also a three-year weighted sum). Since the BIOMED rule deregulated a significant portion of institutional wastes (which thereby changed the mix of institutional wastes disposed in regulated facilities), more recent years were weighted more heavily. The following weighting was assumed: 100 percent x 1983 + 50 percent x 1982 + 25 percent x 1978. The State-by-State "generation rates" (actually, waste received at commercial disposal facilities) are shown in Table A-4 for institutional waste.

For most of the industrial wastes, an estimate (from DM86) of the fraction of waste generated in each NRC region (as defined in DM86) was also included. In order to allocate U.S. generation to States, first, the DM86 estimates by NRC region were used to allocate generation to one of the five NRC regions (the NRC regional breakdowns are also listed in Table A-2; NRC region is also noted next to the name of each State in Table A-5). Within NRC regions, an unweighted sum of the total actual 1978, 1982, and 1983 State-by-State industrial waste generation was used to allocate generation to each State. These State-by-State industrial waste volumes are shown in Table A-5. In several cases, wastes were identified in DM86 (or its references) as originating from a specific plant. In such cases, the location of the plant was used to determine the State in which the waste was generated.

Table A-6 summarizes the estimated volumes for each of the 68 NRC wastes in each State, using the procedures described above. Table A-7 summarizes the State-by-State volumes for 24 EPA wastes (where P-COTRASH and B-COTRASH have been aggregated to form L-COTRASH).

Step 4: Aggregate State-by-State volumes into Compact volumes: Table A-8 lists the States assumed to be in each of 12 Compacts, as used in the analysis. The Compact definitions correspond to those assumed in LLWPA85 for ratified Compacts, and otherwise represent EPA assumptions regarding the likely composition of Compacts as ultimately ratified. It is emphasized that Compact composition is still in a state of flux; these Compact definitions are used for illustration purposes only. Chapter 8 considers a sensitivity analysis wherein these definitions are changed in order to determine the degree to which estimates of cost and health risk are affected by these assumptions (the impact is shown to be small). Compact volumes were calculated simply by summing the State volumes within each Compact.

Step 5: Assign each Compact to a hydrogeologic region: Table A-8 also lists the hydrogeologic region assigned to each Compact in order to derive estimates of total waste volume by region. The final volume estimates by region for each waste were presented in Chapter 5, Table 5-1. Regional volumes are calculated simply by summing the volumes for the Compacts within the region for each waste.

TWO LLW SUBSTREAMS

Waste volume generation rates for two LLW substreams (L-WASTOIL and P-CONDRSN) were not provided in DM86. From OTHA83 and EEI84c, estimates of the average waste oil generation by BWRs and PWRs, respectively, were calculated to be about 4,600 gallons per year (BWR) and 1,100 gallons per year (PWR). These figures were divided by the average plant size for BWRs and PWRs (837 MW and 937 MW, respectively) to determine an average generation rate of 2.08 E-2 cubic meters per MW-year for BWRs, and 4.44 E-3 cubic meters per MW-year for PWRs. Similarly, Appendix E of DM84 lists the average generation rate of P-CONDRSN as 0.335 cubic feet per MW-year (resins plus pre-coat filter sludge), and assumes that 51 percent of the PWRs will be equipped with secondary condensate polishing systems. These assumptions imply an average generation of about 4.84 E-3 cubic meters per MW-year per PWR.

Once the generation rates are determined, the remainder of the estimation procedure is identical to that used for the 25 LLW, using the nuclear plant data in Table A-3.

TWO CONSUMER WASTES

EPA's analysis of a BRC standard considers two consumer wastes in order to provide a reference point for the risk analysis. The two wastes are americium smoke detectors (C-SMOKDET) and tritiated time pieces (C-TIMEPCS). For both wastes, base generation rates were determined from assumptions listed in EEI84c. The derivation of U.S. total annual generation rates for each waste is as follows:

A. C-SMOKDET: EEI84c notes that 100 million detectors will be in operation by the year 2000. Assuming a 10-year life per detector, this figure (which is assumed to be a steady state number and which implies about 1.2 detectors per single family dwelling) results in a disposal rate of about 10 million detectors per year. At a unit volume of 460 cubic centimeters per detector, the annual disposal volume is 4,600 cubic meters per year.

B. C-TIMEPCS: EEI84c assumes that 6.6 million watches per year (at 30 cubic centimeters per watch) and 0.5 million clocks per year (at 630 cubic centimeters per clock) will be disposed. These assumptions are equal in aggregate to an annual disposal rate of 520 cubic meters per year.

The annual rate of waste generation of both C-SMOKDET and C-TIMEPCS is assumed to remain constant, so 20-year volumes are 92,000 and 10,400 cubic meters, respectively (i.e., current rates are simply multiplied by 20). The U.S. waste volume was distributed among the States based on 1983 State populations. Aggregation to Compacts and regions follows the procedure used for the 25 commercial LLW (i.e., by summing the State volumes within each Compact).

SIX NARM WASTES

The total volumes for each of the six NARM wastes analyzed in Chapter 6 were presented in Table 6-2, together with an assumed density. U.S. total volumes were derived by multiplying annual generation rates (converted to cubic meters per year), as listed in various tables in PEI85a, by 20. This procedure implicitly assumes that the rate of NARM generation will not increase. This assumption is plausible since the most important NARM wastes, i.e., those which EPA is proposing to regulate, are either not yet generated, as for R-RAIXRSN, or are no longer manufactured in a significant quantity, as for R-RASOURC.

In order to estimate health effects by region, regional NARM volumes were also estimated. The allocation of U.S. volume to States, Compacts, and hydrogeologic regions was performed by assuming that NARM generation is proportional to 1983 State population, except for R-RASOURC. R-RASOURC volumes were first allocated to NRC region based on data provided in DM86, which in turn were drawn from the actual volume of sources collected at EPA's Eastern Environmental Radiation Facility in Montgomery, Alabama. 1983 State population was then used to allocate R-RASOURC volumes within an NRC region to each State. Table A-9 lists the estimated NARM generation by Compact and hydrogeologic region.

BIOMED WASTE

Since disposal of BIOMED waste is no longer regulated, statistics regarding the volume of waste generated or disposed are not available. An estimate of the total volume of this waste over the next 20 years was derived from the Value/Impact Statement that accompanied the NRC BIOMED rule (10 CFR Part 20.306). The Value/Impact Statement estimates the annual waste volume of liquid scintillation vials deregulated by the rule at 11,034 cubic meters, and the volume of biomedical waste at 2,294 cubic meters. Thus, in aggregate, 13,328 cubic meters of waste per year were deregulated. Empirical evidence seems to support these volume estimates. The volume of institutional waste shipped to commercial disposal sites declined from 21,248 cubic meters in 1978 to 10,658 cubic meters in 1982, 4,916 cubic meters in 1983, and 2,870 cubic meters in 1984. While other factors may have contributed to this decline, such as increased volume reduction or reduced levels of biomedical research, the figures seem to indicate that the BIOMED rule resulted in a decrease of between 5,000 to 15,000 cubic meters per year in the amount of institutional waste sent to regulated disposal sites.

The 20-year waste volume for BIOMED was estimated assuming no growth in the estimated annual deregulated generation rate; thus, total volume is 266,560 cubic meters (20 times 13,328). This volume was not allocated to State or Compact. However, BIOMED waste was allocated to hydrogeologic region based on the regional volumes of the scintillation vial and biomedical waste components of BIOMED, respectively. The regional volumes are listed in Table 5-1.

DOE WASTE VOLUME

Relative to the methodology of estimating waste generation for the other wastes, the methodology used to estimate DOE waste volume was considerably abbreviated. In essence, total U.S. DOE waste generation was taken directly from DOE86, Table 4-13, where the generation between 1985 and 2004, inclusive, was summed. The generation of saltcrete at the Savannah River Plant was not included in the estimate. In general, the DOE estimates of future waste generation assume no growth in annual generation rate, although historical generation rates have increased.

DOE waste generation by State and hydrogeologic region was determined based on the location of DOE facilities. Tables A-10, A-11, and A-12 illustrate the calculations and procedure. Table A-10 shows the DOE projection of aggregate future generation (the left two columns of Table A-10, which are based on Table 4.13 of DOE86) and the historical generation of the six major DOE facilities (from Table 4.3 of DOE86) over the period 1981-1985. Historical generation is used to allocate future generation to specific facilities. Since facility-specific five-year data on the facilities in the "All Other" category are not listed, total cumulative volume for these facilities (from Table 4.4 in DOE86 and shown in Table A-11) is used to allocate "All Other" generation to specific facilities. Finally, Table A-12 summarizes the State, hydrogeologic region, and waste volume assigned to each DOE "generator" facility, using allocation percentages from

Tables A-10 (for major DOE facilities) and A-11 (for "All Other" DOE facilities). Note that since DOE LLW is assumed to be disposed in facilities separate from commercial LLW disposal sites, designation of a Compact for each facility is unnecessary.

Table A-1

CORRESPONDENCE BETWEEN SELECTED
EPA AND NRC WASTE CATEGORIES

Waste Category	EPA Mnemonic	NRC Mnemonics
1. Isotope Production Waste	N-ISOPROD	N-ISOPROD N-ISOTRSH N-SORMFG1 N-SORMFG2 N-SORMFG3 N-SORMFG4
2. Tritium Waste	N-TRITIUM	N-NECOTRA, N-NEABLIQ, N-NESOLIQ, N-NEVIALS, N-NENCGLS, N-NEWOTAL, N-NETRGAS, N-NETRILI, N-NECARLI, N-MWTRASH, N-MWABLIQ, N-MWSOLIQ, N-MWWASTE, N-TRIPLAT, N-TRITGAS, N-TRISCNT, N-TRILIQD, N-TRITRSH
3. Sealed Sources	N-SOURCES	N-TRITSOR, N-CARBSOR, N-COBLSOR, N-NICKSOR, N-STROSOR, N-CESISOR, N-PLU8SOR, N-PLU9SOR, N-AMERSOR, N-PUBESOR, N-AMBESOR

SOURCE: Putnam, Hayes & Bartlett, Inc., June 1987. NRC mnemonics are listed in Table B-1 of DM86.

Table A-2

NUCLEAR WASTE STREAM GENERATION RATES

WASTE STREAM		P-IXRESIN	P-CONCLIQ	P-FSLUDGE	P-FCARTRG	B-IXRESIN	B-CONCLIQ	B-FSLUDGE	P-COTRASH	P-NCTRASH	B-COTRASH	B-NCTRASH	L-NFRCOMP	L-DECONRS	F-PROCESS	F-COTRASH	F-NCTRASH	U-PROCESS
VOLUME REDUCTION FACTOR		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
PWR-F	1	2.24E-02	1.77E-01	2.00E-03	7.36E-03	0.00E+00	0.00E+00	0.00E+00	1.64E-01	1.55E-01	0.00E+00	0.00E+00	2.79E-02	1.00E-04	2.68E-02	8.09E-02	1.43E-02	9.64E-03
PWR-S	2	6.37E-02	8.67E-02	2.00E-03	1.08E-02	0.00E+00	0.00E+00	0.00E+00	1.97E-01	2.74E-01	0.00E+00	0.00E+00	2.79E-02	1.00E-04	2.68E-02	8.09E-02	1.43E-02	9.64E-03
BWR-FDB	3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.90E-02	3.25E-01	3.40E-02	0.00E+00	0.00E+00	2.87E-01	7.00E-02	2.79E-02	3.00E-03	2.68E-02	8.09E-02	1.43E-02	9.64E-03
BWR-FFD	4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.82E-02	0.00E+00	2.23E-01	0.00E+00	0.00E+00	3.98E-01	2.76E-01	2.79E-02	3.00E-03	2.68E-02	8.09E-02	1.43E-02	9.64E-03
BWR-S	5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-01	3.78E-01	2.64E-01	0.00E+00	0.00E+00	9.87E-01	5.09E-01	2.79E-02	3.00E-03	2.68E-02	8.09E-02	1.43E-02	9.64E-03

KEY:
- PWR-F = PRESSURIZED WATER REACTORS - FRESH WATER COOLING
- PWR-S = PRESSURIZED WATER REACTORS - SALT WATER COOLING
- BWR-FDB = BOILING WATER REACTORS - FRESH WATER COOLING; DEEP BED CONDENSATE POLISHING SYSTEM (CPS)
- BWR-FFD = BOILING WATER REACTORS - FRESH WATER COOLING; FILTER/DEMINERALIZER CPS
- BWR-S = BOILING WATER REACTORS - SALT WATER COOLING

SOURCE: Based on data in DN86.

Table continued on following page.

Table A-2 (continued)

INSTITUTIONAL LLW WASTE STREAM GENERATION RATES

WASTE STREAM		I-COTRASH	I+COTRASH	I-ABSLIQD	I+ABSLIQD	I-LIQSCVL	I+LIQSCVL	I-BIOWAST	I+BIOWAST
GROWTH RATE		1.383824	1.383824	1.383824	1.383824	1.00	1.00	1.00	1.00
VOLUME REDUCTION FACTOR		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
GENERATION RATE		5090	5090	201	201	376	376	188	188
% NRC 1	1	31%	31%	31%	31%	31%	31%	31%	31%
% NRC 2	2	22%	22%	22%	22%	22%	22%	22%	22%
% NRC 3	3	27%	27%	27%	27%	27%	27%	27%	27%
% NRC 4	4	8%	8%	8%	8%	8%	8%	8%	8%
% NRC 5	5	12%	12%	12%	12%	12%	12%	12%	12%

Table continued on following page.

Table A 2 (continued)

INDUSTRIAL LLW WASTE STREAM GENERATION RATES

WASTE STREAM		N-SSTRASH	N+SSTRASH	N-SSWASTE	N-LOTRASH	N+LOTRASH	N-LOWASTE	N-ISOPROD	N-ISOTRSH	N-SORMFG1	N-SORMFG2
GROWTH RATE		1.383824	1.383824	1.383824	1.383824	1.383824	1.383824	1.0000	1.0000	1.0000	1.0000
VOLUME REDUCTION FACTOR		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
GENERATION RATE		6494	6494	2292	1833	1833	2179	30	52.2	2.8	253
% NRC 1	1	50.0%	50.0%	50.0%	30.0%	30.0%	30.0%	100.0%	100.0%	100.0%	0.0%
% NRC 2	2	10.0%	10.0%	10.0%	20.0%	20.0%	20.0%	0.0%	0.0%	0.0%	0.0%
% NRC 3	3	20.0%	20.0%	20.0%	30.0%	30.0%	30.0%	0.0%	0.0%	0.0%	0.0%
% NRC 4	4	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	0.0%	0.0%	0.0%	0.0%
% NRC 5	5	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	0.0%	0.0%	0.0%	100.0%

WASTE STREAM		N-SORMFG3	N-SORMFG4	N NECOTRA	N-NEABLIQ	N-NESOLIQ	N NEVIALS	N-NENCGLS	N-NEWTOAL	N-NETRGAS	N-NETRILI	N-NECARLI
GROWTH RATE		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
VOLUME REDUCTION FACTOR		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
GENERATION RATE		0.35	160	158.4	9.9	46.6	0.9	43.7	16.7	0.108	0.972	0.0486
% NRC 1	1	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
% NRC 2	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% NRC 3	3	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% NRC 4	4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
% NRC 5	5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table continued on following page.

Table A-2 (continued)

INDUSTRIAL LLW WASTE STREAM GENERATION RATES

WASTE STREAM		N-MWTRASH	N-MWABLIQ	N-MWSOLIQ	N-MAWASTE	N-TRIPLAT	N-TRITGAS	N-TRISCNT	N-TRILIQD	N-TRITRSH	N-TRIFOIL	N HIGHACT	N-TRITSOR	N CARBSOR	N COBLSOR	N NICKSOR	N-STROSOR	N CESISOR	N-PLUBSOR	N PLUPSOR	N AMERSOR	N-PUBESOR	N AMBESO
GROWTH RATE		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.383824	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1 00	1.00	1.0
VOLUME REDUCTION FACTOR		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0
GENERATION RATE		6.3	0.38	0.36	1.5	4.4	24.6	1.3	7.1	23.9	10.6	94.4	3.491	0.5527	2.7055	1.8909	4.5672	5.3818	1.0763	0	8.9018	0	0.552
% NRC 1	1	0.0%	0.0%	0.0%	0.0%	6.3%	56.9%	16.2%	18.6%	55.6%	89.7%	31.0%	31.0%	31.0%	31.0%	31.0%	31.0%	31.0%	31.0%	31.0%	31.0%	31.0%	31.
% NRC 2	2	0.0%	0.0%	0.0%	0.0%	5.2%	0.0%	67.1%	0.0%	28.3%	9.7%	22.0%	22.0%	22.0%	22.0%	22.0%	22.0%	22.0%	22.0%	22.0%	22.0%	22.0%	22.
% NRC 3	3	100.0%	100.0%	100.0%	100.0%	26.6%	2.4%	11.2%	3.6%	13.2%	0.0%	27.0%	27.0%	27.0%	27.0%	27.0%	27.0%	27.0%	27.0%	27.0%	27.0%	27.0%	27.
% NRC 4	4	0.0%	0.0%	0.0%	0.0%	62.0%	39.2%	5.6%	0.7%	1.9%	0.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8.0%	8
% NRC 5	5	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	77.0%	1.0%	6.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12

Table A-3

PLANT CAPACITY AND ON-LINE DATES

PLANT	UTILITY	STATE	REGION	CAPACITY (MW)	STARTUP	SHUTDOWN	TYPE	
TROJAN	PORTLND	OR	5	1130	1975	2015	PWR	1
WNP 1	WPPSS	WA	5	1218	1989	2029	PWR	1
WNP 2	WPPSS	WA	5	1100	1984	2024	BWR	4
WNP 3	WPPSS	WA	5	1242	1989	2029	PWR	2
PALO VERDE 1	ARIZONA	AZ	5	1270	1985	2025	PWR	1
PALO VERDE 2	ARIZONA	AZ	5	1270	1986	2026	PWR	1
PALO VERDE 3	ARIZONA	AZ	5	1270	1987	2027	PWR	1
DIABLO CANYON 1	PACFG&E	CA	5	1084	1985	2025	PWR	2
DIABLO CANYON 2	PACFG&E	CA	5	1106	1985	2025	PWR	2
HUMBOLDT BAY	PACFG&E	CA	5	50	1960	2000	BWR	5
RANCHO SECO 1	SACRAMN	CA	5	918	1974	2014	PWR	1
SAN ONOFRE 1	SOCALED	CA	5	436	1967	2007	PWR	2
SAN ONOFRE 2	SOCALED	CA	5	1100	1983	2023	PWR	2
SAN ONOFRE 3	SOCALED	CA	5	1100	1984	2024	PWR	2
FORT ST VRAIN	PSCOLO	CO	4	330	1974	2014	HTGR	0
COMANCHE PEAK 1	TEXAS	TX	4	1111	1985	2025	PWR	1
COMANCHE PEAK 2	TEXAS	TX	4	1111	1986	2026	PWR	1
SOUTH TEXAS 1	HOUSTON	TX	4	1250	1987	2027	PWR	2
SOUTH TEXAS 2	HOUSTON	TX	4	1250	1989	2029	PWR	2
ARKANSAS NUCLEAR 1	ARKP&L	AR	4	850	1974	2014	PWR	1
ARKANSAS NUCLEAR 2	ARKP&L	AR	4	912	1980	2020	PWR	1
WOLF CREEK	KANSAS	KS	4	1150	1985	2025	PWR	1
RIVER BEND 1	GULFSTS	LA	4	934	1985	2025	BWR	3
WATERFORD 3	LOUIP&L	LA	4	1113	1985	2025	PWR	1
COOPER	NEBRASK	NE	4	778	1974	2014	BWR	4
FORT CALHOUN 1	OMAHA	NE	4	457	1973	2013	PWR	1
DUANE ARNOLD	IOWA	IA	3	538	1974	2014	BWR	4
BIG ROCK POINT	CONSPOW	MI	3	72	1962	2002	BWR	3
COOK 1	INDMICH	MI	3	1054	1975	2015	PWR	1
COOK 2	INDMICH	MI	3	1100	1978	2018	PWR	1
ENRICO FERMI 2	DETROIT	MI	3	1093	1985	2025	BWR	4
PALISADES	CONSPOW	MI	3	805	1971	2011	PWR	1
MONTICELLO	NSP	MN	3	545	1970	2010	BWR	4
PRAIRIE ISLAND 1	NSP	MN	3	530	1973	2013	PWR	1
PRAIRIE ISLAND 2	NSP	MN	3	530	1974	2014	PWR	1
CALLAWAY 1	UNION	MO	3	1120	1985	2025	PWR	1
DAVIS BESSE 1	TOLEDED	OH	3	906	1977	2017	PWR	1
PERRY 1	CLEVELD	OH	3	1205	1985	2025	BWR	3
PERRY 2	CLEVELD	OH	3	1205	1990	2030	BWR	4
GENOA 2	DAIRYLD	WI	3	50	1967	2007	BWR	3
KEWAUNEE	WISCONS	WI	3	535	1974	2014	PWR	1
POINT BEACH 1	WISCONS	WI	3	497	1970	2010	PWR	1
POINT BEACH 2	WISCONS	WI	3	497	1972	2012	PWR	1
BRAIDWOOD 1	COMMED	IL	3	1120	1986	2026	PWR	1
BRAIDWOOD 2	COMMED	IL	3	1120	1987	2027	PWR	1
BYRON 1	COMMED	IL	3	1120	1985	2025	PWR	1
BYRON 2	COMMED	IL	3	1120	1986	2026	PWR	1
CARROLL COUNTY 1	COMMED	IL	3	1120	2001	2041	PWR	1
CARROLL COUNTY 2	COMMED	IL	3	1120	2002	2042	PWR	1
CLINTON 1	ILLPOWR	IL	3	933	1986	2026	BWR	4
DRESDEN 1	COMMED	IL	3	50	1970	2011	BWR	3
DRESDEN 2	COMMED	IL	3	50	1970	2011	BWR	3
DRESDEN 2	COMMED	IL	3	744	1970	2010	BWR	3
DRESDEN 3	COMMED	IL	3	794	1971	2011	BWR	3
LASALLE 1	COMMED	IL	3	1078	1982	2022	BWR	3
LASALLE 2	COMMED	IL	3	1078	1984	2024	BWR	3
QUAD CITIES 1	COMMED	IL	3	789	1972	2012	BWR	4
QUAD CITIES 2	COMMED	IL	3	789	1972	2012	BWR	4
ZION 1	COMMED	IL	3	1040	1973	2013	PWR	1
ZION 2	COMMED	IL	3	1040	1973	2013	PWR	1
BELLEFONTE 1	TVA	AL	2	1213	1989	2029	PWR	1
BELLEFONTE 2	TVA	AL	2	1213	1991	2031	PWR	1
BROWN'S FERRY 1	TVA	AL	2	1065	1973	2013	BWR	4
BROWN'S FERRY 2	TVA	AL	2	1065	1974	2014	BWR	4
BROWN'S FERRY 3	TVA	AL	2	1065	1976	2016	BWR	4
FARLEY 1	ALABAMA	AL	2	829	1977	2017	PWR	1
FARLEY 2	ALABAMA	AL	2	829	1981	2021	PWR	1

Table continued on following page.

September 1987

PLANT CAPACITY AND ON-LINE DATES

PLANT	UTILITY	STATE	REGION	CAPACITY (MW)	STARTUP	SHUTDOWN	TYPE	
CRYSTAL RIVER 3	FLORP&L	FL	2	825	1977	2017	PWR	2
ST. LUCIE 1	FLORP&L	FL	2	802	1976	2016	PWR	2
ST. LUCIE 2	FLORP&L	FL	2	810	1983	2023	PWR	2
TURKEY POINT 3	FLORP&L	FL	2	693	1972	2012	PWR	2
TURKEY POINT 4	FLORP&L	FL	2	693	1973	2013	PWR	2
HATCH 1	GEORGIA	GA	2	786	1974	2014	BWR	4
HATCH 2	GEORGIA	GA	2	784	1978	2018	BWR	4
VOGTLE 1	GEORGIA	GA	2	1110	1987	2027	PWR	1
VOGTLE 2	GEORGIA	GA	2	1100	1988	2028	PWR	1
GRAND GULF 1	MISSP&L	MS	2	1250	1985	2025	BWR	3
GRAND GULF 2	MISSP&L	MS	2	1250	1989	2029	BWR	4
BRUNSWICK 1	CAROLNA	NC	2	821	1976	2016	BWR	5
BRUNSWICK 2	CAROLNA	NC	2	821	1975	2015	BWR	5
HARRIS 1	CAROLNA	NC	2	900	1986	2026	PWR	1
MCGUIRE 1	DUKEPOW	NC	2	1180	1981	2021	PWR	1
MCGUIRE 2	DUKEPOW	NC	2	1180	1984	2024	PWR	1
CATAWBA 1	DUKEPOW	SC	2	1145	1986	2026	PWR	1
CATAWBA 2	DUKEPOW	SC	2	1145	1987	2027	PWR	1
OCONEE 1	DUKEPOW	SC	2	887	1973	2013	PWR	1
OCONEE 2	DUKEPOW	SC	2	887	1973	2013	PWR	1
OCONEE 3	DUKEPOW	SC	2	887	1974	2014	PWR	1
ROBINSON 2	CAROLNA	SC	2	700	1970	2010	PWR	1
SUMMER	SOCAROL	SC	2	900	1984	2024	PWR	1
SEQUOYAH 1	TVA	TN	2	1148	1981	2021	PWR	1
SEQUOYAH 2	TVA	TN	2	1148	1982	2022	PWR	1
WATTS BAR 1	TVA	TN	2	1177	1985	2025	PWR	1
WATTS BAR 2	TVA	TN	2	1177	1988	2028	PWR	1
NORTH ANNA 1	VEPCO	VA	2	907	1978	2018	PWR	1
NORTH ANNA 2	VEPCO	VA	2	907	1980	2020	PWR	1
SURRY 1	VEPCO	VA	2	822	1972	2012	PWR	2
SURRY 2	VEPCO	VA	2	822	1973	2013	PWR	2
BEAVER VALLEY 1	DUQUESN	PA	1	852	1976	2016	PWR	1
BEAVER VALLEY 2	DUQUESN	PA	1	833	1986	2026	PWR	1
LIMERICK 1	PECO	PA	1	1065	1985	2025	BWR	4
LIMERICK 2	PECO	PA	1	1065	1988	2028	BWR	5
PEACH BOTTOM 2	PECO	PA	1	1065	1973	2013	BWR	4
PEACH BOTTOM 3	PECO	PA	1	1065	1974	2014	BWR	4
SUSQUEHANNA 1	PENNP&L	PA	1	1050	1983	2023	BWR	4
SUSQUEHANNA 2	PENNP&L	PA	1	1050	1985	2025	BWR	4
THREE MILE ISLAND 1	METED	PA	1	50	1979	1986	PWR	1
THREE MILE ISLAND 1	METED	PA	1	819	1974	1979	PWR	1
THREE MILE ISLAND 1	METED	PA	1	819	1986	2014	PWR	1
THREE MILE ISLAND 2	METED	PA	1	100	1979	1990	PWR	1
THREE MILE ISLAND 2	METED	PA	1	906	1990	2019	PWR	1
HADDAM NECK	CTYANK	CT	1	575	1967	2007	PWR	1
MILLSTONE 1	NORTHEA	CT	1	660	1970	2010	BWR	5
MILLSTONE 2	NORTHEA	CT	1	870	1975	2015	PWR	2
MILLSTONE 3	NORTHEA	CT	1	1156	1986	2026	PWR	2
PILGRIM 1	BOSTON	MA	1	655	1974	2014	BWR	5
YANKEE ROWE	YANKATM	MA	1	175	1960	2000	PWR	1
CALVERT CLIFFS 1	BALTG&E	MD	1	845	1974	2014	PWR	2
CALVERT CLIFFS 2	BALTG&E	MD	1	845	1974	2014	PWR	2
HOPE CREEK 1	PSE&G	NJ	1	1067	1986	2026	BWR	5
OYSTER CREEK	JCP&L	NJ	1	650	1969	2009	BWR	5
SALEM 1	PSE&G	NJ	1	1090	1976	2016	PWR	2
SALEM 2	PSE&G	NJ	1	1115	1981	2021	PWR	2
FITZPATRICK	NYPOW	NY	1	821	1974	2014	BWR	3
GINNA 1	ROCHEST	NY	1	470	1969	2009	PWR	1
INDIAN POINT 1	CONSED	NY	1	50	1973	2013	PWR	2
INDIAN POINT 2	CONSED	NY	1	873	1973	2013	PWR	2
INDIAN POINT 3	NYPOW	NY	1	965	1976	2016	PWR	2
NINE MILE POINT 1	NIAGMHK	NY	1	620	1969	2009	BWR	3
NINE MILE POINT 2	NIAGMHK	NY	1	1100	1986	2026	BWR	4
SHOREHAM	LILCO	NY	1	819	1985	2025	BWR	5

Table continued on following page.

Table A-3 (Continued)

PLANT CAPACITY AND ON-LINE DATES

PLANT	UTILITY	STATE	REGION	CAPACITY (MW)	STARTUP	SHUTDOWN	TYPE	
MAINE YANKEE	MEYANKEE	ME	1	825	1972	2012	PWR	2
SEABROOK 1	PSNH	NH	1	1200	1986	2026	PWR	2
SEABROOK 2	PSNH	NH	1	1200	1992	2032	PWR	2
VERMONT YANKEE	VTYANK	VT	1	514	1972	2012	BWR	4

KEY: PWR = PRESSURIZED WATER REACTOR
BWR = BOILING WATER REACTOR
HTGR = HIGH TEMPERATURE GRAPHITE REACTOR

SOURCE: Based on data in DM84.

Table A-4

HISTORICAL INSTITUTIONAL LLW WASTE GENERATION
(cubic meters, as disposed)*

STATE	NRC REGION	1983	1982	1978
ALASKA	5	0	0	33
HAWAII	5	6	4	107
IDAHO	4	0	0	67
MONTANA	5	2	1	90
OREGON	4	28	100	217
UTAH	4	34	109	134
WASHINGTON	5	92	181	265
ARIZONA	5	0	1	201
CALIFORNIA	5	1,028	1,383	1,624
COLORADO	4	40	47	240
NEW MEXICO	4	39	47	142
NEVADA	5	0	125	106
WYOMING	4	0	0	37
TEXAS	4	0	859	1,355
ARKANSAS	4	7	8	221
KANSAS	4	0	2	319
LOUISIANA	4	8	15	445
NEBRASKA	4	0	25	293
OKLAHOMA	4	8	78	295
NORTH DAKOTA	4	0	0	141
SOUTH DAKOTA	4	0	0	159
IOWA	3	31	56	290
INDIANA	3	18	27	365
MICHIGAN	3	119	219	671
MINNESOTA	3	153	367	529
MISSOURI	3	83	171	618
OHIO	3	137	108	938
WISCONSIN	3	4	12	411
ILLINOIS	3	61	1,187	1,056
KENTUCKY	2	74	51	312
ALABAMA	2	49	3	375
FLORIDA	2	11	200	681
GEORGIA	2	5	225	499
MISSISSIPPI	2	1	0	265
NORTH CAROLINA	2	280	254	571
SOUTH CAROLINA	2	156	9	293
TENNESSEE	2	109	115	594
VIRGINIA	2	122	297	465
PENNSYLVANIA	1	395	347	1,200
WEST VIRGINIA	2	20	11	278
CONNECTICUT	1	264	229	280
DELAWARE	1	6	11	38
MASSACHUSETTS	1	208	2,137	665
MARYLAND	1	137	529	391
NEW JERSEY	1	221	433	458
NEW YORK	1	790	634	1,830
RHODE ISLAND	1	50	14	115
WASHINGTON, DC	1	98	0	269
MAINE	1	0	4	91
NEW HAMPSHIRE	1	2	18	118
VERMONT	1	20	5	103

* As disposed = waste as received at commercial disposal sites.

SOURCE: Based on data in NUS80, CRCPD83, CRCPD84 and other sources.

Table A-5

HISTORICAL INDUSTRIAL LLW WASTE GENERATION
(cubic meters, as disposed)*

STATE	NRC REGION	1983	1982	1978
ALASKA	5	0	0	23
HAWAII	5	0	0	44
IDAHO	4	0	0	54
MONTANA	5	0	1	60
OREGON	4	1,127	611	149
UTAH	4	52	56	141
WASHINGTON	5	732	465	795
ARIZONA	5	0	2	144
CALIFORNIA	5	1,746	2,666	1,444
COLORADO	4	0	1	169
NEW MEXICO	4	0	6	75
NEVADA	5	0	0	40
WYOMING	4	0	0	105
TEXAS	4	1,613	970	808
ARKANSAS	4	0	7	138
KANSAS	4	0	12	150
LOUISIANA	4	8	15	25
NEBRASKA	4	0	16	104
OKLAHOMA	4	56	25	291
NORTH DAKOTA	4	0	0	41
SOUTH DAKOTA	4	0	0	25
IOWA	3	20	10	104
INDIANA	3	2	7	290
MICHIGAN	3	26	33	414
MINNESOTA	3	534	234	194
MISSOURI	3	147	130	361
OHIO	3	557	568	844
WISCONSIN	3	1	4	289
ILLINOIS	3	1,354	2,114	775
KENTUCKY	2	0	5	225
ALABAMA	2	44	1	240
FLORIDA	2	10	300	544
GEORGIA	2	10	64	328
MISSISSIPPI	2	0	0	156
NORTH CAROLINA	2	650	2,559	3,179
SOUTH CAROLINA	2	2,979	2,607	1,493
TENNESSEE	2	3,672	2,764	481
VIRGINIA	2	838	889	584
PENNSYLVANIA	1	1,883	1,388	1,428
WEST VIRGINIA	2	0	0	223
CONNECTICUT	1	172	280	382
DELAWARE	1	24	27	51
MASSACHUSETTS	1	3,658	3,958	518
MARYLAND	1	476	108	275
NEW JERSEY	1	320	213	746
NEW YORK	1	1,671	610	1,215
RHODE ISLAND	1	2	136	45
WASHINGTON, DC	1	0	0	22
MAINE	1	18	6	63
NEW HAMPSHIRE	1	5	24	55
VERMONT	1	202	1	20

* As disposed = waste as received at commercial disposal sites.

SOURCE: Based on data in NUS80, CRCPD83, CRCPD84 and other sources.

Table A-6

PROJECTED WASTE VOLUME BY NRC WASTE

(cubic meters as generated)

1985 to 2004

STATE	NRC	P-IXRESIN	P-CONCLIQ	P-FSLUDGE	P-FCARTRG	B-IXRESIN	B CONCLIQ	B FSLUDGE	P COTRASH	P NCTRASH	B COTRASH	B NCTRASH	L-NFRCOMP	L DECONRS	F-PROCESS	F-COTRASH	F NCTRASH	U PROCESS
ALASKA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HAWAII	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IDAHO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MONTANA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OREGON	4	506.2	4,000.2	45.2	166.3	0.0	0.0	0.0	3,706.4	3,503.0	0.0	0.0	630.5	2.3	0.0	0.0	0.0	0.0
UTAH	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WASHINGTON	5	1,649.2	5,010.6	76.3	346.9	840.4	0.0	4,906.0	6,888.6	8,201.0	8,756.0	6,072.0	1,677.6	69.8	16707.5	50434.1	8914.8	0.0
ARIZONA	5	1,578.9	12,475.8	141.0	518.8	0.0	0.0	0.0	11,559.5	10,925.2	0.0	0.0	1,966.5	7.0	0.0	0.0	0.0	0.0
CALIFORNIA	5	6,489.8	11,523.1	227.6	1,165.7	134.1	293.0	204.6	21,809.8	28,992.3	764.9	394.5	3,196.2	13.7	0.0	0.0	0.0	0.0
COLORADO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NEW MEXICO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NEVADA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WYOMING	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TEXAS	4	3,573.3	11,049.0	166.9	756.2	0.0	0.0	0.0	15,050.0	17,846.3	0.0	0.0	2,328.8	8.3	0.0	0.0	0.0	0.0
ARKANSAS	4	789.4	6,237.5	70.5	259.4	0.0	0.0	0.0	5,779.4	5,462.2	0.0	0.0	983.2	3.5	0.0	0.0	0.0	0.0
KANSAS	4	502.3	3,969.2	44.9	165.0	0.0	0.0	0.0	3,677.7	3,475.9	0.0	0.0	625.7	2.2	0.0	0.0	0.0	0.0
LOUISIANA	4	486.2	3,841.5	43.4	159.7	892.4	5,919.2	619.2	3,559.4	3,364.0	5,227.1	1,274.9	1,113.7	56.8	0.0	0.0	0.0	0.0
NEBRASKA	4	204.7	1,617.8	18.3	67.3	594.4	0.0	3,469.9	1,499.0	1,416.7	6,192.9	4,294.6	689.1	47.6	0.0	0.0	0.0	0.0
OKLAHOMA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10693.4
NORTH DAKOTA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SOUTH DAKOTA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IOWA	3	0.0	0.0	0.0	0.0	411.0	0.0	2,399.5	0.0	0.0	4,282.5	2,969.8	300.2	32.3	0.0	0.0	0.0	0.0
INDIANA	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MICHIGAN	3	1,325.6	10,474.9	118.4	435.6	875.9	409.5	4,795.8	9,705.5	9,172.9	8,844.4	5,970.7	2,280.9	73.6	0.0	0.0	0.0	0.0
MINNESOTA	3	474.9	3,752.4	42.4	156.0	416.4	0.0	2,430.7	3,476.8	3,286.0	4,338.2	3,008.4	895.6	34.8	0.0	0.0	0.0	0.0
MISSOURI	3	489.2	3,865.7	43.7	160.7	0.0	0.0	0.0	3,581.8	3,385.2	0.0	0.0	609.3	2.2	0.0	0.0	0.0	0.0
OHIO	3	405.9	3,207.2	36.2	133.4	1,818.8	7,636.7	4,695.3	2,971.7	2,808.6	13,697.8	6,467.2	1,648.6	124.7	0.0	0.0	0.0	0.0
WISCONSIN	3	685.0	5,412.7	61.2	225.1	49.0	325.0	34.0	5,015.1	4,739.9	287.0	70.0	881.1	6.1	0.0	0.0	0.0	0.0
ILLINOIS	3	2,938.9	23,222.4	262.4	965.6	5,583.1	24,661.0	13,466.9	21,516.8	20,336.0	41,208.1	18,786.1	7,139.6	387.2	0.0	0.0	0.0	10693.4
KENTUCKY	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ALABAMA	2	1,530.7	12,095.6	136.7	503.0	2,441.0	0.0	14,249.7	11,207.3	10,592.2	25,432.2	17,636.4	3,689.4	198.5	0.0	0.0	0.0	0.0
FLORIDA	2	4,870.5	6,629.1	152.9	825.8	0.0	0.0	0.0	15,062.6	20,950.0	0.0	0.0	2,133.2	7.6	0.0	0.0	0.0	0.0
GEORGIA	2	841.7	6,650.8	75.2	276.6	1,199.5	0.0	7,002.2	6,162.3	5,824.1	12,497.2	8,666.4	1,924.4	98.0	0.0	0.0	0.0	0.0
MISSISSIPPI	2	0.0	0.0	0.0	0.0	1,934.5	7,921.9	5,149.4	0.0	0.0	14,706.9	7,053.8	1,220.6	131.3	0.0	0.0	0.0	0.0
NORTH CAROLINA	2	1,430.2	11,301.4	127.7	469.9	5,681.3	12,413.5	8,669.8	10,471.4	9,896.8	32,413.1	16,715.6	2,697.7	104.9	24377.4	73587.1	13007.4	0.0
SOUTH CAROLINA	2	2,832.3	22,379.9	252.9	930.6	0.0	0.0	0.0	20,736.2	19,598.2	0.0	0.0	3,527.7	12.6	12188.7	36793.5	6503.7	0.0
TENNESSEE	2	1,977.7	15,627.7	176.6	649.8	0.0	0.0	0.0	14,479.9	13,685.3	0.0	0.0	2,463.3	8.8	0.0	0.0	0.0	0.0
VIRGINIA	2	2,907.1	9,272.3	138.3	622.1	0.0	0.0	0.0	12,427.3	14,632.5	0.0	0.0	1,929.6	6.9	3745.8	11307.3	1998.7	0.0
PENNSYLVANIA	1	1,374.6	10,861.4	122.7	451.6	7,045.0	6,642.4	28,019.0	10,063.7	9,511.4	59,071.4	37,880.9	5,127.4	373.4	0.0	0.0	0.0	0.0
WEST VIRGINIA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CONNECTICUT	1	2,728.3	5,398.2	100.6	503.5	2,283.6	4,989.6	3,484.8	9,526.8	12,409.9	13,028.4	6,718.8	1,771.3	44.6	2437.7	7358.7	1300.7	0.0
DELAWARE	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MASSACHUSETTS	1	60.8	480.1	5.4	20.0	2,266.3	4,951.8	3,458.4	444.9	420.4	12,929.7	6,667.9	441.2	39.6	0.0	0.0	0.0	0.0
MARYLAND	1	2,153.1	2,930.5	67.6	365.0	0.0	0.0	0.0	6,658.6	9,261.2	0.0	0.0	943.0	3.4	0.0	0.0	0.0	0.0
NEW JERSEY	1	2,809.2	3,823.5	88.2	476.3	5,663.9	12,375.5	8,643.2	8,687.7	12,083.4	32,313.9	16,664.4	2,143.8	102.6	0.0	0.0	0.0	0.0
NEW YORK	1	2,615.9	4,937.6	94.3	477.0	4,952.4	15,403.3	9,734.1	8,980.3	11,803.2	32,133.5	15,763.0	3,133.2	200.1	0.0	0.0	0.0	0.0
RHODE ISLAND	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WASHINGTON, DC	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAINE	1	1,051.1	1,430.6	33.0	178.2	0.0	0.0	0.0	3,250.5	4,521.0	0.0	0.0	460.4	1.7	0.0	0.0	0.0	0.0
NEW HAMPSHIRE	1	2,369.6	3,225.2	74.4	401.8	0.0	0.0	0.0	7,328.4	10,192.8	0.0	0.0	1,037.9	3.7	0.0	0.0	0.0	0.0
VERMONT	1	0.0	0.0	0.0	0.0	392.7	0.0	2,292.4	0.0	0.0	4,091.4	2,837.3	286.8	30.8	0.0	0.0	0.0	0.0

SOURCE: PHB, June 87

Table continued on following page.

PROJECTED WASTE VOLUME BY NRC WASTE

(cubic meters as generated)

1985 to 2004

STATE	NRC	I-COTRASH	I+COTRASH	I-ABSLIQD	I+ABSLIQD	I-LIQSCVL	I+LIQSCVL	I BIOWAST	I+BIOWAST	N SSTRASH	N+SSTRASH	N-SSWASTE	N-LOTRASH	N+LOTRASH	N LOWASTE	N-ISOPROD	N-ISOTRSH	N SORMFG
ALASKA	5	74.7	74.7	2.9	2.9	4.0	4.0	2.0	2.0	50.6	50.6	17.9	14.3	14.3	17.0	0.0	0.0	0
HAWAII	5	316.6	316.6	12.4	12.4	16.8	16.8	8.4	8.4	96.9	96.9	34.2	27.3	27.3	32.5	0.0	0.0	0
IDAHO	4	151.6	151.6	6.0	6.0	8.1	8.1	4.0	4.0	141.7	141.7	50.0	40.0	40.0	47.5	0.0	0.0	0.
MONTANA	5	226.3	226.3	8.9	8.9	12.1	12.1	6.0	6.0	134.3	134.3	47.4	37.9	37.9	45.1	0.0	0.0	0
OREGON	4	1,197.3	1,197.3	47.3	47.3	63.9	63.9	32.0	32.0	4,951.1	4,951.1	1,747.5	1,397.5	1,397.5	1,661.3	0.0	0.0	0.
UTAH	4	1,104.5	1,104.5	43.6	43.6	59.0	59.0	29.5	29.5	653.3	653.3	230.6	184.4	184.4	219.2	0.0	0.0	0
WASHINGTON	5	2,252.1	2,252.1	88.9	88.9	120.2	120.2	60.1	60.1	4,386.5	4,386.5	1,548.2	1,238.1	1,238.1	1,471.8	0.0	0.0	0.
ARIZONA	5	459.5	459.5	18.1	18.1	24.5	24.5	12.3	12.3	321.5	321.5	113.5	90.7	90.7	107.9	0.0	0.0	0.
CALIFORNIA	5	19,243.3	19,243.3	759.9	759.9	1,027.2	1,027.2	513.6	513.6	12,895.2	12,895.2	4,551.2	3,639.8	3,639.8	4,326.9	0.0	0.0	0
COLORADO	4	1,118.1	1,118.1	44.2	44.2	59.7	59.7	29.8	29.8	446.0	446.0	157.4	125.9	125.9	149.7	0.0	0.0	0.
NEW MEXICO	4	887.2	887.2	35.0	35.0	47.4	47.4	23.7	23.7	212.5	212.5	75.0	60.0	60.0	71.3	0.0	0.0	0
NEVADA	5	805.8	805.8	31.8	31.8	43.0	43.0	21.5	21.5	88.1	88.1	31.1	24.9	24.9	29.6	0.0	0.0	0.
WYOMING	4	83.7	83.7	3.3	3.3	4.5	4.5	2.2	2.2	275.5	275.5	97.2	77.8	77.8	92.4	0.0	0.0	0
TEXAS	4	6,955.4	6,955.4	274.7	274.7	371.3	371.3	185.6	185.6	8,897.3	8,897.3	3,140.2	2,511.4	2,511.4	2,985.4	0.0	0.0	0.
ARKANSAS	4	599.8	599.8	23.7	23.7	32.0	32.0	16.0	16.0	380.5	380.5	134.3	107.4	107.4	127.7	0.0	0.0	0.
KANSAS	4	731.1	731.1	28.9	28.9	39.0	39.0	19.5	19.5	425.1	425.1	150.0	120.0	120.0	142.6	0.0	0.0	0
LOUISIANA	4	1,147.5	1,147.5	45.3	45.3	61.3	61.3	30.6	30.6	125.9	125.9	44.5	35.5	35.5	42.3	0.0	0.0	0.
NEBRASKA	4	776.3	776.3	30.7	30.7	41.4	41.4	20.7	20.7	314.9	314.9	111.1	88.9	88.9	105.6	0.0	0.0	0
OKLAHOMA	4	1,093.2	1,093.2	43.2	43.2	58.4	58.4	29.2	29.2	976.1	976.1	344.5	275.5	275.5	327.5	0.0	0.0	0
NORTH DAKOTA	4	319.1	319.1	12.6	12.6	17.0	17.0	8.5	8.5	107.6	107.6	38.0	30.4	30.4	36.1	0.0	0.0	0
SOUTH DAKOTA	4	359.9	359.9	14.2	14.2	19.2	19.2	9.6	9.6	65.6	65.6	23.2	18.5	18.5	22.0	0.0	0.0	0
IOWA	3	1,190.5	1,190.5	47.0	47.0	63.6	63.6	31.8	31.8	534.5	534.5	188.6	226.3	226.3	269.0	0.0	0.0	0
INDIANA	3	1,111.3	1,111.3	43.9	43.9	59.3	59.3	29.7	29.7	1,192.6	1,192.6	420.9	504.9	504.9	600.3	0.0	0.0	0.
MICHIGAN	3	3,587.5	3,587.5	141.7	141.7	191.5	191.5	95.8	95.8	1,886.7	1,886.7	665.9	798.8	798.8	949.6	0.0	0.0	0
MINNESOTA	3	4,243.9	4,243.9	167.6	167.6	226.5	226.5	113.3	113.3	3,837.1	3,837.1	1,354.3	1,624.6	1,624.6	1,931.3	0.0	0.0	0
MISSOURI	3	2,924.3	2,924.3	115.5	115.5	156.1	156.1	78.1	78.1	2,544.8	2,544.8	898.2	1,077.4	1,077.4	1,280.8	0.0	0.0	0
OHIO	3	3,852.3	3,852.3	152.1	152.1	205.6	205.6	102.8	102.8	7,853.8	7,853.8	2,771.9	3,325.2	3,325.2	3,952.9	0.0	0.0	0
WISCONSIN	3	1,020.8	1,020.8	40.3	40.3	54.5	54.5	27.2	27.2	1,172.7	1,172.7	413.9	496.5	496.5	590.2	0.0	0.0	0
ILLINOIS	3	8,315.7	8,315.7	328.4	328.4	443.9	443.9	222.0	222.0	16,924.1	16,924.1	5,973.2	7,165.5	7,165.5	8,518.1	0.0	0.0	0
KENTUCKY	2	1,607.0	1,607.0	63.5	63.5	85.8	85.8	42.9	42.9	166.4	166.4	58.7	93.9	93.9	111.7	0.0	0.0	0
ALABAMA	2	1,306.0	1,306.0	51.6	51.6	69.7	69.7	34.9	34.9	206.2	206.2	72.8	116.4	116.4	138.4	0.0	0.0	0
FLORIDA	2	2,546.3	2,546.3	100.6	100.6	135.9	135.9	68.0	68.0	617.8	617.8	218.0	348.8	348.8	414.6	0.0	0.0	0
GEORGIA	2	2,193.2	2,193.2	86.6	86.6	117.1	117.1	58.5	58.5	290.8	290.8	102.6	164.2	164.2	195.2	0.0	0.0	0
MISSISSIPPI	2	608.9	608.9	24.0	24.0	32.5	32.5	16.3	16.3	112.9	112.9	39.8	63.7	63.7	75.7	0.0	0.0	0
NORTH CAROLINA	2	4,977.2	4,977.2	196.5	196.5	265.7	265.7	132.8	132.8	4,621.1	4,621.1	1,631.0	2,608.7	2,608.7	3,101.2	0.0	0.0	0
SOUTH CAROLINA	2	2,116.3	2,116.3	83.6	83.6	113.0	113.0	56.5	56.5	5,121.0	5,121.0	1,807.4	2,890.9	2,890.9	3,436.6	0.0	0.0	0
TENNESSEE	2	2,851.9	2,851.9	112.6	112.6	152.2	152.2	76.1	76.1	5,003.8	5,003.8	1,766.1	2,824.8	2,824.8	3,358.0	0.0	0.0	0
VIRGINIA	2	3,501.5	3,501.5	138.3	138.3	186.9	186.9	93.5	93.5	1,671.8	1,671.8	590.0	943.8	943.8	1,121.9	0.0	0.0	0
PENNSYLVANIA	1	7,863.0	7,863.0	310.5	310.5	419.7	419.7	209.9	209.9	21,111.8	21,111.8	7,451.2	3,575.4	3,575.4	4,250.3	0.0	0.0	0.
WEST VIRGINIA	2	860.1	860.1	34.0	34.0	45.9	45.9	23.0	23.0	161.3	161.3	56.9	91.1	91.1	108.3	0.0	0.0	0
CONNECTICUT	1	4,060.5	4,060.5	160.3	160.3	216.8	216.8	108.4	108.4	3,747.0	3,747.0	1,322.5	634.6	634.6	754.4	0.0	0.0	0
DELAWARE	1	190.1	190.1	7.5	7.5	10.1	10.1	5.1	5.1	458.3	458.3	161.7	77.6	77.6	92.3	0.0	0.0	0
MASSACHUSETTS	1	13,062.0	13,062.0	515.8	515.8	697.3	697.3	348.6	348.6	36,544.7	36,544.7	12,898.1	6,189.1	6,189.1	7,357.3	0.0	0.0	56
MARYLAND	1	4,520.0	4,520.0	178.5	178.5	241.3	241.3	120.6	120.6	3,859.3	3,859.3	1,362.1	653.6	653.6	777.0	0.0	0.0	0
NEW JERSEY	1	4,997.6	4,997.6	197.3	197.3	266.8	266.8	133.4	133.4	5,746.3	5,746.3	2,028.1	973.2	973.2	1,156.9	0.0	0.0	0
NEW YORK	1	14,164.3	14,164.3	559.3	559.3	756.1	756.1	378.1	378.1	15,706.9	15,706.9	5,543.6	2,660.1	2,660.1	3,162.2	600.0	1,044.0	0
RHODE ISLAND	1	776.3	776.3	30.7	30.7	41.4	41.4	20.7	20.7	822.2	822.2	290.2	139.2	139.2	165.5	0.0	0.0	0
WASHINGTON, DC	1	1,496.1	1,496.1	59.1	59.1	79.9	79.9	39.9	39.9	98.8	98.8	34.9	16.7	16.7	19.9	0.0	0.0	0
MAINE	1	224.1	224.1	8.8	8.8	12.0	12.0	6.0	6.0	390.9	390.9	138.0	66.2	66.2	78.7	0.0	0.0	0
NEW HAMPSHIRE	1	366.7	366.7	14.5	14.5	19.6	19.6	9.8	9.8	377.4	377.4	133.2	63.9	63.9	76.0	0.0	0.0	0.
VERMONT	1	436.8	436.8	17.3	17.3	23.3	23.3	11.7	11.7	1,001.9	1,001.9	353.6	169.7	169.7	201.7	0.0	0.0	0

Table continued on following page.

Table A-6

PROJECTED WASTE VOLUME BY NRC WASTE

(cubic meters as generated)

1985 to 2004

STATE	NRC	SORNFG2	SORNFG3	SORNFG4	NECOTRA	NEABLIQ	NESOLIQ	NEVIALS	NENCGLS	NEWTOAL	NETRGAS	NETRILI	NECARLI	NWTRASH	NWABLIQ	NWSOLIQ	NWWASTE	TRIPLAT	TRITGAS	TRISCNT	TRILI
ALASKA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
HAWAII	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
IDAHO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.5	0.0	0
MONTANA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
OREGON	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	53.1	0.4	0
UTAH	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	7.0	0.1	0
WASHINGTON	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	26
ARIZONA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	2
CALIFORNIA	5	5,060.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	78
COLORADO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	4.8	0.0	0
NEW MEXICO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	2.3	0.0	0
NEVADA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	[illegible]
WYOMING	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	3.0	0.0	[illegible]
TEXAS	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.0	95.5	0.7	[illegible]
ARKANSAS	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.1	0.0	[illegible]
KANSAS	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	4.6	0.0	[illegible]
LOUISIANA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.4	0.0	[illegible]
NEBRASKA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.4	0.0	[illegible]
OKLAHOMA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	10.5	0.1	[illegible]
NORTH DAKOTA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.2	0.0	[illegible]
SOUTH DAKOTA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.7	0.0	[illegible]
IOWA	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.1	0.1	0.4	0.3	0.2	0.0	[illegible]
INDIANA	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.3	0.2	1.0	0.8	0.4	0.1	[illegible]
MICHIGAN	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.4	0.4	1.6	1.2	0.6	0.2	[illegible]
MINNESOTA	3	0.0	7.0	3,200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	0.8	0.8	3.2	2.5	1.3	0.3	[illegible]
MISSOURI	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.5	0.5	2.1	1.7	0.8	0.2	[illegible]
OHIO	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.5	1.7	1.6	6.6	5.1	2.6	0.6	
WISCONSIN	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.2	0.2	1.0	0.8	0.4	0.1	[illegible]
ILLINOIS	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.3	3.6	3.4	14.1	11.0	5.6	1.4	[illegible]
KENTUCKY	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	[illegible]
ALABAMA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	[illegible]
FLORIDA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	[illegible]
GEORGIA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	[illegible]
MISSISSIPPI	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	[illegible]
NORTH CAROLINA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	4.5	[illegible]
SOUTH CAROLINA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	5.0	[illegible]
TENNESSEE	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	4.9	[illegible]
VIRGINIA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.6	[illegible]
PENNSYLVANIA	1	0.0	0.0	0.0	744.2	46.5	219.0	4.2	205.3	78.5	0.5	4.6	0.2	0.0	0.0	0.0	0.0	1.3	65.8	1.0	[illegible]
WEST VIRGINIA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	[illegible]
CONNECTICUT	1	0.0	0.0	0.0	132.1	8.3	38.9	0.8	36.4	13.9	0.1	0.8	0.0	0.0	0.0	0.0	0.0	0.2	11.7	0.2	
DELAWARE	1	0.0	0.0	0.0	16.2	1.0	4.8	0.1	4.5	1.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	[illegible]
MASSACHUSETTS	1	0.0	0.0	0.0	1,288.3	80.5	379.0	7.3	355.4	135.8	0.9	7.9	0.4	0.0	0.0	0.0	0.0	2.3	113.8	1.7	1
MARYLAND	1	0.0	0.0	0.0	136.1	8.5	40.0	0.8	37.5	14.3	0.1	0.8	0.0	0.0	0.0	0.0	0.0	0.2	12.0	0.2	
NEW JERSEY	1	0.0	0.0	0.0	202.6	12.7	59.6	1.2	55.9	21.4	0.1	1.2	0.1	0.0	0.0	0.0	0.0	0.4	17.9	0.3	
NEW YORK	1	0.0	0.0	0.0	553.7	34.6	162.9	3.1	152.8	58.4	0.4	3.4	0.2	0.0	0.0	0.0	0.0	1.0	48.9	0.7	
RHODE ISLAND	1	0.0	0.0	0.0	29.0	1.8	8.5	0.2	8.0	3.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	2.6	0.0	
WASHINGTON, DC	1	0.0	0.0	0.0	3.5	0.2	1.0	0.0	1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	
MAINE	1	0.0	0.0	0.0	13.8	0.9	4.1	0.1	3.8	1.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	
NEW HAMPSHIRE	1	0.0	0.0	0.0	13.3	0.8	3.9	0.1	3.7	1.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	
VERMONT	1	0.0	0.0	0.0	35.3	2.2	10.4	0.2	9.7	3.7	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	3.1	0.0	

Table continued on following page.

Table A-6

PROJECTED WASTE VOLUME BY NRC WASTE

(cubic meters as generated)

1985 to 2004

STATE	NRC	N-TRITRSH	N-TRIFOIL	N-HIGHACT	N-TRITSOR	N-CARBSOR	N-COBLSOR	N-NICKSOR	N-STROSOR	N-CESISOR	N-PLUBSOR	N-PLUPSOR	N-AMERSOR	N-PUBESOR	N-AMBESOR
ALASKA	5	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
HAWAII	5	0.0	0.1	1.7	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0
IDAHO	4	0.1	0.0	1.6	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0
MONTANA	5	0.0	0.1	2.3	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0
OREGON	4	2.5	0.0	57.6	1.5	0.2	1.2	0.8	2.0	2.4	0.5	0.0	3.9	0.0	0.2
UTAH	4	0.3	0.0	7.6	0.2	0.0	0.2	0.1	0.3	0.3	0.1	0.0	0.5	0.0	0.0
WASHINGTON	5	1.2	3.1	76.5	2.0	0.3	1.6	1.1	2.7	3.2	0.6	0.0	5.2	0.0	0.3
ARIZONA	5	0.1	0.2	5.6	0.1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.4	0.0	0.0
CALIFORNIA	5	3.4	9.1	224.9	6.0	1.0	4.7	3.3	7.9	9.3	1.9	0.0	15.3	0.0	1.0
COLORADO	4	0.2	0.0	5.2	0.1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.4	0.0	0.0
NEW MEXICO	4	0.1	0.0	2.5	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0
NEVADA	5	0.0	0.1	1.5	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0
WYOMING	4	0.1	0.0	3.2	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0
TEXAS	4	4.5	0.0	103.5	2.8	0.4	2.1	1.5	3.6	4.3	0.9	0.0	7.1	0.0	0.4
ARKANSAS	4	0.2	0.0	4.4	0.1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.3	0.0	0.0
KANSAS	4	0.2	0.0	4.9	0.1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.3	0.0	0.0
LOUISIANA	4	0.1	0.0	1.5	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0
NEBRASKA	4	0.2	0.0	3.7	0.1	0.0	0.1	0.1	0.1	0.2	0.0	0.0	0.2	0.0	0.0
OKLAHOMA	4	0.5	0.0	11.4	0.3	0.0	0.2	0.2	0.4	0.5	0.1	0.0	0.8	0.0	0.0
NORTH DAKOTA	4	0.1	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0
SOUTH DAKOTA	4	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
IOWA	3	0.9	0.0	10.5	0.3	0.0	0.2	0.2	0.4	0.4	0.1	0.0	0.7	0.0	0.0
INDIANA	3	2.1	0.0	23.4	0.6	0.1	0.5	0.3	0.8	1.0	0.2	0.0	1.6	0.0	0.1
MICHIGAN	3	3.3	0.0	37.0	1.0	0.2	0.8	0.5	1.3	1.5	0.3	0.0	2.5	0.0	0.2
MINNESOTA	3	6.7	0.0	75.3	2.0	0.3	1.6	1.1	2.6	3.1	0.6	0.0	5.1	0.0	0.3
MISSOURI	3	4.5	0.0	49.9	1.3	0.2	1.0	0.7	1.7	2.1	0.4	0.0	3.4	0.0	0.2
OHIO	3	13.8	0.0	154.1	4.1	0.7	3.2	2.2	5.4	6.3	1.3	0.0	10.5	0.0	0.7
WISCONSIN	3	2.1	0.0	23.0	0.6	0.1	0.5	0.3	0.8	0.9	0.2	0.0	1.6	0.0	0.1
ILLINOIS	3	29.7	0.0	332.1	8.9	1.4	6.9	4.8	11.6	13.7	2.7	0.0	22.6	0.0	1.4
KENTUCKY	2	1.3	0.2	5.3	0.1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.4	0.0	0.0
ALABAMA	2	1.6	0.2	6.6	0.2	0.0	0.1	0.1	0.2	0.3	0.1	0.0	0.4	0.0	0.0
FLORIDA	2	4.6	0.7	19.8	0.5	0.1	0.4	0.3	0.7	0.8	0.2	0.0	1.3	0.0	0.1
GEORGIA	2	2.2	0.3	9.3	0.2	0.0	0.2	0.1	0.3	0.4	0.1	0.0	0.6	0.0	0.0
MISSISSIPPI	2	0.8	0.1	3.6	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.0
NORTH CAROLINA	2	34.8	5.3	147.8	3.9	0.6	3.1	2.1	5.2	6.1	1.2	0.0	10.1	0.0	0.6
SOUTH CAROLINA	2	38.5	5.9	163.8	4.4	0.7	3.4	2.4	5.7	6.7	1.3	0.0	11.2	0.0	0.7
TENNESSEE	2	37.7	5.7	160.0	4.3	0.7	3.3	2.3	5.6	6.6	1.3	0.0	10.9	0.0	0.7
VIRGINIA	2	12.6	1.9	53.5	1.4	0.2	1.1	0.8	1.9	2.2	0.4	0.0	3.6	0.0	0.2
PENNSYLVANIA	1	62.4	44.7	190.3	5.1	0.8	3.9	2.8	6.7	7.8	1.6	0.0	13.0	0.0	0.8
WEST VIRGINIA	2	1.2	0.2	5.2	0.1	0.0	0.1	0.1	0.2	0.2	0.0	0.0	0.4	0.0	0.0
CONNECTICUT	1	11.1	7.9	33.8	0.9	0.1	0.7	0.5	1.2	1.4	0.3	0.0	2.3	0.0	0.1
DELAWARE	1	1.4	1.0	4.1	0.1	0.0	0.1	0.1	0.1	0.2	0.0	0.0	0.3	0.0	0.0
MASSACHUSETTS	1	108.1	77.3	329.4	8.8	1.4	6.8	4.8	11.5	13.6	2.7	0.0	22.4	0.0	1.4
MARYLAND	1	11.4	8.2	34.8	0.9	0.1	0.7	0.5	1.2	1.4	0.3	0.0	2.4	0.0	0.1
NEW JERSEY	1	17.0	12.2	51.8	1.4	0.2	1.1	0.7	1.8	2.1	0.4	0.0	3.5	0.0	0.2
NEW YORK	1	46.5	33.2	141.6	3.8	0.6	2.9	2.0	4.9	5.8	1.2	0.0	9.6	0.0	0.6
RHODE ISLAND	1	2.4	1.7	7.4	0.2	0.0	0.2	0.1	0.3	0.3	0.1	0.0	0.5	0.0	0.0
WASHINGTON, DC	1	0.3	0.2	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
MAINE	1	1.2	0.8	3.5	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.2	0.0	0.0
NEW HAMPSHIRE	1	1.1	0.8	3.4	0.1	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.0
VERMONT	1	3.0	2.1	9.0	0.2	0.0	0.2	0.1	0.3	0.4	0.1	0.0	0.6	0.0	0.0

STATE	NRC	TOTALS
ALASKA	5	333.5
HAWAII	5	1,022.4
IDAHO	4	804.5
MONTANA	5	947.6
OREGON	4	31,488.9
UTAH	4	4,617.2
WASHINGTON	5	139,988.4
ARIZONA	5	41,256.6
CALIFORNIA	5	165,675.0
COLORADO	4	3,967.4
NEW MEXICO	4	2,684.1
NEVADA	5	2,093.3
WYOMING	4	1,091.6
TEXAS	4	95,550.6
ARKANSAS	4	22,176.5
KANSAS	4	15,494.8
LOUISIANA	4	29,540.4
NEBRASKA	4	22,883.7
OKLAHOMA	4	16,344.3
NORTH DAKOTA	4	1,067.6
SOUTH DAKOTA	4	1,021.1
IOWA	3	15,057.2
INDIANA	3	6,942.5
MICHIGAN	3	69,562.6
MINNESOTA	3	49,352.8
MISSOURI	3	28,189.8
OHIO	3	83,609.7
WISCONSIN	3	24,456.4
ILLINOIS	3	272,994.4
KENTUCKY	2	4,297.4
ALABAMA	2	103,503.3
FLORIDA	2	58,929.3
GEORGIA	2	57,351.1
MISSISSIPPI	2	39,955.8
NORTH CAROLINA	2	253,928.0
SOUTH CAROLINA	2	152,013.7
TENNESSEE	2	76,481.3
VIRGINIA	2	73,853.1
PENNSYLVANIA	1	256,944.3
WEST VIRGINIA	2	2,603.7
CONNECTICUT	1	94,322.4
DELAWARE	1	1,788.7
MASSACHUSETTS	1	170,185.0
MARYLAND	1	43,982.0
NEW JERSEY	1	134,157.2
NEW YORK	1	190,305.0
RHODE ISLAND	1	4,183.8
WASHINGTON, DC	1	3,643.9
MAINE	1	12,590.6
NEW HAMPSHIRE	1	26,577.4
VERMONT	1	13,889.6

Table A-7

Projected Waste Volume By EPA Waste

(cubic meters as generated)

1985 to 2004

STATE	NRC	L-INRESIN	L-CONCLIQ	L-FSLUDGE	P FCARTRG	L COTRASH	L-NCTRASH	F COTRASH	F NCTRASH	F PROCESS	U-PROCESS	I COTRASH	I-LIQSCVL	I ABSLIQD	I-BIOWAST	N SSTRASH	N SSWASTE	N LOTRASH	N-LOWASTE	N NFRCOMP	N IS
ALASKA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	149.4	8.0	5.9	4.0	101.3	17.9	28.6	17.0	0.9	
HAWAII	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	629.2	33.6	24.8	16.8	193.8	34.2	54.7	32.5	1.7	
IDAHO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	303.3	16.2	12.0	8.1	283.4	50.0	80.0	47.5	1.6	
MONTANA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	452.7	24.2	17.9	12.1	268.6	47.4	75.8	45.1	2.3	
OREGON	4	506.2	4,000.2	, 45.2	166.3	3,706.4	3,503.0	0.0	0.0	0.0	0.0	2,394.7	127.8	94.6	63.9	9,902.3	1,747.5	2,795.0	1,661.3	688.1	
UTAH	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,209.1	117.9	87.2	59.0	1,306.7	230 6	368.8	219.2	7.6	
WASHINGTON	5	2,489.6	5,010.6	4,982.3	346.9	15,644.6	14,273.0	50,434.1	8,914 8	16,707.5	0.0	4,504.1	240.4	177.9	120.2	8,773.0	1,548.2	2,476.3	1,471.8	1,754.1	
ARIZONA	5	1,578.9	12,475.8	141.0	518.8	11,559.5	10,925.2	0.0	0.0	0.0	0.0	918.9	49.1	36.3	24.5	643.0	113.5	181.5	107.9	1,972.1	
CALIFORNIA	5	6,623.9	11,816.0	432.2	1,165.7	22,574.7	29,386.7	0.0	0.0	0.0	0.0	38,486.7	2,054.5	1,519.8	1,027.2	25,790.4	4,551.2	7,279.6	4,326.9	3,421.2	5,
COLORADO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,236.2	119.4	88.3	59.7	892.1	157.4	251.8	149.7	5.2	
NEW MEXICO	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,774.5	94.7	70.1	47.4	425.1	75.0	120.0	71.3	2.5	
NEVADA	5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,611.5	86.0	63.6	43.0	176.2	31.1	49.7	29.6	1.5	
WYOMING	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	167.5	8.9	6.6	4.5	551.0	97.2	155.5	92.4	3.2	
TEXAS	4	3,573.3	11,049.0	166.9	756.2	15,050.0	17,846.3	0.0	0.0	0.0	0.0	13,910.8	742.6	549.3	371.3	17,794.7	3,140.2	5,022.7	2,985.4	2,432.2	
ARKANSAS	4	789.4	6,237.5	70.5	259.4	5,779.4	5,462.2	0.0	0.0	0.0	0.0	1,199.6	64.0	47.4	32.0	760.9	134.3	214.8	127.7	987.6	
KANSAS	4	502.3	3,969.2	44.9	165.0	3,677.7	3,475.9	0.0	0.0	0.0	0.0	1,462.1	78.1	57.7	39.0	850.1	150.0	240.0	142.6	630.6	
LOUISIANA	4	1,378.6	9,760.7	662.6	159.7	8,786.5	4,639.0	0.0	0.0	0.0	0.0	2,295.1	122.5	90.6	61.3	251.9	44.5	71.1	42.3	1,115.1	
NEBRASKA	4	799.1	1,617.8	3,488.2	67.3	7,691.8	5,711.3	0.0	0.0	0.0	0.0	1,552.7	82.9	61.3	41.4	629.7	111.1	177.7	105.6	692.8	
OKLAHOMA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,693.4	2,186.4	116.7	86.3	58.4	1,952.1	344.5	551.0	327.5	11.4	
NORTH DAKOTA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	638.3	34.1	25.2	17.0	215.2	38.0	60.7	36.1	1.3	
SOUTH DAKOTA	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	719.8	38.4	28.4	19.2	131.2	23.2	37.0	22.0	0.8	
IOWA	3	411.0	0.0	2,399.5	0.0	4,282.5	2,969.8	0.0	0.0	0.0	0.0	2,381.1	127.1	94.0	63.6	1,069.0	188.6	452.6	269.0	310.7	
INDIANA	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,222.6	118.6	87.8	59.3	2,385.2	420.9	1,009.9	600.3	23.4	
MICHIGAN	3	2,201.5	10,884.4	4,914.1	435.6	18,549.9	15,143.6	0.0	0.0	0.0	0.0	7,174.9	383.0	283.3	191.5	3,773.3	665.9	1,597.6	949.6	2,317.9	
MINNESOTA	3	891.3	3,752.4	2,473.1	156.0	7,815.0	6,294.4	0.0	0.0	0.0	0.0	8,487.7	453.1	335.2	226.5	7,674.3	1,354.3	3,249.2	1,931.3	970.9	3,
MISSOURI	3	489.2	3,865.7	43.7	160.7	3,581.8	3,385.2	0.0	0.0	0.0	0.0	5,848 6	312.2	231.0	156.1	5,089.6	898.2	2,154.9	1,280.8	659.3	
OHIO	3	2,224.7	10,843.9	4,731.5	133.4	16,669.5	9,275.8	0.0	0.0	0.0	0.0	7,704.6	411.3	304.2	205.6	15,707.5	2,771.9	6,650.4	3,952.9	1,802.7	
WISCONSIN	3	734.0	5,737.7	95.2	225.1	5,302.1	4,809.9	0.0	0.0	0.0	0.0	2,041.6	109.0	80.6	54.5	2,345.4	413.9	993.0	590.2	904.1	
ILLINOIS	3	8,521.9	47,883.4	13,729.3	965.6	62,724.9	39,122.1	0.0	0.0	0.0	10,693.4	16,631.4	887.8	656.8	443.9	33,848.2	5,973.2	14,331.0	8,518.1	7,471.7	
KENTUCKY	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,214.0	171.6	126.9	85.8	332.8	58.7	187.9	111.7	5.3	
ALABAMA	2	3,971.7	12,095.6	14,386.4	503.0	36,639.5	28,228.6	0.0	0.0	0.0	0.0	2,612.0	139.4	103.1	69.7	612.3	72.8	232.8	138.4	3,696.0	
FLORIDA	2	4,870.5	6,629.1	152.9	825.8	15,062.6	20,950.0	0.0	0 0	0.0	0.0	5,092.6	271.9	201.1	135.9	1,235.6	218.0	697.5	414.6	2,153.0	
GEORGIA	2	2,041.2	6,650.8	7,077.3	276.6	18,659.5	14,490.5	0.0	0.0	0.0	0.0	4,386.4	234.2	173.2	117.1	581.6	102.6	328.3	195.2	1,933.7	
MISSISSIPPI	2	1,934.5	7,921.9	5,149.4	0.0	14,706.9	7,053.8	0.0	0.0	0.0	0.0	1,217.7	65.0	48.1	32.5	225.7	39.8	127.4	75.7	1,224.2	
NORTH CAROLINA	2	7,111.6	23,715.0	8,797.5	469.9	42,884.5	26,612.3	73,587.1	13,007.4	24,377.4	0.0	9,954.4	531.4	393.1	265.7	9,242.3	1,631.0	5,217.5	3,101.2	2,845.4	
SOUTH CAROLINA	2	2,832.3	22,379.9	252.9	930.6	20,736.2	19,598.2	36,793.5	6,503.7	12,188.7	0.0	4,232.5	225.9	167.1	113.0	10,242.0	1,807.4	5,781.8	3,436.6	3,691.4	
TENNESSEE	2	1,977.7	15,627.7	176.6	649.8	14,479.9	13,685.3	0.0	0.0	0.0	0.0	5,703.7	304.5	225.2	152.2	10,007.6	1,766.1	5,649.5	3,358.0	2,623.4	
VIRGINIA	2	2,907.1	9,272.3	138.3	622.1	12,427.3	14,632.5	11,307.3	1,998.7	3,745.8	0.0	7,002.9	373.8	276.5	186.9	3,343.6	590.0	1,887.5	1,121.9	1,983.0	
PENNSYLVANIA	1	8,419.6	17,503.8	28,141.7	451.6	69,135.1	47,392.4	0.0	0.0	0.0	0.0	15,726.0	839.5	621.0	419.7	42,223.6	7,451.2	7,150.8	4,250.3	5,317.7	
WEST VIRGINIA	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,720.2	91.8	67.9	45.9	322.6	56.9	182.1	108.3	5.2	
CONNECTICUT	1	5,011.9	10,387.8	3,585.4	503.5	22,555.2	19,128.7	7,358.7	1,300.7	2,437.7	0.0	8,121.0	433.5	320.7	216.8	7,494.0	1,322.5	1,269.2	754.4	1,805.0	
DELAWARE	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	380.2	20.3	15.0	10.1	916.5	161.7	155.2	92.3	4.1	
MASSACHUSETTS	1	2,327.1	5,431.9	3,463.8	20.0	13,374.6	7,088.3	0.0	0.0	0.0	0.0	26,124.0	1,394.5	1,031.6	697.3	73,089.3	12,898.1	12,378.1	7,357.3	770.5	
MARYLAND	1	2,153.1	2,930.5	67.6	365.0	6,658.6	9,261.2	0.0	0.0	0.0	0.0	9,040.0	482.6	357.0	241.3	7,718.7	1,362.1	1,307.2	777.0	977.8	
NEW JERSEY	1	8,473.1	16,199.0	8,731.4	476.3	41,001.6	28,747.8	0.0	0.0	0.0	0.0	9,995.1	533.6	394.7	266.8	11,492.7	2,028.1	1,946.4	1,156.9	2,195.6	
NEW YORK	1	7,568.3	20,340.9	9,828.5	477.0	41,113.8	27,566.2	0.0	0.0	0 0	0.0	28,328.6	1,512.2	1,118.7	756.1	31,415.8	5,543.6	5,320.1	3,162.2	3,274.7	1,
RHODE ISLAND	1	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0 0	0.0	1,552.7	82.9	61.3	41.4	1,644.4	290.2	278.5	165.5	7.4	
WASHINGTON, DC	1	0.0	0.0	0.0	0.0	0.0	0 0	0 0	0.0	0.0	0.0	2,992.2	159.7	118.2	79.9	197.7	34.9	33.5	19.9	0.9	
MAINE	1	1,051.1	1,430.6	33.0	178.2	3,250.5	4,521.0	0 0	0.0	0.0	0.0	448 2	23.9	17.7	12.0	781 8	138.0	132.4	78.7	463.9	
NEW HAMPSHIRE	1	2,369.6	3,225.2	74.4	401.8	7,328.4	10,192.8	0.0	0.0	0.0	0.0	733.3	39.1	29.0	19.6	754.8	133 2	127.8	76.0	1,041 3	
VERMONT	1	392.7	0.0	2,292.4	0.0	4,091.4	2,837.3	0.0	0.0	0.0	0.0	873.7	46.6	34.5	23.3	2,003.8	353.6	339.4	201.7	295.8	

SOURCE: PHB June 1987.

Table continued on next page.

Table A-7

Projected Waste Volume By EPA Waste

(calculated meters as generated)

STATE	NRC	N TRITIUM	N-TARGETS	L-DECONRS	N-SOURCES	LLW TOTALS
ALASKA	5	0.3	0.0	0.0	0.2	333.5
HAWAII	5	0.6	0.1	0.0	0.4	1,022.4
IDAHO	4	2.0	0.0	0.0	0.4	804.5
MONTANA	5	0.9	0.1	0.0	0.5	947.6
OREGON	4	71.3	0.0	2.3	12.8	31,488.9
UTAH	4	9.4	0.0	0.0	1.7	4,617.2
WASHINGTON	5	29.1	3.1	69.8	17.1	139,988.4
ARIZONA	5	2.1	0.2	7.0	1.3	41,256.6
CALIFORNIA	5	85.4	9.1	13.7	50.1	165,675.0
COLORADO	4	6.4	0.0	0.0	1.2	3,967.4
NEW MEXICO	4	3.1	0.0	0.0	0.6	2,684.1
NEVADA	5	0.6	0.1	0.0	0.3	2,093.3
WYOMING	4	4.0	0.0	0.0	0.7	1,091.6
TEXAS	4	128.2	0.0	8.3	23.1	95,550.6
ARKANSAS	4	5.5	0.0	3.5	1.0	22,176.5
KANSAS	4	6.1	0.0	2.2	1.1	15,494.8
LOUISIANA	4	1.8	0.0	56.8	0.3	29,540.4
NEBRASKA	4	4.5	0.0	47.6	0.8	22,883.7
OKLAHOMA	4	14.1	0.0	0.0	2.5	16,344.3
NORTH DAKOTA	4	1.5	0.0	0.0	0.3	1,067.6
SOUTH DAKOTA	4	0.9	0.0	0.0	0.2	1,021.1
IOWA	3	4.1	0.0	32.3	2.3	15,057.2
INDIANA	3	9.2	0.0	0.0	5.2	6,942.5
MICHIGAN	3	14.5	0.0	73.6	8.3	69,562.6
MINNESOTA	3	29.6	0.0	34.8	16.8	49,352.8
MISSOURI	3	19.6	0.0	2.2	11.1	28,189.8
OHIO	3	60.6	0.0	124.7	34.4	83,609.7
WISCONSIN	3	9.0	0.0	6.1	5.1	24,456.4
ILLINOIS	3	130.5	0.0	387.2	74.0	272,994.4
KENTUCKY	2	1.5	0.2	0.0	1.2	4,297.4
ALABAMA	2	1.8	0.2	198.5	1.5	103,503.3
FLORIDA	2	5.4	0.7	7.6	4.4	58,929.3
GEORGIA	2	2.5	0.3	98.0	2.1	57,351.1
MISSISSIPPI	2	1.0	0.1	131.3	0.8	39,955.8
NORTH CAROLINA	2	40.4	5.3	104.9	32.9	253,928.0
SOUTH CAROLINA	2	44.8	5.9	12.6	36.5	152,013.7
TENNESSEE	2	43.8	5.7	8.8	35.7	76,481.3
VIRGINIA	2	14.6	1.9	6.9	11.9	73,853.1
PENNSYLVANIA	1	1,439.7	44.7	373.4	42.4	256,944.3
WEST VIRGINIA	2	1.4	0.2	0.0	1.2	2,603.7
CONNECTICUT	1	255.5	7.9	44.6	7.5	94,322.4
DELAWARE	1	31.3	1.0	0.0	0.9	1,788.7
MASSACHUSETTS	1	2,492.2	77.3	39.6	73.4	170,185.0
MARYLAND	1	263.2	8.2	3.4	7.8	43,982.0
NEW JERSEY	1	391.9	12.2	102.6	11.5	134,157.2
NEW YORK	1	1,071.1	33.2	200.1	31.6	190,305.0
RHODE ISLAND	1	56.1	1.7	0.0	1.7	4,183.8
WASHINGTON, DC	1	6.7	0.2	0.0	0.2	3,643.9
MAINE	1	26.7	0.8	1.7	0.8	12,590.6
NEW HAMPSHIRE	1	25.7	0.8	3.7	0.8	26,577.4
VERMONT	1	68.3	2.1	30.8	2.0	13,889.6

Table A-8

STATES INCLUDED IN EACH COMPACT AND REGION

Compact	States Included	Hydrogeologic Region
1. Northwest	AK,HI,ID,MT,OR,UT(2), WA,WY(2)	Arid Permeable
2. California(1)	CA(6)	Arid Permeable
3. Rocky Mountain	AZ(3),CO,NV,NM, UT(2)(3),WY(2)	Arid Permeable
4. Texas(1)	TX(6)	Arid Permeable
5. Central	AR,IA(2)(3),KS,LA,MN(2)(3), MO(2)(3),NE,ND(3)(6),OK	Humid Permeable
6. South Dakota	SD(6)	Humid Permeable
7. Midwest	IA(2),IN,MI,MN(2), MO(2),OH,WI	Humid Permeable
8. Central Midwest	IL,KT	Humid Permeable
9. Southeast	AL,FL,GA,MS,NC SC,TN,VA	Humid Permeable
10. PA/WV	PA,WV	Humid Impermeable
11. Northeast(4)	CT,DE,DC(3)(6),MA(3)(6),MD, NJ,NY(3)(6),RI(3)(6)	Humid Impermeable
12. New England(4)	ME(6),VT(6), NH	Humid Impermeable

Notes on following page.

Table A-8 (Continued)

STATES INCLUDED IN EACH COMPACT AND REGION

NOTES:

Table A-8 lists the status of States and Compacts in January 1986, prior to the passage of LLWPA86. Note that the current status of States and Compacts may have changed since January 1986.

(1) California and Texas were assumed to form single State "Compacts." Currently, the disposition of South Dakota is unclear; however, the State is treated as a "Compact" in the analysis.

(2) For States that are members of two Compacts, State volumes are divided evenly between the Compacts.

(3) Not currently a ratified member of this Compact.

(4) The Northeast Compact States have changed since January 1986. Connecticut and New Jersey are current members of the Northeast Compact. Delaware and Maryland have entered into an agreement with Pennsylvania and West Virginia (PA/WV Compact) to form the Appalachian Compact, although this Compact has not been congressionally ratified.

(5) Not a congressionally ratified Compact.

(6) States currently unaligned.

SOURCE: "The Radioactive Exchange," 1987.

Table A-9

DISTRIBUTION OF NARM WASTES BY
HYDROGEOLOGIC REGION AND COMPACT
(CUBIC METERS AS GENERATED)

COMPACT	R-RAIXRSN	R-RASOURC	R-GLASDS1*	R-GLASDS2*	R-INSTDF1**	R-INSTDF2**
Northwest	319.8	0.014	2,760.1	1.5	243.7	7.3
California	710.1	0.021	6,129.2	3.4	541.2	16.1
Rocky Mountain	266.8	0.013	2,302.9	1.3	203.3	6.1
Texas	443.5	0.027	3,828.4	2.1	338.0	10.1
Subtotal Arid Permeable Region	1,740.2	0.075	15,020.7	8.4	1,326.3	39.5
Central	586.0	0.036	5,058.3	2.8	446.6	13.3
South Dakota	19.7	0.001	170.4	0.1	15.0	0.4
Midwest	1,017.0	0.061	8,778.3	4.9	775.1	23.1
Central Midwest	428.8	0.024	3,700.8	2.1	326.8	9.7
Southeast	1,199.9	0.058	10,357.1	5.8	914.5	27.2
Subtotal Humid Permeable Region	3,251.5	0.180	28,065.0	15.8	2,478.0	73.7
Pennsylvania/West Virginia	391.0	0.043	3,374.6	1.9	298.0	8.9
Northeast	1,143.2	0.138	9,867.5	5.5	871.3	25.9
New England	74.2	0.009	640.3	0.4	56.5	1.7
Subtotal Humid Impermeable Region	1,608.3	0.190	13,882.4	7.8	1,225.8	36.5
TOTAL UNITED STATES	6,600.0	0.445	56,968.1	32.0	5,030.1	149.7

NOTE: Twenty-year waste volumes were estimated for the entire United States based on annual volumes in PEI85a. The allocation of waste generation to Compact was done on the basis of 1983 State populations, with the exception of radium sources (R-RASOURC), which were first allocated to NRC region using EPA/HEW records on waste disposal collected at EPA's Eastern Environmental Radiation Facility in Montgomery, Alabama (the breakdown is listed in DM86). R-RASOURC was then allocated by State population within each NRC region. R-RASOURC volumes represent the volume of individual sources. R-RASOURC disposal volumes are higher by a factor of 2,914.

* R-GLASDS1 represents 99.944 percent of the total GLASDIS waste stream, while R-GLASDS2 represents 0.0561 percent of the total waste stream. These percentages were based on substream volumes in PEI85a.

** R-INSTDF1 represents 97.106 percent of the total R-INSTDIF waste stream, while INSTDF2 represents 2.89 percent of the total waste stream. These percentages were based on substream v[illegible]s in PEI85a.

[illegible]CE: Putnam, Hayes & Bartlett, Inc., June 1987, based on [illegible] in DM86 and PEI85a.

Table A-10

HISTORICAL AND PROJECTED VOLUME OF DOE/DEFENSE LLW
(Excluding SRP Saltcrete)

YEAR	VOLUME (10^3 cubic meters)
1985	119.80
1986	90.10
1987	90.10
1988	90.10
1989	90.10
1990	90.10
1991	90.10
1992	90.10
1993	90.10
1994	90.10
1995	90.10
1996	90.10
1997	90.10
1998	90.10
1999	90.10
2000	90.10
2001	90.10
2002	90.10
2003	90.10
2004	90.10
TOTAL	1,831.70

WEIGHTED FIVE YEAR AVERAGES FOR SIX MAJOR
DOE WASTE GENERATORS

YEAR	LANL	INEL	NTS	ORNL	HANF	SRP	ALL OTHER	ANNUAL ADDITION
1981	5.50	3.10	14.60	1.40	12.90	20.10	4.20	61.80
1982	4.50	3.00	39.20	1.30	11.70	22.40	7.00	89.10
1983	3.20	5.40	26.60	1.80	18.00	26.70	8.20	89.90
1984	5.40	3.80	12.10	2.20	18.70	26.10	21.40	89.70
1985	6.70	3.10	39.40	2.20	16.40	30.50	21.50	119.80
TOTAL	25.30	18.40	131.90	8.90	77.70	125.80	62.30	450.30
% OF TOTAL	5.62%	4.09%	29.29%	1.98%	17.26%	27.94%	13.84%	100.00%
AVERAGE ANNUAL VOLUME	5.06	3.68	26.38	1.78	15.54	25.16	12.46	

KEY: LANL = LOS ALAMOS NATIONAL LABORATORY
INEL = IDAHO NATIONAL ENGINEERING LABORATORY
NTS = NEVADA TEST SITE
ORNL = OAK RIDGE NATIONAL LABORATORY
HANF = HANFORD RESERVATION
SRP = SAVANNAH RIVER PLANT

SOURCE: Based on data in DOE86.

Table A-11

"ALL OTHER" AGGREGATED VOLUMES

GENERATOR	AS OF 12/85 (Thousand of Cubic Meters)	% OF 1985	% OF TOTAL U.S.VOLUME
NLO	298.50	59.23	8.19
PAD	7.60	1.51	0.21
ORGDP	76.90	15.26	2.11
Y12	99.10	19.66	2.72
PANT	0.10	0.02	0.00
SNL	1.90	0.38	0.05
LLNL	9.10	1.81	0.25
BNL	0.80	0.16	0.02
PORT	10.00	1.98	0.27
TOTAL	504.00	100.00%	13.84%

Key:
- NLO = National Lead of Ohio
- PAD = Paducah Gaseous Diffusion Plant
- ORGDP = Oak Ridge Gaseous Diffusion Plant
- Y12 = Y-12 Plant
- PANT = Pantex Plant
- SNL = Sandia National Laboratory
- LLNL = Lawrence Livermore National Laboratory
- BNL = Brookhaven National Laboratory
- PORT = Portsmouth Gaseous Diffusion Plant

NOTE: Facility cumulative historical volumes for this "All Other" category are used to apportion future waste generation to specific facilities.

SOURCE: Adapted from Table 4.4 in DOE86.

Table A-12

TWENTY-YEAR DOE/DEFENSE LLW WASTE ALLOCATION TO HYDROGEOLOGIC REGION
1985-2004

DOE WASTE GENERATOR SITE	STATE	HYDROGEOLOGIC REGION	% OF TOTAL U.S. VOLUME	WASTE GENERATED (Thousand Cubic Meters)
BNL	NEW YORK	NE	0.02%	0.40
HUMID IMPERMEABLE SUBTOTAL			0.02%	0.40
NLO	OHIO	SE	8.19%	150.09
ORGDP	TENNESSEE	SE	2.11%	38.67
ORNL	TENNESSEE	SE	1.98%	36.20
PAD	KENTUCKY	SE	0.21%	3.82
PORT	OHIO	SE	0.27%	5.03
SRP	SOUTH CAROLINA	SE	27.94%	511.72
Y12	TENNESSEE	SE	2.72%	49.83
HUMID PERMEABLE SUBTOTAL			43.42%	795.36
HANF	WASHINGTON	SW	17.26%	316.06
INEL	IDAHO	SW	4.09%	74.85
LANL	NEW MEXICO	SW	5.62%	102.91
LLNL	CALIFORNIA	SW	0.25%	4.58
NTS	NEVADA	SW	29.29%	536.53
PANT	TEXAS	SW	0.00%	0.05
SNL	NEW MEXICO	SW	0.05%	0.96
ARID PERMEABLE SUBTOTAL			56.56%	1,035.94
TOTALS			100.00%	1,831.70

NOTE: Total DOE/Defense 20-year volume generation is estimated at 1,831,700 cubic meters based on actual data for 1985 and projected data without SRP saltcrete.

KEY: See Tables A-10 and A-11.

SOURCE: Putnam, Hayes & Bartlett, Inc., June 1987. Based on DOE86 and Tables A-10 and A-11.

This appendix presents the percentages used in weighting the five unregulated disposal options which characterize the costs and population risks of unregulated disposal practice on average. These unregulated disposal practices are used in the NARM analysis presented in Chapter 6 and the BRC analysis presented in Chapter 7. A weighting scheme is necessary since unit health effects vary significantly by type of disposal option. By estimating a weighted average of the five disposal options, a single unregulated disposal scenario can be compared to a regulated alternative. Through this comparison, the cost-effectiveness of regulation can be calculated. Also, since two of the unregulated disposal options involve incineration, which is characterized by a slightly higher cost than the other three unregulated disposal options, a weighted average unit cost is calculated for these five options as well.

Table B-1 presents the weights and average disposal cost for the different disposal options by waste category. The weights were chosen on a subjective basis, based on our general knowledge concerning the locations of LLW generators and the type of facilities that they are likely to use. The five unregulated disposal options correspond to three types of locations -- an urban, suburban, or rural setting. The urban and suburban disposal options each involve two types of disposal -- with or without incineration. Since no information is readily available on the percentage of waste that is incinerated, an unbiased representation of this percentage would be consistent with assigning an equal probability to whether or not a waste would be incinerated. Waste from light water power reactors, which are generally located away from densely populated urban areas, was judged to be twice as likely to be located in a rural setting vis-a-vis urban areas. Institutional wastes, generated by hospitals, universities, and other medical research facilities (which are generally located in metropolitan areas), was given an equal weighting between a suburban and an urban location and was given a low probability of location in a rural setting. Industrial wastes were assigned weights similar to wastes from light water power reactors for similar reasons. Only two companies in the U.S. generate process wastes from uranium hexafluoride conversion. Since these generators are located in small communities (Metropolis, Illinois and Sequoyah, Oklahoma), U-PROCESS was assumed to be disposed of with equal probability at a rural or suburban site. Likewise, the location of fuel cycle waste generators can be characterized generally by a suburban or rural setting. For these generators, a small probability was assigned to urban disposal. The disposal of consumer wastes and the two consumer-like NARM wastes (R-GLASDS1 and R-INSTDF1) was distributed on the basis of population, with a 50/50 split between suburban and urban disposal and a five percent weight assigned to rural disposal. Radium ion-exchange resins (R-RAIXRSN) were assigned the same weights as those for light water reactors. Radium sources (R-RASOURC) were assigned the same weights as institutional wastes since they result primarily from medical or laboratory applications.

A sensitivity analysis is performed in Chapter 7 to determine the relative importance of these subjective weighting assumptions. Tables B-2 to B-21 present the results of the sensitivity analysis. In summary, the results of the sensitivity analysis suggest that while the incremental costs associated with regulation do not vary much across the five unregulated disposal practices, the avoided health effects do vary significantly. Consequently, cost-effectiveness ratios can vary significantly as well. However, the economic impacts at the proposed 4 millirem BRC standard will not change under National-Explicit implementation if the valuation per avoided health effect exceeds $12 million but is less than $17 million, assuming an extreme weighting scheme of either 100 percent Suburban SLF with incineration (SI) or 100 percent Urban SLF without incineration (UF), the two limiting disposal options. By another interpretation, however, a $3 million to $5 million valuation per avoided health effect would increase BRC savings by $83 million and result in 11 additional health effects, assuming SI is the only unregulated option considered. If a valuation of $23 million to $374 million is used, BRC savings would decrease by $456 million with 20 fewer health effects occurring, assuming UF is the only unregulated disposal option considered. For a more detailed discussion of these results, see Chapter 7.

Table B-1

UNIT COST AND WEIGHTING BY WASTE CATEGORY FOR UNREGULATED DISPOSAL PRACTICES

	Unregulated Disposal Practice	Unit Cost ($/m³)	Scenario Weightings for Unregulated Disposal (%) Power Reactor Waste	Fuel Fabrication Waste	UF_6 Process Waste	Industrial Waste	Radium Ion-Exchange Resins	Institutional Waste	Consumer & All Other NARM Waste	Deregulated BIOMED Waste
1.	Rural Municipal Dump	14.78	25.0	47.5	50	25	25	5.0	5.0	0
2.	Suburban Sanitary Landfill	14.78	25.0	23.75	25	25	25	23.75	23.75	0
3.	Suburban Sanitary Landfill with Incineration	16.27	25.0	23.75	25	25	25	23.75	23.75	0
4.	Urban Sanitary Landfill	14.78	12.5	2.5	0	12.5	12.5	23.75	23.75	0
5.	Urban Sanitary Landfill with Incineration	16.27	12.5	2.5	0	12.5	12.5	23.75	23.75	0
6.	University/Medical Center Landfill with Incineration	$16.27	0	0	0	0	0	0	0	100%
	TOTAL		100%	100%	100%	100%	100%	100%	100%	100%
	Average Unregulated Disposal Cost (Per Cubic Meter)		$15.34	$15.17	$15.15	$15.34	$15.34	$15.49	$15.49	$16.27

NOTE: Costs are in 1985 dollars. Cost estimates are based on [NSWMA86] data. The disposal practices shown are "unregulated" with respect to radiological hazards, but may be subject to other regulatory requirements.

Table B-2

COST EFFECTIVENESS OF REGULATION
HUMID PERMEABLE REGION
(Regulated Disposal versus Unregulated Municipal Dump)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	52.51	1.0588	49.60
P-CONDRSN	11.48	0.0005	25,023.24
L-WASTOIL	9.23	0.0000	393,322.20
B-COTRASH	58.69	0.6620	88.66
I-COTRASH	36.77	68.1458	0.54
I-BIOWAST	3.26	3.5013	0.93
I-ABSLIQD	6.87	4.1884	1.64
I-LQSCNVL	9.29	0.1735	53.52
N-SSTRASH	38.97	0.0000	1,060,547.42
N-SSWASTE	6.88	0.0001	54,588.05
N-LOTRASH	18.01	10.4270	1.73
N-LOWASTE	10.71	3.5252	3.04
F-PROCESS	13.99	0.0007	19,196.87
U-PROCESS	7.42	0.0005	16,276.89
F-COTRASH	42.23	0.0001	372,089.40
F-NCTRASH	10.88	0.0000	568,040.01
C-SMOKDET	329.75	0.0054	61,499.79
C-TIMEPCS	212.29	3.3807	62.79
R-GLASDS1	2615.10	0.1919	13,628.81
R-GLASDS2	0.01	0.0000	194.77
R-INSTDF1	266.77	0.0987	2,701.52
R-INSTDF2	0.03	0.0000	762.69
R-RAIXRSN	9.99	0.2091	47.75
R-RASOURC	1.33	1.5721	0.84
	3,772.44	97.1419	38.83

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-3

COST EFFECTIVENESS OF REGULATION
HUMID IMPERMEABLE REGION
(Regulated Disposal versus Unregulated Municipal Dump)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	19.07	0.2695	70.74
P-CONDRSN	3.74	0.0003	12,752.73
L-WASTOIL	4.84	0.0000	180,510.19
B-COTRASH	53.29	0.6797	78.41
I-COTRASH	36.80	1.6465	22.35
I-BIOWAST	3.27	0.0862	37.90
I-ABSLIQD	6.88	0.1235	55.66
I-LQSCNVL	9.29	0.0038	2,420.30
N-SSTRASH	62.48	0.0001	456,486.94
N-SSWASTE	11.03	0.0005	23,621.36
N-LOTRASH	10.63	0.1482	71.72
N-LOWASTE	6.32	0.0546	115.64
F-PROCESS	0.85	0.0001	8,219.36
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	2.55	0.0000	162,371.97
F-NCTRASH	0.66	0.0000	246,131.06
C-SMOKDET	163.11	0.4684	348.19
C-TIMEPCS	105.01	0.0413	2,545.15
R-GLASDS1	1293.55	0.5550	2,330.66
R-GLASDS2	0.00	0.0000	83.02
R-INSTDF1	142.78	0.8157	175.05
R-INSTDF2	0.01	0.0003	49.36
R-RAIXRSN	4.94	2.7005	1.83
R-RASOURC	1.40	45.4095	0.03
	1,942.49	53.0037	36.65

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very-small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-4

COST EFFECTIVENESS OF REGULATION
ARID PERMEABLE REGION
(Regulated Disposal versus Unregulated Municipal Dump)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	20.48	0.0671	305.31
P-CONDRSN	4.19	0.0000	91,332.87
L-WASTOIL	1.41	0.0000	424,988.32
B-COTRASH	3.30	0.0079	419.69
I-COTRASH	24.20	-1.9940	(12.14)
I-BIOWAST	2.15	-0.1031	(20.83)
I-ABSLIQD	4.52	-0.1198	(37.74)
I-LQSCNVL	6.11	-0.0052	(1,170.72)
N-SSTRASH	23.29	0.0000	491,595.19
N-SSWASTE	4.11	0.0002	25,322.32
N-LOTRASH	6.57	-0.1688	(38.93)
N-LOWASTE	3.91	-0.0572	(68.24)
F-PROCESS	5.80	0.0009	6,686.24
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	17.50	0.0001	130,212.41
F-NCTRASH	4.51	0.0000	197,806.65
C-SMOKDET	176.49	0.0076	23,266.60
C-TIMEPCS	113.62	0.0000	3,037,681.38
R-GLASDS1	1399.63	0.9884	1,416.11
R-GLASDS2	0.00	0.0000	102.27
R-INSTDF1	131.95	0.0418	3,153.35
R-INSTDF2	0.01	0.0000	892.55
R-RAIXRSN	5.34	0.1098	48.68
R-RASOURC	0.55	0.6907	0.80
	1,959.65	(0.5337)	(3,671.95)

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

COST EFFECTIVENESS OF REGULATION
TOTAL U.S.
(Regulated Disposal versus Unregulated Municipal Dump)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	92.06	1.3954	65.97
P-CONDRSN	19.41	0.0008	24,327.16
L-WASTOIL	15.48	0.0001	288,787.24
B-COTRASH	115.29	1.3495	85.43
I-COTRASH	97.77	67.7982	1.44
I-BIOWAST	8.68	3.4844	2.49
I-ABSLIQD	18.27	4.1921	4.36
I-LQSCNVL	24.69	0.1721	143.45
N-SSTRASH	124.74	0.0002	564,459.00
N-SSWASTE	22.01	0.0008	29,154.07
N-LOTRASH	35.21	10.4063	3.38
N-LOWASTE	20.93	3.5226	5.94
F-PROCESS	20.63	0.0017	12,145.78
U-PROCESS	7.42	0.0005	16,276.89
F-COTRASH	62.28	0.0003	236,257.92
F-NCTRASH	16.05	0.0000	359,617.22
C-SMOKDET	669.35	0.4814	1,390.43
C-TIMEPCS	430.91	3.4220	125.92
R-GLASDS1	5308.28	1.7353	3,059.08
R-GLASDS2	0.01	0.0001	124.41
R-INSTDF1	541.51	0.9563	566.27
R-INSTDF2	0.05	0.0003	159.62
R-RAIXRSN	20.27	3.0194	6.71
R-RASOURC	3.28	47.6723	0.07
	7,674.58	149.6119	51.30

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

COST EFFECTIVENESS OF REGULATION
HUMID PERMEABLE REGION
(Regulated Disposal versus Unregulated Suburban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	52.51	1.7798	29.51
P-CONDRSN	11.48	0.0003	41,669.34
L-WASTOIL	9.23	0.0000	773,286.91
B-COTRASH	58.69	0.8408	69.80
I-COTRASH	36.77	151.7716	0.24
I-BIOWAST	3.26	6.6978	0.49
I-ABSLIQD	6.87	7.9954	0.86
I-LQSCNVL	9.29	0.3328	27.91
N-SSTRASH	38.97	0.0000	1,134,146.94
N-SSWASTE	6.88	0.0001	58,477.28
N-LOTRASH	18.01	23.2102	0.78
N-LOWASTE	10.71	6.7695	1.58
F-PROCESS	13.99	0.0011	13,136.30
U-PROCESS	7.42	0.0007	11,137.37
F-COTRASH	42.23	0.0001	398,381.04
F-NCTRASH	10.88	0.0000	607,961.80
C-SMOKDET	329.75	0.0028	117,420.43
C-TIMEPCS.	212.29	7.1670	29.62
R-GLASDS1	2615.10	0.1689	15,483.58
R-GLASDS2	0.01	0.0000	209.07
R-INSTDF1	266.77	0.0624	4,273.75
R-INSTDF2	0.03	0.0000	1,208.30
R-RAIXRSN	9.99	0.1974	50.58
R-RASOURC	1.33	1.5091	0.88
	3,772.44	208.5078	18.09

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-7

COST EFFECTIVENESS OF REGULATION
HUMID IMPERMEABLE REGION
(Regulated Disposal versus Unregulated Suburban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	19.07	0.1855	102.80
P-CONDRSN	3.74	0.0002	19,632.59
L-WASTOIL	4.84	0.0000	276,193.14
B-COTRASH	53.29	0.4381	121.63
I-COTRASH	36.80	1.5616	23.56
I-BIOWAST	3.27	0.1183	27.62
I-ABSLIQD	6.88	0.1549	44.39
I-LQSCNVL	9.29	0.0059	1,584.27
N-SSTRASH	62.48	0.0004	167,376.34
N-SSWASTE	11.03	0.0013	8,612.02
N-LOTRASH	10.63	0.1402	75.80
N-LOWASTE	6.32	0.0727	86.84
F-PROCESS	0.85	0.0003	3,023.36
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	2.55	0.0000	58,688.86
F-NCTRASH	0.66	0.0000	90,068.80
C-SMOKDET	163.11	0.6131	266.04
C-TIMEPCS	105.01	0.0599	1,751.99
R-GLASDS1	1293.55	0.7056	1,833.17
R-GLASDS2	0.00	0.0001	30.67
R-INSTDF1	142.78	0.9735	146.67
R-INSTDF2	0.01	0.0003	41.46
R-RAIXRSN	4.94	2.9916	1.65
R-RASOURC	1.40	49.5895	0.03
	1,942.49	57.6130	33.72

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-8

COST EFFECTIVENESS OF REGULATION
ARID PERMEABLE REGION
(Regulated Disposal versus Unregulated Suburban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	20.48	0.0688	297.45
P-CONDRSN	4.19	-0.0000	(8,080,859.09)
L-WASTOIL	1.41	0.0000	323,890,184,715.99
B-COTRASH	3.30	0.0079	420.20
I-COTRASH	24.20	-1.6241	(14.90)
I-BIOWAST	2.15	-0.1049	(20.48)
I-ABSLIQD	4.52	-0.1255	(36.04)
I-LQSCNVL	6.11	-0.0052	(1,169.63)
N-SSTRASH	23.29	0.0000	483,718.14
N-SSWASTE	4.11	0.0002	24,940.30
N-LOTRASH	6.57	-0.1376	(47.78)
N-LOWASTE	3.91	-0.0588	(66.45)
F-PROCESS	5.80	0.0000	139,187,703.14
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	17.50	0.0001	127,627.41
F-NCTRASH	4.51	0.0000	195,287.93
C-SMOKDET	176.49	0.0076	23,326.32
C-TIMEPCS	113.62	0.0000	5,637,298.23
R-GLASDS1	1399.63	1.0079	1,388.67
R-GLASDS2	0.00	0.0000	100.77
R-INSTDF1	131.95	0.0425	3,105.14
R-INSTDF2	0.01	0.0000	880.10
R-RAIXRSN	5.34	0.0116	460.34
R-RASOURC	0.55	0.0389	14.23
	1,959.65	(0.8705)	(2,251.17)

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

COST EFFECTIVENESS OF REGULATION
TOTAL U.S.
(Regulated Disposal versus Unregulated Suburban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	92.06	2.0341	45.26
P-CONDRSN	19.41	0.0005	41,700.85
L-WASTOIL	15.48	0.0000	525,346.11
B-COTRASH	115.29	1.2868	89.59
I-COTRASH	97.77	151.7091	0.64
I-BIOWAST	8.68	6.7111	1.29
I-ABSLIQD	18.27	8.0248	2.28
I-LQSCNVL	24.69	0.3334	74.06
N-SSTRASH	124.74	0.0005	273,670.53
N-SSWASTE	22.01	0.0016	14,086.47
N-LOTRASH	35.21	23.2129	1.52
N-LOWASTE	20.93	6.7834	3.09
F-PROCESS	20.63	0.0013	15,343.18
U-PROCESS	7.42	0.0007	11,137.37
F-COTRASH	62.28	0.0003	217,286.96
F-NCTRASH	16.05	0.0000	332,302.93
C-SMOKDET	669.35	0.6235	1,073.58
C-TIMEPCS	430.91	7.2269	59.63
R-GLASDS1	5308.28	1.8824	2,819.92
R-GLASDS2	0.01	0.0001	77.44
R-INSTDF1	541.51	1.0784	502.13
R-INSTDF2	0.05	0.0004	141.85
R-RAIXRSN	20.27	3.2006	6.33
R-RASOURC	3.28	51.1375	0.06
	7,674.58	265.2503	28.93

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

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N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-10

COST EFFECTIVENESS OF REGULATION
HUMID PERMEABLE REGION
(Regulated Disposal versus Unregulated Suburban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	52.42	0.9502	55.17
P-CONDRSN	11.48	0.0003	45,831.41
L-WASTOIL	9.22	0.0000	517,270.51
B-COTRASH	58.58	0.7206	81.30
I-COTRASH	36.70	35.6046	1.03
I-BIOWAST	3.26	1.8214	1.79
I-ABSLIQD	6.87	2.1836	3.15
I-LQSCNVL	9.28	0.0902	102.93
N-SSTRASH	38.90	0.0001	567,513.10
N-SSWASTE	6.87	0.0002	29,177.07
N-LOTRASH	17.98	5.4133	3.32
N-LOWASTE	10.69	1.8446	5.79
F-PROCESS	13.96	0.0014	9,738.19
U-PROCESS	7.41	0.0009	8,517.23
F-COTRASH	42.15	0.0002	189,220.64
F-NCTRASH	10.87	0.0000	289,194.72
C-SMOKDET	329.72	0.0073	45,064.78
C-TIMEPCS	212.28	1.1274	188.29
R-GLASDS1	2615.08	0.3637	7,189.77
R-GLASDS2	0.01	0.0001	104.13
R-INSTDF1	266.77	0.0675	3,949.20
R-INSTDF2	0.03	0.0000	1,112.36
R-RAIXRSN	9.98	0.1571	63.55
R-RASOURC	1.33	1.1401	1.16
	3,771.83	51.4949	73.25

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very-small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-11

COST EFFECTIVENESS OF REGULATION
HUMID IMPERMEABLE REGION
(Regulated Disposal versus Unregulated Suburban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	19.03	0.1920	99.12
P-CONDRSN	3.74	0.0002	19,838.98
L-WASTOIL	4.84	0.0000	245,595.34
B-COTRASH	53.19	0.4566	116.50
I-COTRASH	36.73	-0.9123	(40.26)
I-BIOWAST	3.26	-0.0376	(86.79)
I-ABSLIQD	6.87	-0.0309	(222.10)
I-LQSCNVL	9.29	-0.0019	(4,794.92)
N-SSTRASH	62.37	0.0004	155,910.84
N-SSWASTE	11.01	0.0014	8,021.75
N-LOTRASH	10.61	-0.0823	(128.82)
N-LOWASTE	6.30	-0.0201	(312.91)
F-PROCESS	0.84	0.0003	2,802.26
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	2.55	0.0000	54,541.42
F-NCTRASH	0.66	0.0000	82,216.86
C-SMOKDET	163.10	0.5627	289.82
C-TIMEPCS	105.01	0.0168	6,240.37
R-GLASDS1	1293.54	0.7681	1,684.07
R-GLASDS2	0.00	0.0001	28.58
R-INSTDF1	142.78	0.8872	160.94
R-INSTDF2	0.01	0.0003	45.36
R-RAIXRSN	4.94	2.8066	1.76
R-RASOURC	1.40	46.8345	0.03
	1,942.08	51.4420	37.75

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very-small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-12

COST EFFECTIVENESS OF REGULATION
ARID PERMEABLE REGION
(Regulated Disposal versus Unregulated Suburban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	20.44	0.1132	180.55
P-CONDRSN	4.19	0.0001	67,211.19
L-WASTOIL	1.41	0.0000	244,719.34
B-COTRASH	3.30	0.0117	282.81
I-COTRASH	24.16	-2.0327	(11.89)
I-BIOWAST	2.15	-0.1057	(20.32)
I-ABSLIQD	4.52	-0.1208	(37.42)
I-LQSCNVL	6.11	-0.0054	(1,135.70)
N-SSTRASH	23.24	0.0001	342,854.31
N-SSWASTE	4.10	0.0002	17,628.67
N-LOTRASH	6.56	-0.1721	(38.13)
N-LOWASTE	3.90	-0.0584	(66.83)
F-PROCESS	5.79	0.0012	4,765.24
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	17.47	0.0002	92,591.64
F-NCTRASH	4.50	0.0000	141,106.84
C-SMOKDET	176.47	0.0103	17,133.41
C-TIMEPCS	113.61	0.0012	92,526.02
R-GLASDS1	1399.62	1.2708	1,101.41
R-GLASDS2	0.00	0.0000	70.12
R-INSTDF1	131.95	0.0535	2,466.31
R-INSTDF2	0.01	0.0000	696.96
R-RAIXRSN	5.34	0.1369	39.02
R-RASOURC	0.55	0.8722	0.63
	1,959.40	(0.0232)	(84,283.88)

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-13

COST EFFECTIVENESS OF REGULATION

TOTAL U.S.

(Regulated Disposal versus Unregulated Suburban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	91.89	1.2554	73.20
P-CONDRSN	19.40	0.0005	38,720.97
L-WASTOIL	15.46	0.0000	357,391.38
B-COTRASH	115.08	1.1888	96.80
I-COTRASH	97.59	32.6596	2.99
I-BIOWAST	8.67	1.6781	5.17
I-ABSLIQD	18.26	2.0319	8.99
I-LQSCNVL	24.69	0.0829	297.85
N-SSTRASH	124.51	0.0005	232,142.04
N-SSWASTE	21.97	0.0018	11,941.78
N-LOTRASH	35.15	5.1589	6.81
N-LOWASTE	20.89	1.7661	11.83
F-PROCESS	20.60	0.0029	6,982.14
U-PROCESS	7.41	0.0009	8,517.23
F-COTRASH	62.17	0.0005	135,691.25
F-NCTRASH	16.03	0.0001	206,846.02
C-SMOKDET	669.29	0.5804	1,153.23
C-TIMEPCS	430.90	1.1455	376.19
R-GLASDS1	5308.24	2.4026	2,209.39
R-GLASDS2	0.01	0.0002	58.78
R-INSTDF1	541.50	1.0082	537.09
R-INSTDF2	0.05	0.0003	151.29
R-RAIXRSN	20.27	3.1007	6.54
R-RASOURC	3.28	48.8468	0.07
	7,673.31	102.9136	74.56

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very_small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-14

COST EFFECTIVENESS OF REGULATION
HUMID PERMEABLE REGION
(Regulated Disposal versus Unregulated Urban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	52.51	4.3403	12.10
P-CONDRSN	11.48	0.0004	28,304.17
L-WASTOIL	9.23	0.0000	762,760.39
B-COTRASH	58.69	1.8742	31.32
I-COTRASH	36.77	394.8502	0.09
I-BIOWAST	3.26	20.2896	0.16
I-ABSLIQD	6.87	24.2483	0.28
I-LQSCNVL	9.29	1.0066	9.23
N-SSTRASH	38.97	0.0000	1,060,592.80
N-SSWASTE	6.88	0.0001	54,635.32
N-LOTRASH	18.01	60.5843	0.30
N-LOWASTE	10.71	20.4860	0.52
F-PROCESS	13.99	0.0007	18,994.80
U-PROCESS	7.42	0.0005	16,292.64
F-COTRASH	42.23	0.0001	369,278.12
F-NCTRASH	10.88	0.0000	563,533.91
C-SMOKDET	329.75	0.0032	103,387.58
C-TIMEPCS	212.29	18.3926	11.54
R-GLASDS1	2615.10	0.1917	13,642.78
R-GLASDS2	0.01	0.0000	195.61
R-INSTDF1	266.77	0.0627	4,251.81
R-INSTDF2	0.03	0.0000	1,202.85
R-RAIXRSN	9.99	0.1116	89.48
R-RASOURC	1.33	0.9061	1.47
	3,772.44	547.3494	6.89

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-15

COST EFFECTIVENESS OF REGULATION
HUMID IMPERMEABLE REGION
(Regulated Disposal versus Unregulated Urban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	19.07	0.2770	68.83
P-CONDRSN	3.74	0.0002	15,381.73
L-WASTOIL	4.84	0.0000	205,342.24
B-COTRASH	53.29	0.5716	93.23
I-COTRASH	36.80	1.9275	19.09
I-BIOWAST	3.27	0.1004	32.52
I-ABSLIQD	6.88	0.1370	50.20
I-LQSCNVL	9.29	0.0062	1,509.96
N-SSTRASH	62.48	0.0021	30,169.74
N-SSWASTE	11.03	0.0071	1,544.20
N-LOTRASH	10.63	0.1742	61.01
N-LOWASTE	6.32	0.0633	99.80
F-PROCESS	0.85	0.0016	543.55
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	2.55	0.0002	10,621.08
F-NCTRASH	0.66	0.0000	16,185.22
C-SMOKDET	163.11	1.7594	92.71
C-TIMEPCS	105.01	0.2240	468.71
R-GLASDS1	1293.55	1.8440	701.50
R-GLASDS2	0.00	0.0005	5.53
R-INSTDF1	142.78	2.2680	62.96
R-INSTDF2	0.01	0.0008	17.77
R-RAIXRSN	4.94	5.2434	0.94
R-RASOURC	1.40	84.9675	0.02
	1,942.49	99.5759	19.51

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

Table B-16

COST EFFECTIVENESS OF REGULATION
ARID PERMEABLE REGION
(Regulated Disposal versus Unregulated Urban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	20.48	1.9953	10.26
P-CONDRSN	4.19	0.0002	24,176.87
L-WASTOIL	1.41	0.0000	151,440.62
B-COTRASH	3.30	0.1816	18.19
I-COTRASH	24.20	181.2404	0.13
I-BIOWAST	2.15	9.3199	0.23
I-ABSLIQD	4.52	11.1339	0.41
I-LQSCNVL	6.11	0.4630	13.21
N-SSTRASH	23.29	0.0001	170,509.37
N-SSWASTE	4.11	0.0005	8,769.79
N-LOTRASH	6.57	15.3502	0.43
N-LOWASTE	3.91	5.2246	0.75
F-PROCESS	5.80	0.0025	2,311.93
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	17.50	0.0004	45,026.66
F-NCTRASH	4.51	0.0001	68,601.39
C-SMOKDET	176.49	0.0212	8,343.45
C-TIMEPCS	113.62	0.0004	271,341.16
R-GLASDS1	1399.63	2.8780	486.33
R-GLASDS2	0.00	0.0001	35.49
R-INSTDF1	131.95	0.1207	1,092.95
R-INSTDF2	0.01	0.0000	309.84
R-RAIXRSN	5.34	0.2908	18.38
R-RASOURC	0.55	1.9072	0.29
	1,959.65	230.1310	8.52

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

Table B-17

COST EFFECTIVENESS OF REGULATION
TOTAL U.S.
(Regulated Disposal versus Unregulated Urban SLF without Incin.)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	92.06	6.6126	13.92
P-CONDRSN	19.41	0.0008	23,614.45
L-WASTOIL	15.48	0.0000	344,140.57
B-COTRASH	115.29	2.6274	43.88
I-COTRASH	97.77	578.0180	0.17
I-BIOWAST	8.68	29.7100	0.29
I-ABSLIQD	18.27	35.5191	0.51
I-LQSCNVL	24.69	1.4758	16.73
N-SSTRASH	124.74	0.0022	55,580.20
N-SSWASTE	22.01	0.0077	2,845.95
N-LOTRASH	35.21	76.1086	0.46
N-LOWASTE	20.93	25.7739	0.81
F-PROCESS	20.63	0.0048	4,298.01
U-PROCESS	7.42	0.0005	16,292.64
F-COTRASH	62.28	0.0007	83,773.09
F-NCTRASH	16.05	0.0001	127,675.29
C-SMOKDET	669.35	1.7837	375.25
C-TIMEPCS	430.91	18.6170	23.15
R-GLASDS1	5308.28	4.9136	1,080.32
R-GLASDS2	0.01	0.0006	18.53
R-INSTDF1	541.51	2.4514	220.89
R-INSTDF2	0.05	0.0008	62.32
R-RAIXRSN	20.27	5.6457	3.59
R-RASOURC	3.28	87.7808	0.04
	7,674.58	877.0562	8.75

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

COST EFFECTIVENESS OF REGULATION
HUMID PERMEABLE REGION
(Regulated Disposal versus Unregulated Urban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	52.42	2.3110	22.68
P-CONDRSN	11.48	0.0003	33,606.19
L-WASTOIL	9.22	0.0000	230,826.81
B-COTRASH	58.58	1.6165	36.24
I-COTRASH	36.70	97.4127	0.38
I-BIOWAST	3.26	4.9946	0.65
I-ABSLIQD	6.87	5.9918	1.15
I-LQSCNVL	9.28	0.2479	37.45
N-SSTRASH	38.90	0.0001	273,038.21
N-SSWASTE	6.87	0.0005	14,061.35
N-LOTRASH	17.98	14.8645	1.21
N-LOWASTE	10.69	5.0492	2.12
F-PROCESS	13.96	0.0031	4,502.28
U-PROCESS	7.41	0.0018	4,029.35
F-COTRASH	42.15	0.0005	87,352.40
F-NCTRASH	10.87	0.0001	133,383.99
C-SMOKDET	329.72	0.0182	18,117.79
C-TIMEPCS	212.28	2.9145	72.84
R-GLASDS1	2615.08	1.0435	2,506.17
R-GLASDS2	0.01	0.0001	50.47
R-INSTDF1	266.77	0.0799	3,340.21
R-INSTDF2	0.03	0.0000	945.13
R-RAIXRSN	9.98	0.1649	60.54
R-RASOURC	1.33	1.2841	1.03
	3,771.83	137.9998	27.33

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

COST EFFECTIVENESS OF REGULATION
HUMID IMPERMEABLE REGION
(Regulated Disposal versus Unregulated Urban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	19.03	0.3016	63.10
P-CONDRSN	3.74	0.0002	15,122.06
L-WASTOIL	4.84	0.0000	162,150.52
B-COTRASH	53.19	0.6197	85.84
I-COTRASH	36.73	-0.7384	(49.74)
I-BIOWAST	3.26	-0.0291	(112.31)
I-ABSLIQD	6.87	-0.0158	(435.36)
I-LQSCNVL	9.29	-0.0004	(23,280.85)
N-SSTRASH	62.37	0.0020	30,463.13
N-SSWASTE	11.01	0.0071	1,560.08
N-LOTRASH	10.61	-0.0668	(158.90)
N-LOWASTE	6.30	-0.0136	(463.08)
F-PROCESS	0.84	0.0015	548.86
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	2.55	0.0002	10,657.77
F-NCTRASH	0.66	0.0000	16,265.06
C-SMOKDET	163.10	1.6344	99.79
C-TIMEPCS	105.01	0.0619	1,697.42
R-GLASDS1	1293.54	1.9412	666.38
R-GLASDS2	0.00	0.0005	5.59
R-INSTDF1	142.78	2.0795	68.66
R-INSTDF2	0.01	0.0007	19.28
R-RAIXRSN	4.94	4.9056	1.01
R-RASOURC	1.40	79.4385	0.02
	1,942.08	90.1307	21.55

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

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SEPTEMBER 1987

Table B-20

COST EFFECTIVENESS OF REGULATION
ARID PERMEABLE REGION
(Regulated Disposal versus Unregulated Urban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	20.44	1.5031	13.60
P-CONDRSN	4.19	0.0002	23,886.05
L-WASTOIL	1.41	0.0000	96,142.01
B-COTRASH	3.30	0.1783	18.50
I-COTRASH	24.16	44.0052	0.55
I-BIOWAST	2.15	2.2494	0.95
I-ABSLIQD	4.52	2.7028	1.67
I-LQSCNVL	6.11	0.1114	54.86
N-SSTRASH	23.24	0.0002	137,975.12
N-SSWASTE	4.10	0.0006	7,089.37
N-LOTRASH	6.56	3.7263	1.76
N-LOWASTE	3.90	1.2641	3.08
F-PROCESS	5.79	0.0031	1,879.47
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	17.47	0.0005	36,565.65
F-NCTRASH	4.50	0.0001	55,794.57
C-SMOKDET	176.47	0.0259	6,818.04
C-TIMEPCS	113.61	0.0026	44,077.82
R-GLASDS1	1399.62	3.4548	405.13
R-GLASDS2	0.00	0.0001	28.67
R-INSTDF1	131.95	0.1451	909.24
R-INSTDF2	0.01	0.0000	256.96
R-RAIXRSN	5.34	0.3482	15.35
R-RASOURC	0.55	2.2897	0.24
	1,959.40	62.0116	31.60

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

COST EFFECTIVENESS OF REGULATION
TOTAL U.S.
(Regulated Disposal versus Unregulated Urban SLF with Incineration)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS *	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
P-COTRASH	91.89	4.1157	22.33
P-CONDRSN	19.40	0.0008	25,398.45
L-WASTOIL	15.46	0.0001	183,202.28
B-COTRASH	115.08	2.4144	47.66
I-COTRASH	97.59	140.6795	0.69
I-BIOWAST	8.67	7.2149	1.20
I-ABSLIQD	18.26	8.6789	2.10
I-LQSCNVL	24.69	0.3589	68.78
N-SSTRASH	124.51	0.0024	52,798.42
N-SSWASTE	21.97	0.0081	2,705.47
N-LOTRASH	35.15	18.5240	1.90
N-LOWASTE	20.89	6.2997	3.32
F-PROCESS	20.60	0.0077	2,668.09
U-PROCESS	7.41	0.0018	4,029.35
F-COTRASH	62.17	0.0012	51,831.12
F-NCTRASH	16.03	0.0002	79,113.35
C-SMOKDET	669.29	1.6785	398.75
C-TIMEPCS	430.90	2.9789	144.65
R-GLASDS1	5308.24	6.4394	824.34
R-GLASDS2	0.01	0.0007	15.99
R-INSTDF1	541.50	2.3045	234.98
R-INSTDF2	0.05	0.0008	65.98
R-RAIXRSN	20.27	5.4187	3.74
R-RASOURC	3.28	83.0123	0.04
	7,673.31	290.1420	26.45

NOTE: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Note consumer and NARM wastes are currently unregulated.

* Avoided health effects are reported to four significant digits; therefore, "0.0000" does not imply that zero health effects would be avoided with regulation, only that the benefit is very small.

N.A. = Waste not generated in this region.

SEPTEMBER 1987

COST OF REGULATED AND UNREGULATED DISPOSAL

Appendix C

This appendix presents the estimated unit costs for regulated and unregulated disposal of commercial LLW and NARM. The methodology used in constructing these cost estimates is discussed in detail here.

In the BRC analysis presented in Chapter 7, unregulated costs are compared to regulated costs to determine the cost-effectiveness of regulating individual wastes. Savings attributed to EPA's BRC standard were estimated by using the same comparison. In the LLW analysis presented in Chapter 8, the regulated costs of different disposal methods are compared to determine the cost-effectiveness of these methods and to ascertain which disposal methods will meet the alternative LLW standards at least cost. Of course, to estimate the cost-effectiveness of the alternative BRC and LLW standards, the cost components of regulated and unregulated disposal had to be estimated as a first step.

Costs are defined as the real resource costs to society, characterized in the EIA as the before-tax cash cost paid by the generator of LLW. The analysis considers those cost components that vary across alternative disposal options, thus providing the necessary information to measure the relative cost-effectiveness of each option. The costs that do not vary across disposal options, such as enforcement or monitoring costs, for example, are irrelevant for purposes of the analysis and, therefore, are not considered. Because a relative comparison is being used as opposed to an absolute one, the cost numbers presented here should <u>not</u> be construed as being all inclusive; therefore, these costs should be used only in the context of this analysis.

The cost components considered in the analysis for regulated disposal include packaging, processing, transportation, disposal, and, for some consumer-like wastes, collection. Unregulated disposal costs include the transportation and disposal components only. With regulated disposal, processing costs, which involve techniques such as solidification, compaction, and incineration, are paid by the waste generator before shipping to a disposal site. To the extent that compaction or incineration, for example, are performed by an unregulated disposal site operator, these costs would be captured in the tipping fees (disposal costs) charged to the waste generator. In comparison to packaging costs associated with regulated disposal, where wastes must be placed in steel drums or boxes (and sometimes shielded casks for higher activity waste) to meet U.S. Department of Transportation (DOT) regulations, the packaging costs associated with unregulated disposal are negligible. Therefore, this component of cost is not included in the estimates of unregulated disposal cost. Finally, the cost of collecting waste is a unique problem associated with the regulated disposal of some consumer-like wastes that are widely distributed throughout the economy. Collection costs can be quite significant for regulated disposal of consumer-like wastes, since the owners of these wastes are not typically involved with radioactive waste handling. For these generators, the economies of scale in waste disposal that are present for typical low-level waste generators are not realized, since the number of items to be disposed is very low. The methodology used in estimating collection costs is discussed later in this appendix.

This appendix is divided into two sections. The first section discusses the methodology, data sources, and caveats associated with estimating the unregulated costs used in the BRC analysis. The second section has a similar discussion for the regulated disposal costs used in the EIA.

UNREGULATED DISPOSAL COSTS

This section presents estimates of unregulated disposal costs and describes the methodology and assumptions underlying these estimates.

The general methodology involved in estimating the least-cost (i.e., least stringent) form of disposal for the five unregulated disposal practices is presented in Table C-1. The cost estimates include disposal and transportation costs for BRC waste shipped to a sanitary landfill or to a transfer station in the event this latter option was available. The methodology assumes packaging costs are negligible; therefore, this component of cost is not included in the estimates of unregulated disposal cost. Prices, in 1985 dollars, were used to estimate societal cost. A more detailed discussion follows concerning the data sources used and the specific assumptions made in arriving at the unregulated disposal costs presented in Tables C-2 and C-3.

The data were derived from two primary sources. The tipping fees for landfills, transfer stations, and resource recovery plants were taken from a survey by the National Solid Wastes Management Association (NSWMA) conducted in the fall of 1985 [NSWMA85]. All fees reported are gate fees which represent the price (rather than cost) charged to the waste generator. NSWMA emphasizes that the municipality that owns the landfill and/or others under contract will generally face a lower charge. Follow-up discussions confirmed that gate fees were the closest approximation to an unsubsidized charge (i.e., a charge which reflects the societal cost) for solid waste disposal.* The analysis of transportation costs used estimates reported in RAD86.

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* Based on telephone conversation with C.L. Pettit of National Soild Wastes Management Association, February 15, 1986.

Table C-1

SUMMARY OF BRC DISPOSAL COSTS
(in 1985 dollars per cubic meter)

BRC Disposal Site	Average Disposal Cost	Average Transportation Cost	Average Incineration Cost	Total Cost
MUNICIPAL DUMP (MD)	6	8.78	N/A	14.78
SUBURBAN SLF, without INCINERATION (SF)	6	8.78	N/A	14.78
SUBURBAN SLF, with INCINERATION (SI)	N/A*	4.79	11.48	16.27
URBAN SLF, without INCINERATION (UF)	6	8.78	N/A	14.78
URBAN SLF, with INCINERATION (UI)	N/A*	4.79	11.48	16.27

* Disposal cost included under incineration cost.

TABLE C-2
DISPOSAL COSTS FOR BRC WASTE STREAMS BY COMPACT
WITHOUT INCINERATION
(IN 1985 DOLLARS PER CUBIC METER)

STATE	LOCATION	**COMPACT	LANDFILL FEE	TRANSFER STATION FEE	DISPOSAL FEE INCLUDING TRANSPORTATION*
HI	Honolulu	1	4.36	8.28	13.07
ID	Boise	1	1.18		10.76
WA	Bremerton	1	5.04		14.62
		AVERAGE	3.52	8.28	12.82
CA	Long Beach	2	2.62	5.96	10.75
CA	Los Angeles	2	2.18		11.76
CA	Richmond	2	4.80		14.38
CA	Sacramento	2	2.01		11.59
CA	San Diego	2	3.49		13.07
CA	San Francisco	2		15.83	20.62
		AVERAGE	3.02	10.90	13.70
CO	Boulder	3	2.62		12.20
CO	Denver	3	3.60		13.18
CO	Denver	3	3.01		12.59
NM	Albequerque	3	5.49		15.08
NV	Las Vegas	3		3.92	8.71
NV	Las Vegas	3	2.62	3.27	8.06
		AVERAGE	3.47	3.60	11.64
TX	Austin (high)	4	2.15		11.73
TX	Austin (low)	4	1.73		11.31
TX	Clute	4	4.14		13.73
TX	Dallas	4	2.35	4.14	8.93
TX	Houston	4	4.12		13.70
TX	Houston	4	4.77		14.36
TX	San Antonio	4	3.58		13.16
		AVERAGE	3.26	4.14	12.42
AR	Fayettville	5	3.03		12.61
AR	Little Rock	5	5.45		15.03
AR	N. Little Rock	5	3.16		12.75
KS	Wichita (high)	5	1.53		11.11
KS	Wichita (low)	5	1.20		10.78
LA	New Orleans	5	1.74		11.33
LA	Abbeville	5	5.23		14.82
ND	Bismark	5	2.35		11.94
ND	Bismark	5	3.92		13.51
NE	Lincoln (NO FEE)	5			
OK	Tulsa	5	1.87		11.46
IA	Des Moines	5 & 7	4.36		13.94
MN	Minneapolis	5 & 7		14.39	19.17
MN	St. Paul	5 & 7	6.76		16.34
MO	Kansas City	5 & 7	4.36		13.94
MO	St. Joseph (high)	5 & 7	2.90		12.49
MO	St. Joseph (low)	5 & 7	0.90		10.49
MO	St. Louis	5 & 7	6.06		15.64
MO	St. Louis	5 & 7	7.85		17.43
		AVERAGE	3.69	14.39	13.60
IN	Fort Wayne	7	2.62		12.20
IN	Indianapolis	7	4.32		13.90
MI	Detroit	7	2.29		11.87
MI	Lansing	7	4.45		14.03
OH	Akron (high)	7	3.71		13.29
OH	Akron (low)	7	3.53		13.12
OH	Cinncinnati	7	3.07		12.66

Table continued on next page

TABLE C-2 (Continued)
DISPOSAL COSTS FOR BRC WASTE STREAMS BY COMPACT
WITHOUT INCINERATION
(IN 1985 DOLLARS PER CUBIC METER)

STATE	LOCATION	**COMPACT	LANDFILL FEE	TRANSFER STATION FEE	DISPOSAL FEE INCLUDING TRANSPORTATION*
OH	Cleveland	7	16.29		25.88
WI	Green Bay	7	3.49		13.07
WI	Madison	7	4.36		13.94
WI	Menemonee Falls (high)	7	7.85		17.43
WI	Menemonee Falls (low)	7	4.90		14.49
IA	Des Moines	5 & 7	4.36		13.94
MN	Minneapolis	5 & 7		14.39	19.17
MN	St. Paul	5 & 7	6.76		16.34
MO	Kansas City	5 & 7	4.36		13.94
MO	St. Joseph (high)	5 & 7	2.90		12.49
MO	St. Joseph (low)	5 & 7	0.90		10.49
MO	St. Louis	5 & 7	6.06		15.64
MO	St. Louis	5 & 7	7.85		17.43
		AVERAGE	4.95	14.39	14.77
IL	Bloomington	8	3.07		12.66
IL	Chicago	8	4.32		13.90
IL	Macomb	8	1.96		11.55
IL	Ottawa	8	3.92		13.51
		AVERAGE	3.32		12.90
AL	Huntsville	9	1.66		11.24
FL	Broward County	9	9.59		19.18
FL	Dade County	9	6.98	9.72	14.50
FL	Tampa	9	5.10	13.78	18.56
GA	Atlanta	9	3.60		13.18
SC	Spartanburg County	9	1.18		10.76
TN	Memphis	9	2.18		11.76
TN	Nashville	9	2.62		12.20
VA	Fairfax County	9	7.30	7.30	12.09
VA	Prince William County	9	3.27		12.85
VA	Richmond	9	7.63		17.21
VA	Suffolk	9	5.23		14.82
		AVERAGE	4.69	10.27	14.03
PA	Chester County	10	8.72		18.30
PA	Erie	10	5.30		14.88
PA	Northampton County	10	4.80		14.38
PA	Philadelphia	10		21.80	26.59
PA	Pittsburgh	10	3.60		13.18
		AVERAGE	5.60	21.80	17.47
CT	Hartford	11	6.70		16.28
DC	Lorton (VA)	11	4.36	6.10	10.89
DE	Kent County	11	7.69		17.28
DE	New Castle County	11	12.86		22.45
DE	Sussex County	11	9.91		19.49
MA	Hanerhill	11	5.49		15.08
MA	Millbury (NO FEE)	11			
MD	Baltimore County	11	13.08		22.66
MD	Montgomery County	11		13.52	18.30
MD	Ocean City (NO FEE)	11			
MD	Prince Georges County	11	11.12		20.70
NJ	Burlington County	11	10.40		19.98
NJ	Burlington County	11	7.00		16.58
NJ	Cape May County	11	12.53		22.12
NJ	Gloucester County	11	15.05		24.64
NY	Allegany County	11	7.19		16.78
NY	Islip	11	7.85		17.43

Table continued on next page

TABLE C-2 (Continued)
DISPOSAL COSTS FOR BRC WASTE STREAMS BY COMPACT
WITHOUT INCINERATION
(IN 1985 DOLLARS PER CUBIC METER)

STATE	LOCATION	**COMPACT	LANDFILL FEE	TRANSFER STATION FEE	DISPOSAL FEE INCLUDING TRANSPORTATION*
NY	New York City	11	12.10	19.95	24.73
NY	Onondaga County	11	10.90		20.48
NY	Rochester	11	5.62	6.54	11.33
RI	Providence	11	5.23		14.82
RI	Warwick	11		10.90	15.69
		AVERAGE	9.17	11.40	18.39
ME	Bidderford	12	NO FEE		NO FEE
		AVERAGE OVER ALL REGIONS			14.78

* FEE FOR TRANSPORTATION EQUALS $9.58 FOR SHIPMENT TO LANDFILL (ASSUMING 60 MILE ROUNDTRIP) AND $4.79 FOR SHIPMENT TO TRANSFER STATION (ASSUMING 30 MILE ROUNDTRIP). FOR THOSE LOCATIONS THAT REPORT FEES FOR BOTH LANDFILLS AND TRANSFER STATIONS, IT WAS ASSUMED THAT WASTE WILL BE SHIPPED TO A TRANSFER STATION.

** COMPACTS
1 -- NORTHWEST
2 -- CALIFORNIA
3 -- ROCKY MOUNTAIN
4 -- TEXAS
5 -- CENTRAL
6 -- SOUTH DAKOTA (NO DATA)
7 -- MIDWEST
8 -- CENTRAL MIDWEST
9 -- SOUTHEAST
10 - PA / WV
11 - NORTHEAST
12 - NEW ENGLAND

NOTE: BASED ON 1986 SURVEY OF TIPPING FEES CONDUCTED BY NATIONAL SOLID WASTE MANAGEMENT ASSOCIATION.

SEPTEMBER 1987

TABLE C-3
DISPOSAL COSTS FOR BRC WASTE STREAMS
WITH INCINERATION
(IN DOLLARS PER CUBIC METER)

STATE	LOCATION	RESOURCE RECOVERY FEE	TOTAL COST INCLUDING TRANSPORTATION*
CT	Windham	7.24	12.03
FL	Dade County	13.19	17.98
FL	Lakeland	24.41	29.20
FL	Pinellas County	10.46	15.25
IA	AMES (subsidized @ $5/truck)		
IL	Chicago (No fee)		
ME	Auburn	4.85	9.64
MA	N. Andover	12.21	17.00
MA	Pittsfield (subsidized @ $6.54/cubic meter)		
MA	Saugus	15.26	20.05
MN	Duluth	6.80	11.59
MT	Livingston	10.90	15.69
NY	Albany (subsidized @ $5.45/ cubic meter)		
NY	Glen Cove	15.26	20.05
NY	Niagra Falls	5.89	10.68
NY	Westchester County	15.26	20.05
PA	Harrisburg	8.72	13.51
OH	Akron (subsidized @ $3.32/cubic meter**)		
RI	Portsmouth (No fee)		
TN	Sumner County	10.90	15.69
TN	Nashville	10.90	15.69
	AVERAGE	11.48	16.27

* THE FEE FOR TRANSPORTATION IS EQUAL TO $4.79 PER CUBIC METER (ASSUMING A 30 MILE ROUND TRIP).

** $1.92 (SAT.); $3.60 (M-F)

NOTE: BASED ON 1986 SURVEY OF TIPPING FEES CONDUCTED BY NATIONAL SOLID WASTE MANAGEMENT ASSOCIATION (NSWMA)AND CONVERSATIONS WITH C. L. PETTIT FROM NSWMA.

SEPTEMBER 1987

Table C-2 demonstrates that tipping fees were sometimes reported for both landfills and transfer stations. Under this circumstance, the tipping fee for the transfer station was used. Although the per cubic meter cost of disposal at the transfer station is usually higher than the gate fee at the landfill site, transfer stations are located closer to the waste generators. Therefore, the total cost of disposal, including transportation, is lower when shipping waste to a transfer station, since a more efficient mode of transportation can be employed when shipping waste from the transfer station to the landfill. To capture these transportation savings, our analysis assumes that the round trip distance to a landfill is 60 miles, while a round trip to a transfer station is only half that distance. Resource recovery plants were also assumed to be located closer to the generator site -- the round trip distance being 30 miles as well.

The per cubic meter transportation cost was estimated in RAD86 at about 15 cents per mile. To be consistent with estimates of disposal fees which represent prices and not simply costs, an operating profit of 8.5 percent was assumed.* Thus, the fee for transportation equals $9.58 per cubic meter for a round trip of 60 miles and $4.79 for a round trip of 30 miles. Some evidence suggests that, unlike disposal costs, transportation costs do not vary significantly by geographic region. A 1984 survey of private trucking fleet operators [ATK84] estimated that the cost per mile varied from a low $1.19 in the Southeast to a high of $1.28 in the Rocky Mountain region -- a difference of only about 7.5 percent.

Tables C-2 and C-3 present the cost of BRC disposal by Compact. Table C-2 reports the cost of BRC disposal assuming the waste is not incinerated (i.e., shipped to a landfill or transfer station), whereas Table

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* This operating profit is the 1985 industry average for Refuse Systems (SIC# 4953) reported by Robert Morris Associates. This profit is assumed to reflect a fair return on investment and, thus, to be a legitimate component of societal cost. Profit is also included in the regulated disposal cost estimates.

C-3 reports the cost associated with incineration (i.e., waste shipped to a resource recovery plant). The average tipping fee (including transportation) for waste not incinerated is $14.78 per cubic meter, compared to $16.27 for waste that is shipped to a resource recovery plant.

The cost reported in these tables are those used in the BRC analysis. These costs, it should be emphasized, assume complete deregulation. Some waste streams that are still considered hazardous (e.g., I-LQSCNVL) or possibly unsuitable for disposal at a municipal facility (e.g., animal carcasses found in I-BIOWAST) may have disposal costs that are much higher, however. The range in possible costs for these two wastes, which also are similar to the types of wastes deregulated under NRC's BIOMED rule, are considered below. One additional observation with respect to the costs presented in Tables C-2 and C-3 is that these costs assume a zero cost component for packaging. The underlying assumption is that the deregulated waste would be treated in the same fashion as other non-hazardous wastes (e.g., placed in a dumpster). While this may be a slight understatement of actual unregulated disposal costs for some wastes, the additional costs will likely be negligible in comparison to the regulated alternatives, if wastes are actually treated as nonhazardous.

As mentioned above, an exception to this assumption is the disposition of I-LQSCNVL and I-BIOWAST. Since the EIA is limited to analyzing only the radiological hazards resulting from LLW disposal, however, the health risks associated with disposing these two wastes in a hazardous waste facility was not modeled. Therefore, costs were developed consistent with the risk model, where disposal in unregulated sanitary landfills was assumed. For illustration purposes, however, the following discussion presents the possible range in costs associated with disposing I-LQSCNVL and I-BIOWAST in a more stringent fashion. Use of these alternative disposal technologies would reduce the potential savings of the proposed 4 millirem BRC standard by as much as $31 million under National Implicit implementation or $23 million under National Explicit implementation (since I-BIOWAST is regulated).

Since the liquid scintillation medium (often a toluene/xylene mixture) is considered hazardous under the Resource Conservation and Recovery Act of 1976 [RCRA76], I-LQSCNVL waste would normally require disposal at a hazardous waste facility or incineration at the generator site or regional facility. The cost per cubic meter is $3,592 for hazardous waste disposal and $2,584 for incinerated waste disposal (although, as discussed below, incineration costs may be much lower for small quantity generators of I-LQSCNVL). The cost for hazardous waste disposal is based on fees currently charged for hazardous waste disposal services, as reported in EPA86a. The cost of disposal is approximately $529 per cubic meter; the cost of transporting hazardous waste is about 21 cents per mile per cubic meter. The cost of packaging I-LQSCNVL is assumed to be the same as for regulated LLW disposal, i.e., $1,880 per cubic meter (with a volume increase factor of 3). Assuming that the transportation distance is 200 miles, the cost of disposing I-LQSCNVL at a hazardous waste site, therefore, would be equal to $3,592 per cubic meter (compared to $3,872 per cubic meter at a commercial LLW disposal site).

The costs of incinerating I-LQSCNVL and I-BIOWAST are calculated using the same methodology. Costs consistent with the regulated incineration of I-BIOWAST are considered since municipal facilities may not accept animal carcasses for unregulated incineration at the municipal site. Thus, the unregulated disposal of I-BIOWAST could cost as much as $2,482 per cubic meter, based on costs for a pathological incinerator used for processing radioactive waste [DM86]. This cost and the incinerated cost for I-LQSCNVL assume that the waste is incinerated at the generator site; then, the untreated ashes are disposed of at an unregulated facility.

As mentioned above, a lower cost incineration scenario can be envisioned for I-LQSCNVL. Factors that may contribute to a lower cost include: 1) the possibility of receiving a credit for the fuel value of the scintillation fluid and 2) the lower cost of disposing the glass vials at a local sanitary landfill. If we assume that a $5 per gallon credit is received for the scintillation fluid, then a savings of $13 per cubic meter can be achieved.* This credit would be approximately offset by the $15 per cubic meter cost of disposing the glass vials at an unregulated sanitary landfill. Information on the relative volume of glass to fluid in a scintillation vial is necessary to precisely calculate the net cost (or savings). Nonetheless, the actual cost will be quite low relative to regulated costs.

REGULATED DISPOSAL COSTS

This section presents the unit costs associated with regulated disposal. Total unit costs are calculated by aggregating the four main cost components -- packaging, processing, transportation, and disposal. Collection costs also are added to the four consumer-like wastes -- C-SMOKDET, C-TIMEPCS, R-INSTDF1, and R-GLASDS1. Since costs generally are positively correlated with waste activity, the unit costs are reported for each type of waste. Two exceptions involve disposal costs and solidification costs (a sub-component of processing cost), neither of which vary by waste.

Unit costs are based on the as generated waste volumes. Therefore, if any stage of the disposal process results in altering the as generated volume of the waste, all unit costs in the later stages of the process must be multiplied by a volume increase factor (VIF) to reflect the change in volume. For example, if solidification doubles the volume of a given waste, transportation and disposal unit costs will be doubled since twice as much waste must be transported and buried. Likewise, compaction and incineration reduce volume; hence, the VIF is less than one.

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* This credit is based on actual 1984 figures for hazardous waste resource recovery facilities [EPA86a].

The following sections discuss the methodology, data sources, and caveats associated with estimating each of the five cost components.

Packaging Costs

The cost of packaging regulated LLW was reported in EEI84a. These costs, presented in 1980 dollars, were escalated to 1985 dollars by using the change in the producer price index for capital equipment. Between 1980 and 1985, the producer price index for capital equipment increased by a factor of 1.253. Packaging costs for all wastes include both material and labor costs.

To comply with DOT regulations, some wastes require special packaging treatment. For some industrial wastes, the cost estimates assume a special container is used because of the high activity of the waste. For three of the institutional wastes -- I-BIOWAST, I-ABSLIQD, and I-LQSCNVL -- the cost estimates assume these wastes are packaged with absorbent materials. As a result, as generated volumes are increased by a factor of 1.92 for I-BIOWAST and by a factor of 3 for I-ABSLIQD and I-LQSCNVL. Estimates for the four LWR wastes containing liquids reflect the cost of dewatering these wastes.

R-RAIXRSN is assumed to have the same cost of packaging as L-IXRESIN, one of the four LWR wastes, since these wastes have similar characteristics. Likewise, R-RASOURC is assumed to have the same packaging cost as N-SOURCES. Under current practice, CRCPD86 recommends a maximum of 500 millicuries of radium-226 per 55 gallon drum. Since R-RASOURC has a total of 620 curies of radium-226, the minimum volume (i.e., assuming the maximum of 500 millicuries per drum) would involve the disposal of 1,240 drums or, at .208 cubic meters per drum, a total of 258 cubic meters. At the other extreme, disposal of all 17,200 radium sources disposed over the next 20 years at one source per drum would result in a disposal volume of 3,578 cubic meters. As an approximation, it is assumed that 500 millicuries total activity is disposed per drum, on average. This results in disposal of 6,230 drums (3,115 total curies), or 1,296.9 cubic meters. The VIF is calculated by the ratio of this volume to the as generated 20-year volume for R-RASOURC of 0.445 cubic meters, and is equal to 2,914.

Table C-4 presents packaging costs and associated VIFs for each waste. The footnotes accompanying the table document the assumptions underlying each cost estimate.

Processing Cost

LLW processing involves either compaction, solidification, or incineration. Compaction costs are estimated for comparison purposes. CPG risks associated with disposal of compacted LLW were not modeled, however. CPG risk would likely increase under a scenario that assumed compacted waste is placed in the disposal trench since a larger as generated volume (more activity) could be disposed per 250,000 cubic meter site (or, alternatively, the site size is smaller for a given activity).

The general methodology used in estimating processing costs involves three steps. First, a representative processing technique is identified for each LLW waste, as defined by the Nuclear Regulatory Commission (NRC). This allocation of waste to processing technique was reported in studies by Dames and Moore [DM81, DM86] for the NRC. The allocation was made on the basis of what is currently being practiced and what is technically feasible.* Each processing technique has an associated cost expressed in dollars per cubic meter. The cost is the same per cubic meter for all wastes treated under that particular technique. However, each waste has a unique volume reduction factor (VRF) for a given processing technique.

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* Reports by Envirodyne Engineers, Inc. [EEI84a] and TRW Energy Development Group/RAE [TRW83a] also used this methodology.

TABLE C-4

PACKAGING COST DATA

EPA WASTE STREAM MNEMONIC		PHB ESTIMATE (1) (1985 DOLLARS PER CU. METERS, As Generated)	VOLUME INCREASE FACTORS
P-COTRASH	(2)	303	1.0
B-COTRASH	(2)	303	1.0
L-NCTRASH	(3)	383	1.0
L-IXRESIN	(4)	449	1.0
P-FCARTRG	(5)	449	1.0
L-FSLUDGE	(4)	449	1.0
L-CONCLIQ	(4)	512	1.0
L-DECONRS	(4)	449	1.0
F-COTRASH	(2)	303	1.0
F-NCTRASH	(3)	355	1.0
F-PROCESS	(2)	303	1.0
U-PROCESS	(2)	303	1.0
N-SSTRASH	(2)	303	1.0
N-SSWASTE	(2)	303	1.0
N-LOTRASH	(2)	303	1.0
N-LOWASTE	(2)	303	1.0
L-NFRCOMP	(6)	501	1.0
N-ISOPROD	(7)	449	1.0
N-TRITIUM	(5)	501	1.0
N-TARGETS	(5)	501	1.0
N-SOURCES	(5)	501	1.0
I-COTRASH	(2)	303	1.0
I-BIOWAST	(8)	1,451	1.92
I-ABSLIQD	(8)	1,879	3.0
I-LQSCNVL	(8)	1,879	3.0
R-RASOURC	(9)	501	2914.0
R-RAIXRSN	(10)	449	1.0

NOTES:

(1) ALL ESTIMATES INCLUDE COMPONENT COSTS FOR LABOR, MATERIALS, AND UTILITIES, AND REFLECT VOLUME INCREASES WHERE APPROPRIATE.

(2) ESTIMATE REFLECT PACKING IN A DRUM ONLY. COSTS ALSO INCLUDE LABOR (FOR A TOTAL PER DRUM COST OF $50 IN 1980, OF WHICH $22 REPRESENTS THE COST OF THE DRUM ALONE).

(3) ESTIMATE REFLECTS MIX OF DRUMS AND BOXES AND INCLUDES LABOR. COSTS ARE ALSO ASSUMED TO DEPEND ON ACTIVITY (HIGHEST FOR B-COTRASH, THEN P-COTRASH, THEN F-NCTRASH).

(4) ESTIMATE REFLECTS DRUM PACKING, BUT ALSO REFLECTS DEWATERING COST AND ASSUMES THAT DRUMS WILL BE SHIPPED IN REUSABLE SHIELDED CASKS (CASK COST INCLUDED IN TRANSPORT COST).

(5) ESTIMATE REFLECTS MIX OF DRUMS AND (APPARENTLY) BOXES, AND INCLUDES LABOR. COSTS ARE ALSO ASSUMED TO DEPEND ON ACTIVITY. FILTER CARTRIDGE ESTIMATE REFLECTS TRW83a ASSUMPTION THAT FILTER CARTRIDGE COSTS ARE THE SAME AS RESINS AND SLUDGES.

(6) ESTIMATE REFLECTS MIX OF DRUMS AND (APPARENTLY) BOXES, AND INCLUDES LABOR. COSTS ARE ALSO ASSUMED TO DEPEND ON ACTIVITY.

(7) ESTIMATE REFLECTS TRW83a ASSUMPTION FOR PACKAGING AT A COST EQUAL TO RESINS. THIS COST IS APPROXIMATELY THE SAME AS 1/2 L-CONCLIQ AND 1/2 F-NCTRASH, SINCE N-ISOPROD IS HALF LIQUID AND HALF SOLID.

(8) ESTIMATE REFLECTS COST OF A DRUM, LABOR AND ABSORBENT, AND A VIF OF 1.92 (I-BIOWAST) OR 3.0 (I-ABSLIQD AND I-LQSCNVL).

(9) ESTIMATE REFLECTS ASSUMPTION THAT PACKAGING COSTS FOR R-RASOURC ARE THE SAME AS N-SOURCES.

(10) ESTIMATE REFLECTS ASSUMPTION THAT PACKAGING COSTS FOR R-RAIXRSN ARE THE SAME AS L-IXRESIN.

SEPTEMBER 1987

The next step in the general methodology involves calculating costs for each LLW waste as defined by EPA (in general, this involves simple aggregations of NRC wastes). In the situation where the NRC waste is the same as the EPA waste, no special assumptions are necessary. However, when the NRC waste streams that map into the EPA waste streams require different processing techniques, then a weighted average usually is calculated when estimating processing costs.* The footnotes to Table C-5 identify those wastes that have costs calculated by a weighted average methodology.

The last step in the methodology accounts for inflation. All costs were calculated from 1980 dollar estimates reported in DM81. Similar to packaging costs, these figures were escalated to 1985 dollars by using a single factor -- the change in the producer -ice index for capital equipment. Although the cost of processing includes other factors such as labor and fuel, using the capital equipment index as the only escalation factor will not significantly affect the cost-effectiveness results. The 1985 update [DM86] by Dames and Moore of its original 1981 NRC report adopts this same methodology.

As mentioned above, the cost of compaction is estimated for purposes of illustration. Compaction can be considered an intermediate method of processing in comparison to the two extreme methods of processing assumed in the analysis, i.e., either packaging waste in an untreated form or engaging in maximum processing by incinerating and solidifying the waste. Two types of compaction techniques were considered -- regular compaction at the generator site and compaction using an industrial hydraulic press at

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* For some EPA waste streams, it was assumed that all of the associated NRC waste substreams were treated under the same processing technique even though not all of these NRC substreams (such as small generators) were included in the NRC report [DM86] under that particular processing technique. See Table C-5, footnotes 4 and 10.

Table C-5
PROCESSING COSTS PER CUBIC METER OF UNTREATED WASTE
(IN 1985 DOLLARS)

WASTE	COMPACT & PACKAGE	INCINERATE (6) & PACKAGE	SOLIDIFY W/ CEMENT & PACKAGE	SOLIDIFY W/ POLYMER & PACKAGE	INCINERATE, SOLIDIFY W/ CEMENT, & PACKAGE	INCINERATE, SOLIDIFY W/ POLYMER, & PACKAGE
P-COTRASH	420	2,428	1,606	3,064	2,448	2,467
B-COTRASH	420	2,428	1,606	3,064	2,448	2,467
L-NCTRASH	1,644 (1)	-	1,606	3,064	-	-
L-IXRESIN	-	2,428	1,606	3,064	2,518	2,599
P-FCARTRG	1,709 (1)	-	1,606	3,064	-	-
L-FSLUDGE	-	2,428	1,606	3,064	2,750	3,041
L-CONCLIQ	-	2,428	1,606	3,064	2,645	2,841
L-DECONRS	-	2,428	1,606	3,064	2,518	2,599
F-COTRASH	420	2,428	1,606	3,064	2,468	2,505
F-NCTRASH	1,615 (1)	-	1,606	3,064	-	-
F-PROCESS	-	-	1,606	3,064	-	-
U-PROCESS	-	-	1,606	3,064	-	-
N-SSTRASH	420 (2)	1,942 (7)	1,606	3,064	2,043	2,134
N-SSWASTE	-	-	1,606	3,064	-	-
N-LOTRASH	420 (2)	1,942 (7)	1,606	3,064	1,992	2,038
N-LOWASTE	-	2,428	1,606	3,064	2,479	2,524
L-NFRCOMP	-	-	1,606	3,064	-	-
N-ISOPROD	992 (3)	2,428	1,606	3,064	2,479	2,524
N-TRITIUM	566 (4)	2,581 (8)	1,606	3,064	2,661	2,733
N-TARGETS	1,762 (1)	-	1,606	3,064	-	-
N-SOURCES	-	-	1,606	3,064	-	-
I-COTRASH	420 (2)	1,942 (7)	1,606	3,064	1,992	2,038
I-BIOWAST	-	2,581 (8)	1,606	3,064	2,688	2,785
I-ABSLIQD	-	2,581 (8)	1,606	3,064	2,597	2,612
I-LQSCNVL	1,888 (5)	2,581 (8)	1,606	3,064	2,937	3,259
R-RASOURC	-	-	1,606	3,064	-	-
R-RAIXRSN	-	1,302 (9)	1,606	3,064	1,391	1,472

SEE NOTES ON FOLLOWING PAGE

Table C-5 (Continued)

PROCESSING COSTS PER CUBIC METER OF UNTREATED WASTE

NOTES:

(1) Compaction done by hydraulic press at burial site, therefore packaging and transportation costs would remain the same although burial costs would be reduced because of volume reduction.

(2) Assumes small generators are included. Also, the option of using an improved compactor with VRFs of 5 to 6, but at a higher cost, is not considered.

(3) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-ISOTRSH = 1,044 m^3 with VRF = 6, N-SORMFG1 = 56 m^3, with VRF = 6, N-SORMFG4 = 3,200 m^3 with VRF = 6, and all others = 5,667 m^3 with VRF = 1.

(4) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-NECOTRA = 3,168 m^3 with VRF = 2, N-TRIPLAT = 88.1 m^3 with VRF = 6, N-TRITRSH = 478 m^3 with VRF = 6, and others = 3206.8 m^3 with VRF = 1.

Notes continued on following page.

Table C-5 (Continued)

PROCESSING COSTS PER CUBIC METER OF UNTREATED WASTE

(5) The cost of compaction and packaging is calculated by multiplying the volume increase factor for compaction by the cost of packaging, then adding in the cost of compaction.

(6) Fluidized Bed Incinerator at generator site unless otherwise noted.

(7) A weighted average is calculated where 50 percent of the waste is burned in a Pathological Incinerator and 50 percent is burned in a Fluidized Bed Incinerator at a regional facility.

(8) Pathological Incinerator at generator site. Also, assumes small generators are included in this scenario.

(9) Fluidized Bed Incinerator at regional processing center.

the disposal site. Like incineration and solidification, it is assumed that regular compaction includes packaging costs. For compaction done by a hydraulic press at the disposal site, however, packaging and transportation costs would remain the same, although disposal costs would be reduced due to volume reduction.

Table C-5 presents the unit costs for processing; note that all wastes cannot be compacted. Likewise, not all of the NRC substreams comprising the EPA wastes can be compacted. For two waste streams, N-ISOPROD and N-TRITIUM, a weighted average was used in calculating compaction costs and volume reduction factors. Three N-TRITIUM NRC substreams, accounting for approximately 54 percent of the waste volume, and three N-ISOPROD NRC substreams, accounting for approximately 43 percent of the waste volume, were considered for compaction. For those waste streams that excluded small producers from compaction scenarios, a weighted average was not calculated, however. The implicit assumption here was that small generators can compact their waste at the same cost as large generators (perhaps at regional facilities).

Table C-5 also presents the costs for solidification (which include the cost of packaging). All wastes, it is assumed, are capable of being solidified. More important, however, is the assumption made concerning the solidification agent. The table reports solidification costs for two alternative techniques -- solidifying with cement and solidifying with a synthetic polymer. Significantly, the costs associated with the polymer are about double. These costs are further magnified, given the higher volume increase factor when using the polymer. The VIFs are reported in Table C-6 for the various processing techniques. These VIFs were taken from DM86 or, where noted, were calculated from NRC substreams. Since the VIF for solidifying with a polymer is 2 versus 1.4 with cement, the costs of transporting and disposal will be greater per cubic meter of untreated waste under the scenario where a polymer is used. The use of a polymer, however, results in a more stable waste form, since the first-year leach

Table C-6
VOLUME INCREASE FACTORS

WASTE	COMPACT & PACKAGE	INCINERATE & PACKAGE	SOLIDIFY W/ CEMENT & PACKAGE	SOLIDIFY W/ POLYMER & PACKAGE	INCINERATE, SOLIDIFY, W/ CEMENT & PACKAGE	INCINERATE, SOLIDIFY, W/ POLYMER & PACKAGE
P-COTRASH	0.333	0.013	1.4	2.0	0.017	0.025
B-COTRASH	0.500	0.013	1.4	2.0	0.017	0.025
L-NCTRASH	0.167	-	1.4	2.0	-	-
L-IXRESIN	-	0.056	1.4	2.0	0.078	0.111
P-FCARTRG	0.100	-	1.0 (6)	1.0 (6)	-	-
L-FSLUDGE	-	0.200	1.4	2.0	0.280	0.400
L-CONCLIQ	-	0.135 (3)	1.4	2.0	0.189	0.270
L-DECONRS	-	0.056	1.4	2.0	0.078	0.111
F-COTRASH	0.667	0.025	1.4	2.0	0.035	0.050
F-NCTRASH	0.167	-	1.4	2.0	-	-
F-PROCESS	-	-	1.4	2.0	-	-
U-PROCESS	-	-	1.4	2.0	-	-
N-SSTRASH	0.667	0.063	1.4	2.0	0.088	0.125
N-SSWASTE	-	-	1.4	2.0	-	-
N-LOTRASH	0.500	0.031	1.4	2.0	0.044	0.063
N-LOWASTE	-	0.031 (4)	1.4	2.0	0.044	0.063
L-NFRCOMP	-	-	1.4	2.0	-	-
N-ISOPROD	0.641 (1)	0.031 (4)	1.4	2.0	0.044	0.063
N-TRITIUM	0.704 (2)	0.050 (5)	1.4 (7)	2.0 (7)	0.069	0.099
N-TARGETS	0.167	-	1.0 (6)	1.0 (6)	-	-
N-SOURCES	-	-	1.4	2.0	-	-
I-COTRASH	0.500	0.031	1.4	2.0	0.044	0.063
I-BIOWAST	-	0.067	1.4	2.0	0.093	0.133
I-ABSLIQD	-	0.010	1.4	2.0	0.014	0.020
I-LQSCNVL	0.781	0.221	1.4	2.0	0.310	0.442
R-RASOURC	-	-	1.4	2.0	-	-
R-RAIXRSN	-	0.056	1.4	2.0	0.078	0.111

SEE NOTES ON THE FOLLOWING PAGE

Table C-6 (Continued)

VOLUME INCREASE FACTORS

NOTES:

(1) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-ISOTRSH = 1,044 m^3 with VRF = 6, N-SORMFG1 = 56 m^3, with VRF = 6, N-SORMFG4 = 3,200 m^3 with VRF = 6, and all others = 5,667 m^3 with VRF = 1.

(2) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-NECOTRA = 3,168 m^3 with VRF = 2, N-TRIPLAT = 88.1 m^3 with VRF = 6, N-TRITRSH = 478 m^3 with VRF = 6, and others = 3206.8 m^3 with VRF = 1.

(3) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: P-CONCLIQ = 226,703.8 m^3 with a VRF = 8 and B-CONCLIQ = 103,942.4 with VRF = 6.4.

(4) VRF for incineration is assumed to be equal to 32.

Notes continued on following page.

Table C-6 (Continued)

VOLUME INCREASE FACTORS

(5) The NRC substreams for this waste, as reported in DM86, are used to calculate a weighted average where: N-NECOTRA = 3,168 m^3 with VRF = 20, N-TRISCNT = 26 m^3 with VRF = 4.52, and N-TRILIQD = 141.9m^3 with VRF = 100. All other substreams were not included.

(6) Volume does not increase, since solidifying agent is used only to fill voids in shipping package.

(7) If not incinerated, VRF = 1.0 since volume does not increase, because solidifying agent is used only to fill voids in shipping package.

rate fractions for cement exceed the leach rate fractions for the polymer by one to two orders of magnitude [TRW83a].

The population health effects and CPG risk would consequently be lower, everything else being equal, when the polymer is used. As a result, the choice of the appropriate solidifying agent is a decision that could be based on the relative cost-effectiveness of using the polymer versus the cement agent. EPA's risk assessment assumes the polymer will be used in all cases. Risks for solidification with cement or bitumen were not estimated.

Finally, the costs of incineration and the associated VIFs are shown in Tables C-5 and C-6, respectively. Three types of incineration technologies were considered based on information contained in DM86 -- fluidized bed incinerator at the generator site, fluidized bed incinerator at a regional processing center, and pathological incinerator at the generator site.* Similar to compaction and solidification, packaging costs are included in incineration costs. Since the analysis assumes that, when incinerated, a waste is also solidified, Table C-5 also reports the combined cost of incineration and solidification for the two types of solidifying agents.

Table C-5 demonstrates that not all wastes can be incinerated. Generally, those wastes considered for incineration in DM86 also were considered for incineration in the EPA analysis. However, EPA's analysis considers two additional wastes for incineration -- N-LOWASTE and N-ISOPROD. Since incineration costs were based on those reported in DM86, it was necessary to assume an incineration scenario for these two wastes. Therefore, we assume these wastes are burned in a fluidized bed incinerator at the generator site, resulting in VRFs of 32 for both N-LOWASTE (assumed equal to the VRF for N-LOTRASH) and N-ISOPROD.

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* DM86 costs were derived originally from TEK81.

The NARM wastes, R-RASOURC and R-RAIXRSN, also were not given full treatment in DM86. Since the cost data were generally incomplete for these two wastes, special assumptions were made to facilitate the analysis. Processing costs were reported by DM86 for R-RAIXRSN, although not for R-RASOURC. Therefore, it was assumed that the type of R-RASOURC processing and its associated costs are the same as those processing methods and costs used for N-SOURCES, since these wastes are similar in character.

Transportation Costs

Transportation is one of the largest components of LLW disposal costs. Given the current operation of only three commercial LLW disposal facilities, with the Beatty, Nevada, site accepting very small amounts of LLW, the distance from the LLW generator site to the disposal site can be quite significant. The analysis considers two relatively lengthy transportation distances -- 650 miles and 2,300 miles [EEI84a]. The latter is used only for deep geological disposal (DGD), since the availability of this option is expected to be limited to a single site.

The methodology for estimating transportation costs involves, first, adopting the 1980 dollar estimates reported in TRW83a.* These estimates assume that current processing methods are employed before shipping the waste. The 1980 dollar estimates are then escalated using the GNP implicit price deflator, which increased by a factor of 1.3 between 1980 and 1985. Concerns about the escalation factor will be discussed below. Transportation cost estimates are reported on a waste-specific basis since costs are related to waste activity.

The limitations of the above methodology should be highlighted. First, under a no-processing (i.e., as generated) scenario, transportation costs

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* TRW83a based its estimates on transportation tariffs listed in SL80.

used in the analysis may be slightly understated since these costs are based on the assumption that current processing techniques are employed. Current processing techniques, assumed in TRW82, involves some volume expansion due to solidification of some waste and the addition of packaging materials for other wastes. This volume expansion deconcentrates radioactivity, resulting in lower transportation rates (due to lower surface activity). When comparing two regulated disposal options, this bias cancels since both options include the same transportation. When comparing a regulated to an unregulated disposal option, however, these lower regulated transportation costs result in incremental costs being understated since transportation costs for unregulated disposal are based on an entirely different set of assumptions. BRC savings, therefore, may be slightly understated since the appropriate measure of these savings involves the comparison of unregulated costs to current practice, which assumes no processing for Class A wastes.

Similarly, when analyzing a maximum processing scenario, such as incineration, where as disposed volumes are lower than for current processing techniques, transportation costs for all wastes are understated. Again, the reduction of waste volumes, relative to current practice, concentrates the radionuclides present in the waste, resulting in higher transportation rates than assumed under current processing. This bias is minimized somewhat because the cost of transportation is reduced by the VRF. Therefore, the higher the volume reduction factor, everything else being equal, the lower the distortion of costs. Conversely, under the processing scenario that involves the solidification of all wastes, transportation costs will be overstated since TRW83a assumes that under current processing techniques, only a subset of wastes will be solidified; therefore, on average, the waste activity will be less highly concentrated when all wastes are solidified. In short, the analysis of transportation costs does not consider the effect of a change in the as disposed waste activity resulting from different processing techniques.

Another potential area of concern arises since the transportation cost estimates reported in TRW83a were based on previous estimates of nuclide concentrations. New analysis has resulted in a substantial revision of these concentrations for some waste streams. For most waste streams, transportation costs were calculated on the basis of an average activity for a general waste type (as reported in SL80). Therefore, the new concentrations will not, in all likelihood, substantially affect these cost estimates. In the TRW83a report, however, some wastes (footnoted in Table C-7) have costs presumably calculated on the basis of an assumed activity. Since these assumed activities are not altogether clear, there is little basis for revising the estimates reported in TRW83a and, therefore, the estimates in that report were simply adopted and escalated from 1980 to 1985 dollars.

Finally, the appropriate escalation factor used is of some concern. The TRW83a study used cost estimates reported in SL80, escalating 1980 dollar estimates to 1982 dollars by using a factor of 1.2 (implying that transportation costs are increasing by about 10 percent per year). In contrast, this analysis inflates 1980 dollars to 1985 dollars by using a factor of 1.3, which implies that transportation costs are escalating at a rate of about five percent per year. The rate of inflation in recent years has slowed, which may account for the difference assuming the escalation factor used in TRW83a was based on general inflation. However, if the escalation rate reported in TRW83a is based on knowledge of actual rates of increase in transporting LLW, or if it is known otherwise that the cost of transporting LLW has increased at a faster rate than general inflation, then using a higher escalation factor would be appropriate. Historical evidence suggests that LLW transportation costs have increased at about the same rate as inflation, however. Transportation rates per mile increased between a factor of 1.45 to 1.49 from 1975 to 1980, whereas the implicit price deflator increased by a factor of 1.45 during the same period [SL80]. The 1985 dollar estimates of transportation costs are reported in Table C-7.

Table C-7

TRANSPORATION COSTS PER CUBIC METER
ASSUMING NO PROCESSING
(IN 1985 DOLLARS)

	650 MILES	2300 MILES
P-COTRASH (1)	134	405
B-COTRASH (1)	134	405
L-NCTRASH (2)	548	1,380
L-IXRESIN (1)	1,176	3,991
P-FCARTRG (1)	1,176	3,991
L-FSLUDGE (1)	1,176	3,991
L-CONCLIQ (1)	821	2,782
L-DECONRS (3)	542	1,820
F-COTRASH (1)	134	405
F-NCTRASH (2)	455	1,148
F-PROCESS (1)	134	405
U-PROCESS (1)	134	405
N-SSTRASH (1)	134	405
N-SSWASTE (1)	134	405
N-LOTRASH (1)	134	405
N-LOWASTE (1)	134	405
N-NFRCOMP (3)	542	1,820
N-ISOPROD (3)	311	923
N-TRITIUM (3)	542	1,820
N-TARGETS (3)	542	1,820
N-SOURCES (3)	542	1,820
I-COTRASH (1)	134	405
I-BIOWAST (3)	271	813
I-ABSLIQD (3)	271	813
I-LQSCNVL (3)	271	813
R-RASOURC (4)	542	1,820
R-RAIXRSN (5)	1,176	3,998

NOTES:

(1) THESE COSTS WERE CALCULATED DIRECTLY FROM SL80; COSTS WERE REPORTED FOR THREE WASTE CATEGORIES--DRY ACTIVE WASTE, RESINS & SLUDGES, AND CONCENTRATES.

(2) THESE COSTS WERE REPORTED IN TRW83a BASED ON ANALYSIS IN: "A HANDBOOK FOR LOW-LEVEL RADIOACTIVE WASTE DISPOSAL FACILITIES," ROGERS & ASSOCIATES ENGINEERING CORPORATION, RAE-20-5, SEPTEMBER 1982.

(3) THESE COSTS WERE ADOPTED DIRECTLY FROM TRW83a. COSTS WERE FIRST DEFLATED FROM 1982 TO 1980 DOLLARS BY USING A FACTOR OF 1.2 THEN WERE INFLATED FROM 1980 DOLLARS TO 1985 BY USING A FACTOR OF 1.3.

(4) COST ASSUMED TO BE EQUAL TO N-SOURCES.

(5) COST ASSUMED TO BE EQUAL TO L-IXRESIN.

Disposal Costs

Disposal costs were estimated in NRC81b assuming a disposal site sized for an as generated volume of 1,000,000 cubic meters. Using a capital scaling factor, these disposal costs were recalculated in EEI84a on the basis of a 250,000 cubic meter site and reported in 1980 dollars.* Similar to packaging and processing costs, disposal costs were escalated from 1980 to 1985 dollars by a factor of 1.253, the change in the producer price index for capital equipment during this time period. Disposal costs for two additional disposal technologies -- earth mounded concrete bunker and concrete canister -- were estimated in RAE86a. These costs also were escalated from 1980 to 1985 dollars. Disposal costs per cubic meter are reported in Table C-8 for the nine major disposal options considered in the EIA.

Collection Costs

Four wastes considered in the EIA, the two consumer wastes and the two "consumer-like" NARM wastes, have atypical costs associated with their regulated disposal. These four wastes are highly dispersed across the population and would be difficult to collect. In addition, enforcement of any hypothetical collection process could be very expensive. Although not quantified, enforcement costs and an additional cost (namely, the dead weight loss to society) are characterized below. The methodology used in estimating collection costs for the four consumer-like wastes then is discussed. Finally, the unit collection costs used for purposes of evaluating the cost-effectiveness of regulating these four wastes are presented in a summary table.

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* The capital scaling factor is calculated as follows:

$$\left(\frac{250,000}{1,000,000}\right)^{.6} = .435$$

Table C-8

DISPOSAL COSTS
BY DISPOSAL PRACTICE

DISPOSAL OPTION	BURIAL COST (1985 Dollars per Cubic Meter)
REGULATED SANITARY LANDFILL	238
SHALLOW LAND DUMP DISPOSAL	393
IMPROVED SHALLOW LAND DISPOSAL	907
INTERMEDIATE DEPTH DISPOSAL	732
DEEP WELL INJECTION	5,244
HYDROFRACTURE	3,027
DEEP GEOLOGICAL DISPOSAL	959
EARTH MOUND/CONCRETE BUNKER	520/4,040
CONCRETE CANISTER	540

The additional costs associated with the regulated disposal of the consumer-like wastes include the following:

1) Collection costs: Significant collection costs may arise because the owners of the consumer-like wastes are not typically involved with radioactive waste handling. For these generators, the economies of scale in waste disposal that are present for typical low-level waste generators are not realized, since the number of items to be disposed is very low. In this analysis of regulated disposal, it is assumed that each item is disposed of individually by mailing the item to a regulated disposal facility where the waste is packaged and disposed of under the same conditions as other LLW.

2) Enforcement costs: The consumer-like wastes are distributed among many generators who may be unfamiliar with the hazards of radioactive wastes and unaware of regulatory requirements. For these wastes, compliance with regulated disposal requirements may be very low. To induce compliance, substantial costs may be incurred to educate these generators about existing laws and potential health effects and to enforce regulated disposal requirements through monitoring and inspection.

3) The dead weight loss to society: To the extent that certain consumer-like wastes are regulated, the additional costs of collection that must be borne by the purchaser of the item effectively increase the price of the item. As a result, demand for the product is likely to fall. This loss of demand results in a "the dead weight loss" or efficiency loss to society. That is, the loss of demand for the regulated product translates into a reallocation of resources (i.e., less of the regulated-product is purchased, freeing up resources to be spent elsewhere), which presumably is a less <u>efficient</u> allocation (assuming resources were allocated efficiently prior to the regulation).

To quantify the additional collection and enforcement costs associated with consumer wastes, an economic model was developed that describes the costs and benefits facing an individual generator contemplating regulatory requirements. This model was used to improve our understanding of factors that contribute to collection and enforcement costs, as well as the dead weight loss. However, only collection costs are quantified in the analysis that follows.

The decision facing an individual generator who is considering whether to comply with a regulated disposal requirements can be viewed in economic terms. A generator will choose to comply if the incremental cost of compliance is less than the cost of noncompliance. The incremental cost of compliance is the additional cost of regulated disposal vis-a-vis nonregulated disposal.

Compliance can be achieved through several mechanisms, which may be used in combination. These mechanisms can be in the form of either a positive or negative incentive. In the case of a positive incentive, regulators can offer an economic benefit (e.g., the return of a deposit) that will induce individuals into compliance. The cost of noncompliance then becomes the opportunity cost in the form of a forgone payment (the deposit) if noncompliance is chosen. In the case of a negative incentive, regulators can impose an economic cost (e.g., a fine) on individuals for noncompliance. The cost of noncompliance, in this case, is the expected cost of noncompliance defined as the probability of detection multiplied by the amount of the fine.

For purposes of this analysis, the focus will be on the incremental cost of compliance. The greater the incremental cost of compliance, the larger the cost of noncompliance must be to induce adherence to the law. Significantly, real resources must be expended (in the form of greater enforcement efforts or higher deposits) to increase the cost of noncompliance.

The incremental cost of compliance is made up of several components. The following list itemizes these incremental costs:

1. Postage.

2. Transportation to and from the collection station (e.g., post office).

3. Packaging.

4. Value of time in traveling to the collection station.

5. Value of time spent at the collection station.

6. Value of time spent packaging item.

7. Value of time spent investigating appropriate actions to take for regulatory compliance.

Additional costs that are not quantified but may be quite significant include:

8. Cost to manufacturer of labeling products and record-keeping.

9. Cost to government of enforcing regulations.

10. Cost to society of dead weight loss associated with increasing the price of a product.

Determining the level of compliance, given an assumed compliance mechanism, is very complex. The above model, weighing the incremental cost of compliance against the cost of noncompliance, implies that compliance will be an all-or-nothing affair. However, in reality, some individuals will comply and some will not. One reason for this is the simplifying assumption made for the value of people's time -- an average wage rate. If the incremental cost of compliance equaled the cost of noncompliance at a given wage rate, then an individual with a lower wage rate will comply, while an individual with a higher rate will not comply.

This variable is very important in trying to determine the cost-effectiveness of consumer waste disposal. For purposes of analysis, however, all that needs to be determined, at any level of compliance, is the cost-effectiveness of regulating consumer waste disposal, when collection costs are taken into account. If it can be demonstrated that regulation will be very costly at compliance rates that are expected to be zero, then a strong case for unregulated disposal exists. By using the minimum wage as the average wage rate to calculate the value of time, compliance rates will be very close to zero since most people will have a wage greater than the minimum wage rate.

Table C-9 reports the calculations and the basic assumptions underlying these calculations. Postage costs are excluded since these vary with the weight of the product. Table C-10 reports these collection costs and postage costs on a cubic meter basis for the four consumer-like wastes -- R-GLASDS1, R-INSTDF1, C-TIMEPCS, and C-SMOKDET.

The total cost of consumer-like waste collection is very significant compared to the typical costs associated with regulated disposal (i.e., packaging, processing, transportation, and disposal emplacement). Again, these costs do not include the important costs of enforcement and of the dead weight loss to society. Ignoring these costs, Table C-10 demonstrates that the regulation of R-GLASDS1 will have costs about 264 times higher than regulated shallow land disposal, as generated; R-INSTDF1 costs will increase by a factor of 305, C-TIMEPCS by a factor of 117, and C-SMOKDET by a factor of 21. Table C-11 presents the unit costs of shallow land disposal, as generated, for these four wastes when collection costs are included.

Table C-9

INCREMENTAL COST OF COMPLIANCE

Wage Rate	$3.35
Transportation to Collection Station (e.g., post office)	$2.20
Packaging (paper & tape)	$0.20
Time Investigating Appropriate Response	$0.56
Travel Time to Collection Station	$1.68
Time Spent at Collection Station	$0.56
Packaging Time (& administrative effort)	$0.84
Total	$6.03

BASIC ASSUMPTIONS

1. Consumer lives five miles from collection center.
2. This five-mile trip can be made by auto in 15 minutes.
3. Consumer's value of time is equal to minimum wage.
4. Cost of transportation is $0.22/mile.
5. Packaging time is 15 minutes.
6. Consumer spends 10 minutes investigating appropriate action to take for compliance.
7. Time spent at collection station is 10 minutes.

TABLE C-10
CALCULATION OF COLLECTION COSTS

	Assumed Mass (g) (1)	Assumed Specific Gravity (2)	Production (Items/yr) (3)	Cubic Meters (4)	Costs to the Manufacturer ($/m^3) (5)	Costs to the Consumer excluding Collection ($/m^3) (6)	Consumer Shipping Costs ($/m^3) (7)	Other Consumer Collection Costs ($/m^3) (8)	Total Consumer Costs ($/m^3) (9)	Ratio of Consumer to Manufacturer Costs (10)
R-GLASDS1										
Ophthalmic Glass	50	2.5	3.5E+07	7.0E+02	8.3E+02	7.0E+02	2.0E+04	3.0E+05	3.2E+05	387.59
Sun, Germicidal Exterior Lamps	100	2.5	1.0E+06	4.0E+01	8.3E+02	7.0E+02	1.8E+04	1.5E+05	1.7E+05	204.45
Incandescent Mantles (U-238)	0.4	2.5	2.0E+07	3.2E+00	8.3E+02	7.0E+02	1.4E+06	3.8E+07	3.9E+07	47064.09
Incandescent Mantles (Th-232)	0.4	2.5	2.5E+07	4.0E+00	8.3E+02	7.0E+02	1.4E+06	3.8E+07	3.9E+07	47064.09
Illumination Equipment	500	2.5	1.0E+07	2.0E+03	8.3E+02	7.0E+02	6.8E+03	3.0E+04	3.8E+04	45.30
Florescent Lamp	50	2.5	5.0E+06	1.0E+02	8.3E+02	7.0E+02	2.0E+04	3.0E+05	3.2E+05	387.59
Artificial Teeth	10	2.5	5.0E+05	2.0E+00	8.3E+02	7.0E+02	5.5E+04	1.5E+06	1.6E+06	1883.37
			TOTAL	2.8E+03						
				WEIGHTED AVERAGES	8.3E+02	7.0E+02	1.4E+04	2.0E+05	2.2E+05	263.75
R-INSTDF1										
Timepieces	100	4.0	8.0E+06	2.0E+02	8.3E+02	7.0E+02	2.9E+04	2.4E+05	2.7E+05	326.62
Smokedetectors	1000	4.0	7.0E+04	1.8E+01	8.3E+02	7.0E+02	5.6E+03	2.4E+04	3.0E+04	36.70
Static Eliminators	1000	4.0	6.0E+03	1.5E+00	8.3E+02	7.0E+02	5.6E+03	2.4E+04	3.0E+04	36.70
Ra dials Private	500	4.0	2.0E+01	2.5E-03	8.3E+02	7.0E+02	1.1E+04	4.8E+04	6.0E+04	71.97
Ra Dials Watches	100	4.0	5.0E+01	1.3E-03	8.3E+02	7.0E+02	2.9E+04	2.4E+05	2.7E+05	326.62
Uranium Paints	100	4.0	1.3E+06	3.2E+01	8.3E+02	7.0E+02	2.9E+04	2.4E+05	2.7E+05	326.62
			TOTAL	2.5E+02						
				WEIGHTED AVERAGES	8.3E+02	7.0E+02	2.7E+04	2.2E+05	2.5E+05	304.72
C-TIMEPCS	288	4.0	7.1E+06	5.1E+02	8.3E+02	7.0E+02	1.3E+04	8.4E+04	9.7E+04	117.29
C-SMOKDET	1840	4.0	1.0E+07	4.6E+03	8.3E+02	7.0E+02	3.3E+03	1.3E+04	1.7E+04	20.61

SEE NOTES ON NEXT PAGE

NOTES:

(1) Data from: RAE85d.

(2) Data from: RAE85d.

(3) Data from: RAE85d.

(4) Cubic Meters = (1)/(2)*(3)/10 6.

(5) Incremental costs from LLW analysis, regulated SLF versus unregulated disposal; includes packaging, transportation, and disposal.

(6) Incremental costs from LLW analysis, regulated SLF versus unregulated disposal; includes packaging and disposal.

(7) Assumes third class, local zone mailing rates; each item returned individually to manufacturer for regulated disposal.

(8) Derived from Table 1.

(9) Total Consumer Costs = (6)+(7)+(8).

(10) Ratio of Consumer to Manufacturer Costs = (9)/(5).

Table C-11

TOTAL COST OF REGULATED SHALLOW LAND DISPOSAL, AS GENERATED

(in dollars per cubic meter)

	Excluding Collection Costs	Including Collection Costs
C-SMOKDET	$830	$17,106
C-TIMEPCS	$830	$97,351
R-CLASDS1	$830	$218,913
R-INSTDF1	$830	$252,918

The computer model (PATHMAX) that generates the estimates of maximum CPG dose used in the BRC analysis (presented in Chapter 7) is discussed in this appendix. Since alternative BRC standards permit the unregulated disposal of different combinations of BRC wastes, a multitude of PATHRAE runs would be required to estimate CPG doses because CPG dose depends in a non-linear fashion on the dose contributions of many nuclides (see EPA85d and EPA87 for documentation of PATHRAE). Therefore, the contributions to maximum dose of different BRC candidates are not independent. By making some simplifying assumptions, however, only one PATHRAE run is necessary to evaluate different BRC standards. The importance of these assumptions is evaluated below.

PATHMAX uses the data generated by the one PATHRAE run to calculate the maximum CPG dose for different combinations of BRC wastes. The result from PATHRAE are reported in PEI86a and PEI86b. The structure of the PATHMAX model, the necessary inputs to the model, and the methodology used in estimating maximum CPG dose are the topics discussed below.

STRUCTURE OF THE PATHMAX MODEL

PATHMAX calculates the maximum CPG dose occurring over the 10 pathways, the 15 disposal scenarios, and the three hydrogeologic regions for the 19 wastes evaluated in the BRC analysis. In Chapter 3, the exposure pathways and disposal scenarios are defined. These pathways and scenarios also are summarized in the first page of Table D-1, which presents the output from a PATHMAX run. Two of the disposal scenarios included in PATHMAX involve the disposal of BIOMED waste unregulated under the NRC's rule [NRC81a]. Also note that the exposure pathway that evaluates CPG doses resulting from direct gamma exposure to transportation workers is not included in PATHMAX. This exposure pathway was evaluated by a different computer model [RAE86d] and was included in the results presented in the BRC analysis.

INPUTS TO THE PATHMAX MODEL

Each disposal scenario includes a different set of wastes, depending on the type of waste generator defined in the scenario. The number of wastes included in each disposal scenario varies from one to 11 wastes per scenario, as can be seen by inspection of Table D-1, which is a printout of PATHMAX. Disposal scenarios are arrayed in rows; exposure pathways are arrayed in columns for each disposal scenario. The contribution to CPG dose associated with the top three nuclides in each of the 10 exposure pathways was aggregated for each waste in a disposal scenario. These data were input into the PATHMAX model and are listed in Table D-1 for each hydrogeologic region.

PATHMAX METHODOLOGY

Based on both the individual waste contribution to maximum CPG dose and on the least-cost method of regulating each waste, PATHMAX can be used to determine an optimal ranking for meeting the alternative BRC limits considered in the BRC analysis. PATHMAX estimates the maximum CPG doses associated with this optimal ranking. The alternative standards considered in the BRC analysis are based on the CPG doses calculated under this ranking of BRC candidates. At each successively lower level of an alternative standard, an additional waste (or wastes) fails to meet the standard. PATHMAX estimates the CPG dose resulting from unregulated disposal of the remaining set of wastes that meet the standard. An implicit assumption underlying this methodology concerns the year at which the maximum dose is attained within each CPG scenario, which is assumed not to change with a different combination of BRC wastes. As long as the dominant pathway and nuclide are constant, this assumption almost invariably holds true.

EVALUATION OF KEY ASSUMPTIONS

The BRC exposure analysis uses two key assumptions to approximate the CPG dose contributions of individual wastes. First, the contributions of only the top three nuclides were considered under the assumption that these nuclides accounted for most of the maximum CPG dose. This assumption simplified the computation of CPG. Second, the year at which the maximum dose is attained was assumed not to change with a different combination of BRC wastes. This assumption allows us to avoid the large number of PATHRAE runs that could be required to evaluate the different combinations of unregulated wastes at alternative BRC standards. The following analysis evaluates the importance of these two assumptions.

The first assumption is important to ensure that the estimation of CPG dose is indeed the maximum. Review of Table D-1 will support the notion that the top three nuclides account for most of the maximum CPG dose. A comparison of the CPGs reported in the row labeled "ACTUAL Total," which includes all 40 nuclides, to the CPGs reported in the row labeled "BRC Total," which is the sum of the top three nuclides, shows that over the 17 disposal scenarios and three hydrogeologic regions, the top three nuclides account for at least 96 percent of the maximum CPG dose for the pathway dominant at the higher levels of the alternative standards -- direct gamma exposure.

The second assumption, concerning the peak year, is not important for several of the pathways since the maximum CPG dose occurs in the first year of exposure. These exposure pathways include food grown onsite, natural biointrusion, atmospheric transport, and two pathways that are dominant at different levels of the alternative -- direct gamma and dust inhalation. Groundwater to well is the only pathway that has a peak year occurring later in time and also exceeds an alternative standard, but this pathway only exceeds the 0.1 millirem alternative.

In conclusion, the two simplifying assumptions that were used in estimating the CPGs associated with unregulated disposal would not appear to influence the results from the BRC analysis significantly.

PATHMAX MODEL

File name : Pathmax

GLOBAL FLAGS

Region :	
Humid Impermeable (HI)	1
Humid Permeable (HP)	1
Arid Permeable (AP)	1

Pathways :	
1. Groundwater to river (GW-R)	1
2. Groundwater to well (GW-W)	1
3. Spillage (SPILL)	1
4. Erosion (EROS)	1
5. Bathtub effect (BATH)	1
6. Food grown on site (ON FOOD)	1
7. Natural biointrusion (BIOWAS)	1
8. Direct Gamma (GAMMA)	1
9. Dust inhalation (DUST)	1
10. Atmospheric Transport (ATMOS)	1

Scenario :	
1 PWR-MD	1
2 BWR-MD	1
3 LUMC-UF	1
4 MAFC-SF	1
5 MAFC-SI	1
6 PWRHU-MD	1
7 UHX-MD	1
8 UF-MD	1
9 LURO-ON	1
10 LMACW-SI	1
11 LMACW-UI	1
12 CW-SF	1
13 CW-UF	1
14 LURO-ON*	1
15 LURO-ON**	1

Waste Streams -- BRC Candidates:	
P-COTRASH	1
B-COTRASH	1
I-COTRASH	1
F-COTRASH	1
I-ABSLIQD	1
I-BIOWAST	1
I-LQSCNVL	1
N-LOTRASH	1
N-LOWASTE	1
N-SSTRASH	1
N-SSWASTE	1
F-PROCESS	1
U-PROCESS	1
F-NCTRASH	1
P-CONDRSN	1
L-WASTOIL	1
C-TIMEPCS	1
C-SMOKDET	1
BIOMED *	1

* For Scenario 14 and 15 only.

NE MAX: 21.45256 US MAX: 40.703
SE MAX: 40.703
SW MAX: 21.45256

NOTE: See Chapter 3 or EPA87 for explanation of mnemonics used in disposal scenarios above. The scenario numbering follows the numbering used in the Background Information Document (EPA87) rather than the scenario numbering used in Chapter 3.

Maximum HI	1.83E-05	9.06E+00	3.35E-03	4.75E-05	1.44E-03	8.02E-01	2.68E+00	2.15E+01	2.08E-01	1.09E-05	2[illegible]

HI	PATHWAYS [Dose (mrem/yr)]										
	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	ƏMAX
1 PWR-MD											
BRC total	7.66E-07	3.14E-02	1.98E-03	2.73E-06	2.03E-04	3.20E-01	1.07E+00	1.24E+01	2.40E-02	1.55E-06	1.24E+01
ACTUAL Total	7.66E-07	3.14E-02	2.10E-03	2.77E-06	2.10E-04	3.23E-01	1.80E+00	1.24E+01	3.15E-02	2.05E-06	1.24E+01
P-COTRASH	7.66E-07	3.14E-02	1.98E-03	2.73E-06	2.02E-04	3.20E-01	1.07E+00	1.24E+01	2.40E-02	1.55E-06	1.24E+01
P-CONDRSN	5.91E-12	2.40E-07	1.31E-06	3.95E-11	2.36E-08	3.94E-04	1.32E-03	9.85E-04	7.58E-07	4.91E-11	1.32E-03
L-WASTOIL	0.00E+00	0.00E+00	9.32E-08	0.00E+00	5.46E-10	8.90E-06	2.97E-05	8.47E-04	0.00E+00	0.00E+00	8.47E-04

HI	PATHWAYS [Dose (mrem/yr)]										
	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	ƏMAX
2 BWR-MD											
BRC total	1.73E-06	7.10E-02	3.35E-03	1.72E-06	4.63E-04	8.02E-01	2.68E+00	1.07E+01	8.09E-03	1.33E-06	1.07E+01
ACTUAL Total	1.73E-06	7.10E-02	3.50E-03	1.77E-06	4.66E-04	8.05E-01	2.69E+00	1.07E+01	1.07E-02	1.75E-06	1.07E+01
B-COTRASH	1.73E-06	7.10E-02	3.35E-03	1.72E-06	4.63E-04	8.02E-01	2.68E+00	1.07E+01	8.09E-03	1.33E-06	1.07E+01
L-WASTOIL	0.00E+00	0.00E+00	2.39E-07	0.00E+00	1.41E-09	2.60E-05	7.70E-05	2.19E-03	7.97E-07	1.30E-10	2.19E-03

HI	PATHWAYS [Dose (mrem/yr)]										
	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	ƏMAX
3 LUMC-UF											
BRC total	7.29E-07	1.47E-03	4.18E-04	1.09E-06	6.25E-04	0.00E+00	0.00E+00	1.80E-01	1.56E-04	1.00E-09	1.80E-01
ACTUAL Total	7.29E-07	1.47E-03	5.40E-04	1.09E-06	6.27E-04	0.00E+00	0.00E+00	1.81E-01	1.61E-04	1.08E-09	1.81E-01
I-COTRASH	6.54E-07	1.32E-03	3.66E-04	9.83E-07	5.60E-04			1.59E-01	1.45E-04	9.32E-10	1.59E-01
I-ABSLIQD	4.00E-08	8.07E-05	3.81E-05	5.93E-08	3.48E-05			1.89E-02	7.69E-06	5.02E-11	1.89E-02
I-BIOWAST	3.34E-08	6.73E-05	1.44E-05	4.95E-08	2.87E-05			1.93E-03	1.92E-06	2.13E-11	1.93E-03
I-LQSCNVL	1.67E-09	3.36E-06	2.31E-07	2.47E-09	1.66E-06			0.00E+00	1.41E-06	1.09E-12	3.36E-06

HI	PATHWAYS [Dose (mrem/yr)]										
	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	[illegible]
4 MAFC-SF											
BRC total	1.37E-06	1.81E-02	3.66E-04	4.00E-06	5.61E-04	2.27E-02	7.56E-02	8.94E-01	5.25E-02	7.84E-06	8.9[illegible]
ACTUAL Total	1.37E-06	1.81E-02	5.16E-04	4.14E-06	5.67E-04	2.27E-02	7.57E-02	8.94E-01	5.33E-02	8.04E-06	8.94E-01
I-COTRASH	6.96E-07	9.17E-03	1.83E-04	4.84E-07	2.80E-04	1.03E-02	3.45E-02	4.63E-01	0.00E+00	0.00E+00	4.63E-01
I-ABSLIQD	4.26E-08	5.61E-04	1.91E-05	2.96E-08	1.73E-05	1.23E-03	4.09E-03	5.48E-02	0.00E+00	0.00E+00	5.48E-02
I-BIOWAST	3.56E-08	4.68E-04	7.23E-06	2.47E-08	1.43E-05	6.49E-04	2.16E-03	5.61E-03	0.00E+00	0.00E+00	5.61E-03
I-LQSCNVL	1.78E-09	2.34E-05	1.16E-07	1.23E-09	7.03E-07	2.01E-04	6.69E-04	0.00E+00	0.00E+00	0.00E+00	6.69E-04
N-LOTRASH	4.36E-07	5.73E-03	1.15E-04	3.03E-07	1.74E-04	6.47E-03	2.15E-02	2.91E-01	0.00E+00	0.00E+00	2.91E-01
N-LOWASTE	1.48E-07	1.94E-03	4.17E-05	1.03E-07	5.95E-05	3.80E-03	1.27E-02	8.03E-02	0.00E+00	0.00E+00	8.03E-02
F-PROCESS	9.97E-09	1.43E-04	0.00E+00	2.59E-06	1.24E-05	0.00E+00	0.00E+00	1.13E-08	4.45E-02	6.63E-06	4.45E-02
F-COTRASH	1.55E-09	2.24E-05	0.00E+00	4.03E-07	1.92E-06	0.00E+00	0.00E+00	1.74E-09	6.92E-03	1.03E-06	6.92E-03
F-NCTRASH	2.62E-10	3.77E-06	0.00E+00	6.80E-08	3.25E-07	0.00E+00	0.00E+00	2.95E-10	1.17E-03	1.75E-07	1.17E-03

HI	PATHWAYS [Dose (mrem/yr)]										
	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	ƏMAX
5 MAFC-SI											
BRC total	8.28E-07	6.89E-02	2.20E-04	3.28E-06	1.49E-04	9.01E-02	3.00E-01	5.36E+00	2.08E-01	2.52E-26	5.36E+00
ACTUAL Total	8.28E-07	6.89E-02	2.80E-04	3.42E-06	1.53E-04	9.02E-02	3.00E-01	5.36E+00	2.11E-01	2.57E-26	5.36E+00
I-COTRASH	4.09E-07	3.40E-02	9.94E-05	1.21E-07	7.11E-05	4.10E-02	1.37E-01	2.78E+00	0.00E+00	0.00E+00	2.78E+00
I-ABSLIQD	2.51E-08	2.08E-03	1.26E-05	7.40E-09	4.49E-06	4.87E-03	1.62E-02	3.28E-01	0.00E+00	0.00E+00	3.28E-01
I-BIOWAST	2.09E-08	1.74E-03	5.07E-06	6.17E-09	3.63E-06	2.57E-03	8.58E-03	3.36E-02	0.00E+00	0.00E+00	3.36E-02
I-LQSCNVL	1.04E-09	8.68E-05	1.83E-06	3.08E-10	1.75E-07	7.96E-04	2.66E-03	0.00E+00	0.00E+00	0.00E+00	2.66E-03
N-LOTRASH	2.56E-07	2.13E-02	6.65E-05	7.56E-08	4.44E-05	2.57E-02	8.54E-02	1.74E+00	0.00E+00	0.00E+00	1.74E+00
N-LOWASTE	8.68E-08	7.21E-03	3.42E-05	2.56E-08	1.53E-05	1.51E-02	5.03E-02	4.81E-01	0.00E+00	0.00E+00	4.81E-01
F-PROCESS	2.45E-08	2.10E-03	0.00E+00	2.57E-06	8.24E-06	0.00E+00	0.00E+00	6.76E-08	1.76E-01	2.13E-26	1.76E-01
F-COTRASH	3.80E-09	3.27E-04	0.00E+00	4.02E-07	1.28E-06	0.00E+00	0.00E+00	1.05E-08	2.74E-02	3.30E-27	2.74E-02
F-NCTRASH	6.42E-10	5.52E-05	0.00E+00	6.78E-08	2.16E-07	0.00E+00	0.00E+00	1.77E-09	4.63E-03	5.57E-28	4.63E-03

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
6 PWRHU-MD											
BRC total	9.50E-07	3.75E-02	1.43E-03	1.92E-06	2.42E-04	2.36E-01	7.91E-01	8.76E+00	1.62E-02	8.90E-07	8.76E+00
ACTUAL Total	9.50E-07	3.75E-02	1.59E-03	2.03E-06	2.48E-04	2.43E-01	8.13E-01	8.76E+00	2.14E-02	1.20E-06	8.76E+00
I-COTRASH	2.86E-07	1.12E-02	6.87E-05	1.21E-07	6.98E-05	1.43E-02	4.78E-02	3.33E-01	1.66E-04	9.16E-09	3.33E-01
I-ABSLIQD	1.74E-08	6.80E-04	8.09E-06	7.38E-09	4.30E-06	1.69E-03	5.63E-03	3.91E-02	0.00E+00	0.00E+00	3.91E-02
I-BIOWAST	1.47E-08	1.47E-08	2.48E-06	6.26E-09	3.61E-06	7.26E-04	2.43E-03	4.07E-03	0.00E+00	0.00E+00	4.07E-03
I-LQSCNVL	7.33E-10	2.87E-05	0.00E+00	3.11E-10	1.77E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.87E-05
N-LOTRASH	8.94E-08	3.50E-03	2.16E-05	3.80E-08	2.19E-05	4.47E-03	1.49E-02	1.04E-01	5.23E-05	2.88E-09	1.04E-01
N-LOWASTE	3.03E-08	1.19E-03	8.00E-06	1.29E-08	7.44E-06	1.93E-03	6.44E-03	2.88E-02	0.00E+00	0.00E+00	2.88E-02
P-CONDRSN	3.93E-12	1.60E-07	8.76E-07	2.36E-11	1.57E-08	2.62E-04	8.78E-04	6.56E-04	5.04E-07	2.78E-11	8.78E-04
P-COTRASH	5.11E-07	2.09E-02	1.32E-03	1.74E-06	1.35E-04	2.13E-01	7.13E-01	8.25E+00	1.59E-02	8.78E-07	8.25E+00
L-WASTOIL	0.00E+00	0.00E+00	6.22E-08	0.00E+00	3.65E-10	5.94E-06	1.98E-05	5.63E-04	0.00E+00	0.00E+00	5.63E-04

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
7 UHX-MD											
BRC total	1.79E-08	7.37E-04	5.89E-05	2.74E-06	1.52E-05	1.24E-04	4.15E-04	2.42E-02	1.28E-01	6.66E-06	1.28E-01
ACTUAL Total	1.79E-08	7.37E-04	5.89E-05	2.74E-06	1.52E-05	1.24E-04	4.15E-04	2.42E-02	1.28E-01	6.66E-06	1.28E-01
U-PROCESS	1.79E-08	7.37E-04	5.89E-05	2.74E-06	1.52E-05	1.24E-04	4.15E-04	2.42E-02	1.28E-01	6.66E-06	1.28E-01

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
8 UF-MD											
BRC total	5.52E-09	2.27E-04	1.82E-05	8.46E-07	4.68E-06	3.84E-05	1.28E-04	4.89E-03	3.88E-02	1.09E-05	3.88E-02
ACTUAL Total	5.52E-09	2.27E-04	1.82E-05	8.46E-07	4.68E-06	3.83E-05	1.28E-04	4.89E-03	3.88E-02	1.09E-05	3.88E-02
N-SSTRASH	1.25E-09	5.13E-05	4.10E-06	1.91E-07	1.06E-06	8.66E-06	2.89E-05	1.10E-03	8.75E-03	2.46E-06	8.75E-03
N-SSWASTE	4.28E-09	1.75E-04	1.41E-05	6.55E-07	3.62E-06	2.97E-05	9.90E-05	3.79E-03	3.01E-02	8.44E-06	3.01E-02

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	[illegible]
					PATHWAYS [Dose (mrem/yr)]						
9 LURO-ON											
BRC total	1.08E-06	5.35E-01	1.25E-05	6.44E-08	8.86E-05	0.00E+00	0.00E+00	1.55E-01	7.39E-03	1.54E-06	[illegible]
ACTUAL Total	1.08E-06	5.35E-01	1.42E-05	6.44E-08	8.88E-05	0.00E+00	0.00E+00	1.55E-01	7.62E-03	1.62E-06	5.35E-01
I-COTRASH	9.69E-07	4.80E-01	1.06E-05	5.78E-08	7.92E-05			1.37E-01	6.87E-03	1.40E-06	4.80E-01
I-ABSLIQD	5.93E-08	2.94E-02	1.25E-06	3.52E-09	5.03E-06			1.63E-02	3.64E-04	1.10E-07	2.94E-02
I-BIOWAST	4.95E-08	2.45E-02	5.06E-07	2.94E-09	4.10E-06			1.41E-03	9.09E-05	3.21E-08	2.45E-02
I-LQSCNVL	2.47E-09	1.22E-03	1.83E-07	1.47E-10	2.79E-07			0.00E+00	6.69E-05	1.65E-09	1.22E-03

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
10 LMACW-SI											
BRC total	1.34E-06	1.14E-01	6.06E-04	1.91E-06	2.35E-04	1.98E-01	6.61E-01	2.15E+01	3.03E-02	1.2E-27	2.15E+01
ACTUAL Total	1.34E-06	1.14E-01	6.90E-04	2.07E-06	2.41E-04	2.05E-01	6.84E-01	2.14E+01	3.85E-02	1.29E-27	2.14E+01
I-COTRASH	4.08E-07	3.40E-02	9.44E-05	1.21E-07	7.11E-05	4.00E-02	1.34E-01	2.77E+00	1.56E-03	4.95E-29	2.77E+00
P-COTRASH	7.17E-07	6.16E-02	4.56E-04	1.72E-06	1.26E-04	1.30E-01	4.34E-01	1.72E+01	2.11E-02	6.68E-28	1.72E+01
I-ABSLIQD	2.50E-08	2.08E-03	1.12E-05	7.41E-09	4.29E-06	4.74E-03	1.59E-02	3.28E-01	7.61E-05	2.41E-30	3.28E-01
I-BIOWAST	2.08E-08	1.73E-03	3.31E-06	6.18E-09	3.63E-06	2.53E-03	8.44E-03	3.35E-02	6.56E-06	2.08E-31	3.35E-02
I-LQSCNVL	1.04E-09	8.66E-05	0.00E+00	3.09E-10	1.75E-07	7.63E-04	2.54E-03	0.00E+00	0.00E+00	0.00E+00	2.54E-03
N-LOTRASH	1.28E-07	1.06E-02	2.95E-05	3.78E-08	2.22E-05	1.25E-02	4.18E-02	8.68E-01	4.90E-04	1.55E-29	8.68E-01
N-LOWASTE	4.33E-08	3.60E-03	1.09E-05	1.28E-08	7.62E-06	7.36E-03	2.46E-02	2.41E-01	5.42E-05	1.72E-30	2.41E-01
P-CONDRSN	4.75E-12	4.07E-07	2.94E-07	2.31E-11	1.05E-08	1.65E-04	5.51E-04	1.37E-03	6.08E-07	1.92E-32	1.37E-03
L-WASTOIL	0.00E+00	0.00E+00	2.18E-08	0.00E+00	2.40E-10	3.40E-06	1.14E-05	1.17E-03	2.83E-07	8.95E-33	1.17E-03
C-TIMEPCS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-28	2.20E-28
C-SMOKDET	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.96E-03	2.20E-28	6.96E-03

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
11 LMACW-UI											
BRC total	8.46E-07	1.19E-02	7.57E-04	2.14E-06	3.43E-04	0.00E+00	0.00E+00	4.44E+00	1.11E-02	2.96E-22	[illegible]
ACTUAL Total	8.46E-07	1.19E-02	9.04E-04	2.50E-06	3.54E-04	0.00E+00	0.00E+00	4.44E+00	1.26E-02	3.56E-22	[illegible]
I-COTRASH	3.57E-07	4.88E-03	2.10E-04	2.55E-07	1.42E-04			9.58E-01	5.39E-04	2.27E-23	[illegible]
P-COTRASH	2.98E-07	4.42E-03	4.09E-04	1.48E-06	1.25E-04			2.97E+00	3.64E-03	7.15E-23	2.97E+00
I-ABSLIQD	2.19E-08	2.99E-04	2.50E-05	1.48E-08	8.98E-06			1.13E-01	2.63E-05	1.22E-24	1.13E-01
I-BIOWAST	1.82E-08	2.49E-04	9.95E-06	1.23E-08	7.25E-06			1.16E-02	2.26E-06	5.06E-25	1.16E-02
I-LQSCNVL	9.11E-10	1.24E-05	3.51E-06	6.16E-10	3.50E-07			0.00E+00	0.00E+00	2.57E-26	1.24E-05
N-LOTRASH	1.12E-07	1.53E-03	6.58E-05	7.96E-08	4.43E-05			3.00E-01	1.69E-04	7.11E-24	3.00E-01
N-LOWASTE	3.79E-08	5.17E-04	3.36E-05	2.56E-08	1.47E-05			8.30E-02	1.87E-05	1.42E-24	8.30E-02
P-CONDRSN	1.98E-12	2.93E-08	2.30E-07	6.41E-11	1.05E-08			2.36E-04	1.05E-07	2.37E-27	2.36E-04
L-WASTOIL	0.00E+00	0.00E+00	2.18E-08	0.00E+00	2.40E-10			2.03E-04	4.88E-08	1.26E-27	2.03E-04
C-TIMEPCS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00			0.00E+00	0.00E+00	1.85E-23	1.85E-23
C-SMOKDET	3.72E-10	5.52E-06	0.00E+00	2.75E-07	0.00E+00			0.00E+00	6.70E-03	1.73E-22	6.70E-03

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
12 CW-SF											
BRC total	6.51E-11	9.32E-07	2.64E-05	5.11E-08	1.52E-06	1.33E-05	4.45E-05	3.86E-06	1.75E-03	2.74E-10	1.75E-03
ACTUAL Total	6.51E-11	9.32E-07	2.64E-05	5.11E-08	1.52E-06	1.33E-05	4.45E-05	3.86E-06	1.75E-03	2.74E-10	1.75E-03
C-TIMEPCS	0.00E+00	0.00E+00	2.38E-05	0.00E+00	5.20E-07	0.00E+00	0.00E+00	0.00E+00	5.09E-07	2.60E-11	2.38E-05
C-SMOKDET	6.51E-11	9.32E-07	2.57E-06	5.11E-08	1.00E-06	1.33E-05	4.45E-05	3.86E-06	1.75E-03	2.48E-10	1.75E-03

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
13 CW-UF											
BRC total	1.51E-10	3.75E-07	1.44E-04	2.86E-07	8.45E-06	0.00E+00	0.00E+00	3.73E-06	1.69E-03	3.57E-10	1.69E-03
ACTUAL Total	1.51E-10	3.75E-07	1.44E-04	2.86E-07	8.45E-06	0.00E+00	0.00E+00	3.73E-06	1.69E-03	3.57E-10	1.69E-03
C-TIMEPCS	0.00E+00	0.00E+00	1.30E-04	0.00E+00	2.83E-06			0.00E+00	4.79E-07	3.30E-11	1.30E-04
C-SMOKDET	1.51E-10	3.75E-07	1.44E-05	2.86E-07	5.62E-06			3.73E-06	1.69E-03	3.24E-10	1.69E-03

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
14 LURO-ON*											
BRC total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-07	3.92E-07
ACTUAL Total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.92E-07	3.92E-07
BIOMED *										3.92E-07	3.92E-07

HI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
15 LURO-ON**											
BRC total	1.83E-05	9.06E+00	2.24E-05	1.09E-06	1.44E-03	0.00E+00	0.00E+00	0.00E+00	3.77E-06	1.96E-07	9.06E+00
ACTUAL Total	1.83E-05	9.06E+00	2.24E-05	1.09E-06	1.44E-03	0.00E+00	0.00E+00	0.00E+00	3.77E-06	1.96E-07	9.06E+00
BIOMED *	1.83E-05	9.06E+00	2.24E-05	1.09E-06	1.44E-03				3.77E-06	1.96E-07	9.06E+00

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
Maximum HP		4.07E+01		5.75E-02		4.76E-01	1.59E+00	2.15E+01	2.08E-01	2.36E-05	[illegible]

PATHWAYS [Dose (mrem/yr)]

HP 1 PWR-MD	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
BRC total	0.00E+00	1.82E-01	0.00E+00	3.21E-03	0.00E+00	1.90E-01	6.34E-01	1.24E+01	2.40E-02	3.37E-06	1.24E+01
ACTUAL Total		1.82E-01		3.26E-03		1.93E-01	6.42E-01	1.24E+01	3.15E-02	4.44E-06	1.24E+01
P-COTRASH		1.82E-01		3.21E-03		1.90E-01	6.33E-01	1.24E+01	2.40E-02	3.37E-06	1.24E+01
P-CONDRSN		3.13E-06		4.73E-08		2.34E-04	7.79E-04	9.85E-04	7.58E-07	1.07E-10	9.85E-04
L-WASTOIL		0.00E+00		0.00E+00		5.28E-06	1.76E-05	8.47E-04	0.00E+00	0.00E+00	8.47E-04

PATHWAYS [Dose (mrem/yr)]

HP 2 BWR-MD	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
BRC total	0.00E+00	3.45E-01	0.00E+00	1.85E-03	0.00E+00	4.76E-01	1.59E+00	1.07E+01	8.09E-03	2.88E-06	1.07E+01
ACTUAL Total		3.45E-01		1.91E-03		4.76E-01	1.59E+00	1.07E+01	1.07E-02	3.80E-06	1.07E+01
B-COTRASH		3.45E-01		1.85E-03		4.76E-01	1.59E+00	1.07E+01	8.09E-03	2.88E-06	1.07E+01
L-WASTOIL		0.00E+00		0.00E+00		1.37E-05	4.56E-05	2.19E-03	7.97E-07	2.84E-10	2.19E-03

PATHWAYS [Dose (mrem/yr)]

HP 3 LUMC-UF	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
BRC total	0.00E+00	3.31E-02	0.00E+00	1.74E-03	0.00E+00	0.00E+00	0.00E+00	1.80E-01	1.56E-04	2.18E-09	1.80E-01
ACTUAL Total		3.31E-02		1.75E-03		0.00E+00	0.00E+00	1.81E-01	1.61E-04	2.34E-09	1.81E-01
I-COTRASH		1.97E-02		1.57E-03				1.59E-01	1.45E-04	2.02E-09	1.59E-01
I-ABSLIQD		7.18E-03		9.50E-05				1.89E-02	7.69E-06	1.09E-10	1.89E-02
I-BIOWAST		5.99E-03		7.92E-05				1.93E-03	1.92E-06	4.64E-11	5.99E-03
I-LQSCNVL		3.03E-04		3.96E-06				0.00E+00	1.41E-06	2.38E-12	3.03E-04

PATHWAYS [Dose (mrem/yr)]

HP 4 MAFC-SF	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	[illegible]
BRC total	0.00E+00	1.25E+00	0.00E+00	5.50E-03	0.00E+00	1.38E-02	4.61E-02	8.94E-01	5.25E-02	1.70E-05	1.25E+00
ACTUAL Total		1.25E+00		5.50E-03		1.38E-02	4.62E-02	8.94E-01	5.33E-02	1.74E-05	1.25E+00
I-COTRASH		6.40E-01		7.73E-04		6.24E-03	2.08E-02	4.63E-01	0.00E+00	0.00E+00	6.40E-01
I-ABSLIQD		3.91E-02		4.74E-05		7.39E-04	2.47E-03	5.48E-02	0.00E+00	0.00E+00	5.48E-02
I-BIOWAST		3.27E-02		3.95E-05		4.04E-04	1.35E-03	5.61E-03	0.00E+00	0.00E+00	3.27E-02
I-LQSCNVL		1.66E-03		4.74E-05		1.42E-04	4.75E-04	0.00E+00	0.00E+00	0.00E+00	1.66E-03
N-LOTRASH		4.00E-01		4.84E-04		3.89E-03	1.30E-02	2.91E-01	0.00E+00	0.00E+00	4.00E-01
N-LOWASTE		1.36E-01		1.64E-04		2.40E-03	8.01E-03	8.03E-02	0.00E+00	0.00E+00	1.36E-01
F-PROCESS		5.66E-04		3.34E-03		0.00E+00	0.00E+00	1.13E-08	4.45E-02	1.44E-05	4.45E-02
F-COTRASH		8.81E-05		5.19E-04		0.00E+00	0.00E+00	1.74E-09	6.92E-03	2.24E-06	6.92E-03
F-NCTRASH		1.49E-05		8.77E-05		0.00E+00	0.00E+00	2.95E-10	1.17E-03	3.78E-07	1.17E-03

PATHWAYS [Dose (mrem/yr)]

HP 5 MAFC-SI	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
BRC total	0.00E+00	1.56E+00	0.00E+00	4.32E-03	0.00E+00	5.50E-02	1.83E-01	5.36E+00	2.08E-01	0.00E+00	5.36E+00
ACTUAL Total		1.56E+00		4.48E-03		5.50E-02	1.83E-01	5.36E+00	2.11E-01	0.00E+00	5.36E+00
I-COTRASH		7.98E-01		1.94E-04		2.48E-02	8.26E-02	2.78E+00	0.00E+00		2.78E+00
I-ABSLIQD		4.89E-02		1.19E-05		2.94E-03	9.79E-03	3.28E-01	0.00E+00		3.28E-01
I-BIOWAST		4.07E-02		9.89E-06		1.61E-03	5.36E-03	3.36E-02	0.00E+00		4.07E-02
I-LQSCNVL		2.05E-03		4.94E-07		5.67E-04	1.89E-03	0.00E+00	0.00E+00		2.05E-03
N-LOTRASH		4.99E-01		1.21E-04		1.55E-02	5.16E-02	1.74E+00	0.00E+00		1.74E+00
N-LOWASTE		1.70E-01		4.11E-05		9.54E-03	3.18E-02	4.81E-01	0.00E+00		4.81E-01
F-PROCESS		2.96E-03		3.34E-03		0.00E+00	0.00E+00	6.76E-08	1.76E-01		1.76E-01
F-COTRASH		4.61E-04		5.18E-04		0.00E+00	0.00E+00	1.05E-08	2.74E-02		2.74E-02
F-NCTRASH		7.78E-05		8.75E-05		0.00E+00	0.00E+00	1.77E-09	4.63E-03		4.63E-03

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
6 PWRHU-MD											
BRC total	0.00E+00	8.58E-01	0.00E+00	2.34E-03	0.00E+00	1.41E-01	4.68E-01	8.76E+00	1.62E-02	1.93E-06	8.76E+
ACTUAL Total		8.58E-01		2.47E-03		1.45E-01	4.84E-01	8.76E+00	2.14E-02	2.60E-06	8.76E+
I-COTRASH		4.80E-01		1.95E-04		8.41E-03	2.81E-02	3.33E-01	1.66E-04	2.00E-08	4.80E-
I-ABSLIQD		2.93E-02		1.18E-05		9.91E-04	3.32E-03	3.91E-02	0.00E+00	0.00E+00	3.91E-
I-BIOWAST		2.48E-02		1.00E-05		4.26E-04	1.43E-03	4.07E-03	0.00E+00	0.00E+00	2.48E-
I-LQSCNVL		1.26E-03		4.99E-07		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.26E-
N-LOTRASH		1.51E-01		6.09E-05		2.63E-03	8.80E-03	1.04E-01	5.23E-05	6.28E-09	1.51E-
N-LOWASTE		5.10E-02		2.06E-05		1.14E-03	3.79E-03	2.88E-02	0.00E+00	0.00E+00	5.10E-
P-CONDRSN		2.09E-06		2.84E-08		1.56E-04	5.19E-04	6.56E-04	5.04E-07	6.03E-11	6.56E-
P-COTRASH		1.21E-01		2.04E-03		1.27E-01	4.22E-01	8.25E+00	1.59E-02	1.91E-06	8.25E+
L-WASTOIL		0.00E+00		0.00E+00		3.52E-06	1.17E-05	5.63E-04	0.00E+00	0.00E+00	5.63E-

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
7 UHX-MD											
BRC total	0.00E+00	2.46E-03	0.00E+00	3.55E-03	0.00E+00	1.14E-04	3.82E-04	2.42E-02	1.28E-01	1.45E-05	1.28E-
ACTUAL Total		2.46E-03		3.55E-03		1.14E-04	3.82E-04	2.42E-02	1.28E-01	1.45E-05	1.28E-
U-PROCESS		2.46E-03		3.55E-03		1.14E-04	3.82E-04	2.42E-02	1.28E-01	1.45E-05	1.28E-

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
8 UF-MD											
BRC total	0.00E+00	7.57E-04	0.00E+00	1.09E-03	0.00E+00	3.53E-05	1.18E-04	4.89E-03	3.88E-02	2.36E-05	3.88E-
ACTUAL Total		7.57E-04		1.09E-03		3.53E-05	1.18E-04	4.89E-03	3.88E-02	2.36E-05	3.88E-
N-SSTRASH		1.71E-04		2.47E-04		7.98E-06	2.65E-05	1.10E-03	8.75E-03	5.33E-06	8.75E-
N-SSWASTE		5.86E-04		8.46E-04		2.73E-05	9.11E-05	3.79E-03	3.01E-02	1.83E-05	3.01E-

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	[illegible]
	PATHWAYS [Dose (mrem/yr)]										
9 LURO-ON											
BRC total	0.00E+00	2.65E+00	0.00E+00	1.03E-04	0.00E+00	0.00E+00	0.00E+00	1.55E-01	7.39E-03	3.28E-06	[illegible]
ACTUAL Total		2.65E+00		1.03E-04		0.00E+00	0.00E+00	1.55E-01	7.62E-03	3.52E-06	2.65E+00
I-COTRASH		2.38E+00		9.27E-05				1.37E-01	6.87E-03	3.04E-06	2.38E+00
I-ABSLIQD		1.46E-01		5.66E-06				1.63E-02	3.64E-04	1.64E-07	1.46E-01
I-BIOWAST		1.21E-01		4.72E-06				1.41E-03	9.09E-05	6.98E-08	1.21E-01
I-LQSCNVL		6.16E-03		2.36E-07				0.00E+00	6.69E-05	3.58E-09	6.16E-03

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
	PATHWAYS [Dose (mrem/yr)]										
10 LMACW-SI											
BRC total	0.00E+00	1.37E+00	0.00E+00	2.32E-03	0.00E+00	1.18E-01	3.95E-01	2.15E+01	3.03E-02	0.00E+00	2.15E+01
ACTUAL Total		1.37E+00		2.52E-03		1.23E-01	4.10E-01	2.14E+01	3.85E-02	0.00E+00	2.14E+01
I-COTRASH		7.91E-01		1.93E-04		2.41E-02	8.05E-02	2.77E+00	1.56E-03		2.77E+00
P-COTRASH		1.20E-01		2.02E-03		7.70E-02	2.57E-01	1.72E+01	2.11E-02		1.72E+01
I-ABSLIQD		4.85E-02		1.18E-05		2.86E-03	9.53E-03	3.28E-01	7.61E-05		3.28E-01
I-BIOWAST		4.04E-02		9.88E-06		1.58E-03	5.25E-03	3.35E-02	6.56E-06		4.04E-02
I-LQSCNVL		2.04E-03		4.93E-07		5.40E-04	1.80E-03	0.00E+00	0.00E+00		2.04E-03
N-LOTRASH		2.48E-01		6.05E-05		7.54E-03	2.51E-02	8.68E-01	4.90E-04		8.68E-01
N-LOWASTE		8.39E-02		2.05E-05		4.64E-03	1.55E-02	2.41E-01	5.42E-05		2.41E-01
P-CONDRSN		1.28E-06		2.78E-08		9.78E-05	3.26E-04	1.37E-03	6.08E-07		1.37E-03
L-WASTOIL		0.00E+00		0.00E+00		2.00E-06	6.69E-06	1.17E-03	2.83E-07		1.17E-03
C-TIMEPCS		4.13E-02		0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00		4.13E-02
C-SMOKDET		0.00E+00		0.00E+00		0.00E+00	0.00E+00	0.00E+00	6.96E-03		6.96E-03

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
	PATHWAYS [Dose (mrem/yr)]										
11 LMACW-UI											
BRC total	0.00E+00	5.72E-01	0.00E+00	2.73E-03	0.00E+00	0.00E+00	0.00E+00	4.44E+00	1.11E-02	0.00E+00	[illegible]
ACTUAL Total		5.72E-01		3.10E-03		0.00E+00	0.00E+00	4.44E+00	1.26E-02	0.00E+00	[illegible]
I-COTRASH		3.34E-01		4.03E-04				9.58E-01	5.39E-04		[illegible]
P-COTRASH		3.15E-02		1.79E-03				2.97E+00	3.64E-03		2.97E+00
I-ABSLIQD		2.04E-02		2.37E-05				1.13E-01	2.63E-05		1.13E-01
I-BIOWAST		1.71E-02		1.98E-05				1.16E-02	2.26E-06		1.71E-02
I-LQSCNVL		8.58E-04		9.88E-07				0.00E+00	0.00E+00		8.58E-04
N-LOTRASH		1.04E-01		1.26E-04				3.00E-01	1.69E-04		3.00E-01
N-LOWASTE		3.54E-02		4.11E-05				8.30E-02	1.87E-05		8.30E-02
P-CONDRSN		3.08E-07		2.91E-08				2.36E-04	1.05E-07		2.36E-04
L-WASTOIL		0.00E+00		0.00E+00				2.03E-04	4.88E-08		2.03E-04
C-TIMEPCS		2.81E-02		0.00E+00				0.00E+00	0.00E+00		2.81E-02
C-SMOKDET		0.00E+00		3.32E-04				0.00E+00	6.70E-03		6.70E-03

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
12 CW-SF											
BRC total	0.00E+00	4.26E-02	0.00E+00	6.18E-05	0.00E+00	1.36E-05	4.55E-05	3.86E-06	1.75E-03	5.95E-10	4.26E-0
ACTUAL Total		4.26E-02		6.18E-05		1.36E-05	4.55E-05	3.86E-06	1.75E-03	5.95E-10	4.26E-0
C-TIMEPCS		4.25E-02		0.00E+00		0.00E+00	0.00E+00	0.00E+00	5.09E-07	5.65E-11	4.25E-0
C-SMOKDET		6.34E-05		6.18E-05		1.36E-05	4.55E-05	3.86E-06	1.75E-03	5.38E-10	1.75E-0

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
13 CW-UF											
BRC total	0.00E+00	1.66E-02	0.00E+00	3.46E-04	0.00E+00	0.00E+00	0.00E+00	3.73E-06	1.69E-03	7.75E-10	1.66E-0
ACTUAL Total		1.66E-02		3.46E-04		0.00E+00	0.00E+00	3.73E-06	1.69E-03	7.75E-10	1.66E-0
C-TIMEPCS		1.66E-02		0.00E+00				0.00E+00	4.79E-07	7.17E-11	1.66E-0
C-SMOKDET		2.65E-05		3.46E-04				3.73E-06	1.69E-03	7.03E-10	1.69E-0

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
14 LURO-ON*											
BRC total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.51E-07	8.51E-0
ACTUAL Total		0.00E+00		0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.51E-07	8.51E-0
BIOMED *										8.51E-07	8.51E-0

HP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
15 LURO-ON**											
BRC total	0.00E+00	4.07E+01	0.00E+00	1.74E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.77E-06	4.26E-07	4.07E+0
ACTUAL Total		4.07E+01		1.74E-03		0.00E+00	0.00E+00	0.00E+00	3.77E-06	4.25E-07	4.07E+0
BIOMED *		4.07E+01		1.74E-03					3.77E-06	4.26E-07	4.07E+0

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

Maximum AP		2.20E-03				6.63E-01	2.22E+00	2.15E+01	2.08E-01	2.67E-05	[illegible]

AP	GW - R	GW - W	SPILL	EROS	BATH	PATHWAYS [Dose (mrem/yr)] ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	[illegible]
1 PWR-MD											
BRC total	0.00E+00	7.35E-04	0.00E+00	0.00E+00	0.00E+00	2.66E-01	8.85E-01	1.24E+01	2.40E-02	3.80E-06	1.24E+01
ACTUAL Total		7.35E-04		0.00E+00		2.69E-01	8.95E-01	1.24E+01	3.15E-02	5.00E-06	1.24E+01
P-COTRASH		7.35E-04				2.65E-01	8.84E-01	1.24E+01	2.40E-02	3.80E-06	1.24E+01
P-CONDRSN		4.72E-09				3.27E-04	1.09E-03	9.85E-04	7.58E-07	1.20E-10	1.09E-03
L-WASTOIL		0.00E+00				7.36E-06	2.46E-05	8.47E-04	0.00E+00	0.00E+00	8.47E-04

AP	GW - R	GW - W	SPILL	EROS	BATH	PATHWAYS [Dose (mrem/yr)] ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
2 BWR-MD											
BRC total	0.00E+00	1.69E-03	0.00E+00	0.00E+00	0.00E+00	6.63E-01	2.22E+00	1.07E+01	8.09E-03	3.24E-06	1.07E+01
ACTUAL Total		1.69E-03		0.00E+00		6.66E-01	2.22E+00	1.07E+01	1.07E-02	4.28E-06	1.07E+01
B-COTRASH		1.69E-03				6.63E-01	2.22E+00	1.07E+01	8.09E-03	3.24E-06	1.07E+01
L-WASTOIL		0.00E+00				1.90E-05	6.36E-05	2.19E-03	7.97E-07	3.19E-10	2.19E-03

AP	GW - R	GW - W	SPILL	EROS	BATH	PATHWAYS [Dose (mrem/yr)] ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
3 LUMC-UF											
BRC total	0.00E+00	6.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-01	1.56E-04	2.46E-09	1.80E-01
ACTUAL Total		6.42E-05		0.00E+00		0.00E+00	0.00E+00	1.81E-01	1.61E-04	2.64E-09	1.81E-01
I-COTRASH		5.76E-05						1.59E-01	1.45E-04	2.28E-09	1.59E-01
I-ABSLIQD		3.53E-06						1.89E-02	7.69E-06	1.23E-10	1.89E-02
I-BIOWAST		2.94E-06						1.93E-03	1.92E-06	5.23E-11	1.93E-03
I-LQSCNVL		1.47E-07						0.00E+00	1.41E-06	2.68E-12	1.41E-06

AP	GW - R	GW - W	SPILL	EROS	BATH	PATHWAYS [Dose (mrem/yr)] ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	[illegible]
4 MAFC-SF											
BRC total	0.00E+00	1.96E-04	0.00E+00	0.00E+00	0.00E+00	1.93E-02	6.42E-02	8.94E-01	5.25E-02	1.91E-05	8[illegible]
ACTUAL Total		1.96E-04		0.00E+00		1.93E-02	6.43E-02	8.94E-01	5.33E-02	1.96E-05	8.9[illegible]
I-COTRASH		6.92E-05				8.73E-03	2.90E-02	4.63E-01	0.00E+00	0.00E+00	4.63E-01
I-ABSLIQD		4.23E-06				1.03E-03	3.44E-03	5.48E-02	0.00E+00	0.00E+00	5.48E-02
I-BIOWAST		3.53E-06				5.63E-04	1.87E-03	5.61E-03	0.00E+00	0.00E+00	5.61E-03
I-LQSCNVL		1.76E-07				1.94E-04	6.48E-04	0.00E+00	0.00E+00	0.00E+00	6.48E-04
N-LOTRASH		4.32E-05				5.45E-03	1.82E-02	2.91E-01	0.00E+00	0.00E+00	2.91E-01
N-LOWASTE		1.47E-05				3.34E-03	1.11E-02	8.03E-02	0.00E+00	0.00E+00	8.03E-02
F-PROCESS		5.17E-05				0.00E+00	0.00E+00	1.13E-08	4.45E-02	1.62E-05	4.45E-02
F-COTRASH		8.04E-06				0.00E+00	0.00E+00	1.74E-09	6.92E-03	2.52E-06	6.92E-03
F-NCTRASH		1.36E-06				0.00E+00	0.00E+00	2.95E-10	1.17E-03	4.26E-07	1.17E-03

AP	GW - R	GW - W	SPILL	EROS	BATH	PATHWAYS [Dose (mrem/yr)] ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
5 MAFC-SI											
BRC total	0.00E+00	1.97E-04	0.00E+00	0.00E+00	0.00E+00	7.65E-02	2.56E-01	5.36E+00	2.08E-01	4.47E-27	5.36E+00
ACTUAL Total		1.97E-04		0.00E+00		7.66E-02	2.56E-01	5.36E+00	2.11E-01	4.58E-27	5.36E+00
I-COTRASH		4.81E-05				3.45E-02	1.16E-01	2.78E+00	0.00E+00	0.00E+00	2.78E+00
I-ABSLIQD		2.94E-06				4.09E-03	1.36E-02	3.28E-01	0.00E+00	0.00E+00	3.28E-01
I-BIOWAST		2.46E-06				2.23E-03	7.44E-03	3.36E-02	0.00E+00	0.00E+00	3.36E-02
I-LQSCNVL		1.23E-07				7.71E-04	2.57E-03	0.00E+00	0.00E+00	0.00E+00	2.57E-03
N-LOTRASH		3.01E-05				2.16E-02	7.23E-02	1.74E+00	0.00E+00	0.00E+00	1.74E+00
N-LOWASTE		1.02E-05				1.32E-02	4.40E-02	4.81E-01	0.00E+00	0.00E+00	4.81E-01
F-PROCESS		8.74E-05				0.00E+00	0.00E+00	6.38E-08	1.76E-01	3.78E-27	1.76E-01
F-COTRASH		1.36E-05				0.00E+00	0.00E+00	1.05E-08	2.74E-02	5.88E-28	2.74E-02
F-NCTRASH		2.30E-06				0.00E+00	0.00E+00	1.77E-09	4.63E-03	9.94E-29	4.63E-03

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
6 PWRHU-MD											
BRC total	0.00E+00	4.69E-05	0.00E+00	0.00E+00	0.00E+00	1.90E-01	6.53E-01	8.76E+00	1.62E-02	2.18E-06	8.76E+00
ACTUAL Total		4.69E-05		0.00E+00		2.02E-01	6.75E-01	8.76E+00	2.14E-02	2.93E-06	8.76E+00
I-COTRASH		2.94E-05				1.18E-02	3.94E-02	3.33E-01	1.66E-04	2.24E-08	3.33E-01
I-ABSLIQD		1.79E-06				1.39E-03	4.64E-03	3.91E-02	0.00E+00	0.00E+00	3.91E-02
I-BIOWAST		1.52E-06				6.01E-04	2.00E-03	4.07E-03	0.00E+00	0.00E+00	4.07E-03
I-LQSCNVL		7.54E-08				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.54E-08
N-LOTRASH		9.20E-06				3.70E-03	1.24E-02	1.04E-01	5.23E-05	7.04E-09	1.04E-01
N-LOWASTE		3.12E-06				1.59E-03	5.31E-03	2.88E-02	0.00E+00	0.00E+00	2.88E-02
P-CONDRSN		8.69E-11				2.17E-04	7.26E-04	6.78E-11	5.04E-07	6.78E-11	7.26E-04
P-COTRASH		1.81E-06				1.70E-01	5.89E-01	8.25E+00	1.59E-02	2.15E-06	8.25E+00
L-WASTOIL		0.00E+00				4.92E-06	1.64E-05	5.63E-04	0.00E+00	0.00E+00	5.63E-04

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
7 UHX-MD											
BRC total	0.00E+00	9.26E-05	0.00E+00	0.00E+00	0.00E+00	1.31E-04	4.37E-04	2.65E-03	1.28E-01	1.63E-05	1.28E-01
ACTUAL Total		9.26E-05		0.00E+00		1.31E-04	4.37E-04	2.65E-03	1.28E-01	1.63E-05	1.28E-01
U-PROCESS		9.26E-05				1.31E-04	4.37E-04	2.65E-03	1.28E-01	1.63E-05	1.28E-01

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
8 UF-MD											
BRC total	0.00E+00	2.85E-05	0.00E+00	0.00E+00	0.00E+00	4.04E-05	1.35E-04	4.65E-04	3.88E-02	2.67E-05	3.88E-02
ACTUAL Total		2.85E-05		0.00E+00		4.05E-05	1.35E-04	4.65E-04	3.88E-02	2.67E-05	3.88E-02
N-SSTRASH		6.44E-06				9.14E-06	3.05E-05	1.05E-04	8.75E-03	6.03E-06	8.75E-03
N-SSWASTE		2.20E-05				3.13E-05	1.05E-04	3.60E-04	3.01E-02	2.07E-05	3.01E-02

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	[illegible]
					PATHWAYS [Dose (mrem/yr)]						
9 LURO-ON											
BRC total	0.00E+00	1.31E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-01	7.39E-03	3.69E-06	1.55E-01
ACTUAL Total		1.31E-04		0.00E+00		0.00E+00	0.00E+00	1.55E-01	7.62E-03	3.97E-06	1.55E-01
I-COTRASH		1.17E-04						1.37E-01	6.87E-03	3.43E-06	1.37E-01
I-ABSLIQD		7.16E-06						1.63E-02	3.64E-04	1.84E-07	1.63E-02
I-BIOWAST		5.96E-06						1.41E-03	9.09E-05	7.85E-08	1.41E-03
I-LQSCNVL		2.97E-07						0.00E+00	6.69E-05	4.02E-09	6.69E-05

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
10 LMACW-SI											
BRC total	0.00E+00	8.05E-04	0.00E+00	0.00E+00	0.00E+00	1.65E-01	5.51E-01	2.15E+01	3.03E-02	1.71E-28	2.15E+01
ACTUAL Total		8.05E-04		0.00E+00		1.71E-01	5.71E-01	2.14E+01	3.85E-02	2.30E-28	2.14E+01
I-COTRASH		4.80E-05				3.37E-02	1.13E-01	2.77E+00	1.56E-03	8.82E-30	2.77E+00
P-COTRASH		7.31E-04				1.07E-01	3.59E-01	1.72E+01	2.11E-02	1.19E-28	1.72E+01
I-ABSLIQD		2.94E-06				3.99E-03	1.33E-02	3.28E-01	7.61E-05	4.29E-31	3.28E-01
I-BIOWAST		2.45E-06				2.19E-03	7.32E-03	3.35E-02	6.56E-06	3.69E-32	3.35E-02
I-LQSCNVL		1.22E-07				7.36E-04	2.46E-03	0.00E+00	0.00E+00	0.00E+00	2.46E-03
N-LOTRASH		1.50E-05				1.05E-02	3.52E-02	8.68E-01	4.90E-04	2.76E-30	8.68E-01
N-LOWASTE		5.09E-06				6.43E-03	2.15E-02	2.41E-01	5.42E-05	3.05E-31	2.41E-01
P-CONDRSN		4.60E-09				1.37E-04	4.56E-04	1.37E-03	6.08E-07	3.44E-33	1.37E-03
L-WASTOIL		0.00E+00				2.81E-06	9.39E-06	1.17E-03	2.83E-07	1.59E-33	1.17E-03
C-TIMEPCS		0.00E+00				0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-SMOKDET		0.00E+00				0.00E+00	0.00E+00	0.00E+00	6.96E-03	3.93E-29	6.96E-03

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
					PATHWAYS [Dose (mrem/yr)]						
11 LMACW-UI											
BRC total	0.00E+00	3.64E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.44E+00	1.11E-02	7.36E-23	[illegible]
ACTUAL Total		3.64E-04		0.00E+00		0.00E+00	0.00E+00	4.44E+00	1.26E-02	8.87E-23	[illegible]
I-COTRASH		3.95E-05						9.58E-01	5.39E-04	5.65E-24	9.58E-01
P-COTRASH		3.03E-04						2.97E+00	3.64E-03	1.78E-23	2.97E+00
I-ABSLIQD		2.45E-06						1.13E-01	2.63E-05	3.03E-25	1.13E-01
I-BIOWAST		2.04E-06						1.16E-02	2.26E-06	1.26E-25	1.16E-02
I-LQSCNVL		1.02E-07						0.00E+00	0.00E+00	6.40E-27	1.02E-07
N-LOTRASH		1.25E-05						3.00E-01	1.69E-04	1.77E-24	3.00E-01
N-LOWASTE		4.24E-06						8.30E-02	1.87E-05	3.52E-25	8.30E-02
P-CONDRSN		1.91E-09						2.36E-04	1.05E-07	5.89E-28	2.36E-04
L-WASTOIL		0.00E+00						2.03E-04	4.88E-08	3.14E-28	2.03E-04
C-TIMEPCS		0.00E+00						0.00E+00	0.00E+00	4.60E-24	4.60E-24
C-SMOKDET		0.00E+00						0.00E+00	6.70E-03	4.30E-23	6.70E-03

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

PATHWAYS [Dose (mrem/yr)]

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
12 CW-SF											
BRC total	0.00E+00	2.76E-08	0.00E+00	0.00E+00	0.00E+00	1.53E-05	5.13E-05	1.37E-09	1.75E-03	6.70E-10	1.75E-03
ACTUAL Total		2.76E-08		0.00E+00		1.53E-05	5.13E-05	1.37E-09	1.75E-03	6.70E-10	1.75E-03
C-TIMEPCS		1.50E-09				0.00E+00	0.00E+00	0.00E+00	5.09E-07	6.36E-11	5.09E-07
C-SMOKDET		2.61E-08				1.53E-05	5.13E-05	1.37E-09	1.75E-03	6.06E-10	1.75E-03

PATHWAYS [Dose (mrem/yr)]

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
13 CW-UF											
BRC total	0.00E+00	6.21E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-09	1.69E-03	8.73E-10	1.69E-03
ACTUAL Total		6.21E-08		0.00E+00		0.00E+00	0.00E+00	1.32E-09	1.69E-03	8.73E-10	1.69E-03
C-TIMEPCS		1.53E-09						0.00E+00	4.79E-07	8.07E-11	4.79E-07
C-SMOKDET		6.06E-08						1.32E-09	1.69E-03	7.92E-10	1.69E-03

PATHWAYS [Dose (mrem/yr)]

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
14 LURO-ON*											
BRC total	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.58E-07	9.58E-07
ACTUAL Total		0.00E+00		0.00E+00		0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.58E-07	9.58E-07
BIOMED *										9.58E-07	9.58E-07

PATHWAYS [Dose (mrem/yr)]

AP	GW - R	GW - W	SPILL	EROS	BATH	ON FOOD	BIOWAS	GAMMA	DUST	ATMOS	@MAX
15 LURO-ON**											
BRC total	0.00E+00	2.20E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.77E-06	4.79E-07	2.20E-03
ACTUAL Total		2.20E-03		0.00E+00		0.00E+00	0.00E+00	0.00E+00	3.77E-06	4.79E-07	2.20E-03
BIOMED *		2.20E-03							3.77E-06	4.79E-07	2.20E-03

Note: "ACTUAL Total" represents the maximum CPG dose for 40 nuclides.
"BRC total" represents the maximum CPG dose for the top three nuclides.

September 1987

BACKGROUND

In the main text, total costs were discounted at a 10 percent real rate over the 20-year period in which they occurred. Health effects, occurring over a 10,000-year period (due to the assumed 20-year disposal volume), were not discounted, however. This appendix analyzes the sensitivity of our results to changes in the discount rate assumptions that were used in calculating both costs and health effects. A comparison is made between the base case of 10 percent discount rate for costs, zero percent discount rate for health effects (10%/0%), and two alternative cases which assume discount rates of 5%/5% and 2%/2% for costs/health effects.

Economic theory supports the notion of discounting economic costs and benefits that occur over time since a dollar today is worth more to society than a dollar tomorrow, even with zero inflation. Economists refer to this as the "time value of money." However, choosing the appropriate discount rate is a difficult matter since this is an empirical question related to the project specific risk.* In the past, the Office of Management and Budget has recommended using a 10 percent real discount rate. This rate is not inconsistent with empirical evidence from the 1960s, where the average

* Although all economists would support the need for discounting, theoretical complexities also complicate the process of selecting the appropriate discount rate. These complexities are beyond the scope of this discussion, however.

pre-tax real rate of return to the private sector was found to range between eight and 12 percent [LIND82]. Based on estimated real rates of return during the 1980s, however, using a lower discount rate of five percent has been suggested for those projects that are expected primarily to displace private investments in the short run. A rate of two percent has been suggested for projects that primarily displace private consumption. The two percent discount rate represents the social rate of time preference (or the cost of "foregone" consumption) which has been estimated from historical data to range from one to three percent. These suggested alternative discount rates have been used in the sensitivity analysis presented below.

Since radiological health effects span many generations, the application of the discounting framework to the costs and health effects associated with LLW disposal is more complex in comparison to other EPA programs. Socio-economic theory cannot provide a solution to this problem of valuing inter-generational redistributions of costs and benefits. Calculating cost-effectiveness ratios will allow for the determination of only the most economically efficient disposal options, assuming intergeneration redistributions of wealth are valued equally over time.

SELECTION OF CASES FOR SENSITIVITY ANALYSIS

Given the lack of unanimity concerning the use of discounting under these circumstances, particularly since the focus has been centered mainly on discounting health effects, EPA assumes a base case in which costs, discounted at 10 percent, are compared to the undiscounted health effects. Economic theory suggests that, if health effects can be explicitly valued, this approach understates the actual costs of disposal relative to the associated benefits, resulting in improving the relative economics of the more costly disposal options.

METHODOLOGY

The following is a brief summary of the methodology used in discounting costs and health effects.

Annual costs were assumed to remain fixed over a 20-year period coincident with disposal volumes. This assumption is a slight simplification since annual volumes increase year to year from zero to five percent, depending on the particular waste. These annualized costs were discounted using the following formula:

$$PV = \sum_{t=1}^{N} \frac{C_t}{(1+d)^t}$$

Where: C_t = cost in year t
d = discount rate
N = total number of years = 20

EPA uses a range of analytical procedures when evaluating regulations with long-term benefits, including: 1) analyzing the time-line of costs and risks, 2) evaluating the environmental risks by eliminating the lag between expenditures on environmental controls and benefits, and 3) using a two-step discounting procedure. The methodology used in this appendix is analogous to the third approach.

Under this procedure, capital costs are annualized over the lifetime of the capital asset using the pre-tax rate of return on private investment as the discount rate. This cost stream is added to the other annual costs associated with the project and then discounted (along with the benefit stream) by a rate representing the social rate of time preference. As a simplification of this procedure, all costs associated with LLW disposal are assumed to be annual operating costs requiring no capital investment. This assumption makes it possible to avoid the complicated task of re-estimating all disposal costs. Given a five percent pre-tax rate of return on private investment and a two percent social rate of time preference, by assuming all costs are annual operating expenses (i.e., by not annualizing any capital costs), total disposal costs would be understated by a maximum of about 60 percent if all project costs were treated as capital investments.* This 60 percent estimate is a maximum for two reasons. First, all disposal costs cannot be characterized as capital investments. For example, capital costs of incineration represent about 50 percent of total costs (i.e., capital costs plus operating and maintenance costs) [TEK81]. As a result, disposal costs are understated by only 30 percent, rather than by 60 percent. Another reason this 60 percent figure might overstate the potential bias introduced by assuming all costs are operating expenses is that, to some extent, the costs used in the LLW analysis have already been annualized (albeit at different discount rates potentially). This annualization was calculated explicitly in the engineering costs estimated for the 10 alternative disposal options and various processing techniques. (A 10 percent rate of return was employed when estimating the costs of disposal options.) To the extent this annualization of capital costs has already been considered, the appropriate methodology in eliminating any bias would involve the complicated task of annualizing the capital costs associated with disposal at a different discount rate, which matches the particular rate chosen in the sensitivity analysis (e.g., two and five percent). Nevertheless, the extreme effect of discounting health effects can be seen since the potential bias introduced by making the above simplifying assumption on costs is small in comparison to the change in health effects that results from discounting.

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* The 60 percent figure is calculated as follows: if all costs represent capital investments, then all nominal disposal costs are assumed to be expended upfront, which is then annualized at a five percent rate, and discounted at a two percent rate. This calculation is divided by the present value of the annual nominal cost stream (in this case, assumed to be operating expenses), which is discounted at a two percent rate.

The discounting of health effects is more complicated than the discounting of costs since the methodology in this case involves manipulating cumulative health effects data that are reported over four time horizons -- a 100-, 500-, 1,000-, and 10,000-year horizon. Health effects are assumed not to occur until site closure, 24 years after the disposal site begins accepting waste. The health effects occurring in four discrete time periods were calculated by subtracting the cumulative health effects reported at each time horizon. Thus, health effects were calculated for a 100-, 400-, 500-, and 9,000-year time interval. For purposes of discounting, the health effects are assumed to be evenly distributed over each time interval in which they are estimated. Health effects associated with the release of radon, which were calculated by a different computer model covering a 1,000-year period, were equally distributed over this period and added to the other health effects. The formula used in discounting these total health effects is:

$$\sum_{i=1}^{4} (HE_i/N_i) * \left(\frac{d}{1-(1+d)^{-N_i}}\right) * (1+d)^{-(N_i+24)}$$

Where:
- i = period 1, 2, 3, or 4.
- HE_i = health effects over period i.
- N_i = number of years in period i.
- d = discount rate

With discounting, health effects occurring after the first 100 years contribute very little to the present value of health effects.

RESULTS

Tables E-1, E-2, and E-3 list the distribution of health effects over time for disposal practices affecting the BRC, NARM, and LLW standards, respectively. Tables E-4, E-5, and E-6 demonstrate the effect that discounting costs and health effects has on the cost-effectiveness ratios.

The base case of 10%/0% is compared to two alternative cases, 5%/5% and 2%/2%, under the National-Implicit implementation assumption. Table E-4, which presents the impacts associated with alternative LLW standards, demonstrates that cost-effectiveness ratios increase from one to two orders of magnitude when comparing the base case, 10%/0%, to the case 2%/2%, and from 1.5 to 2.5 orders of magnitude when comparing the base case to the 5%/5% case. Likewise, Table E-5, which presents the impacts associated with alternative BRC standards, shows a similar one to two order of magnitude increase in the marginal cost-effectiveness ratio.

Table E-6 presents the discounted cost and health effects associated with the two NARM wastes EPA is proposing to regulate under TSCA authority. The cost-effectiveness of regulating R-RASOURC remains relatively low, even when discounting at EPA's recommended two percent rate. However, the average cost-effectiveness for both NARM wastes increases by two orders of magnitude in comparison to the base case.

Table E-1

WEIGHTED AVERAGE HEALTH EFFECTS
FOR FIVE UNREGULATED DISPOSAL METHODS

Wastes*	U.S. Totals By Time Period (Years) 0-100**	101-500	501-1,000	1,001-10,000	Total
P-CONDRSN	5.56E-04	7.73E-05	9.38E-06	7.05E-07	6.43E-04
L-WASTOIL	4.51E-05	2.71E-06	-5.75E-08	1.70E-15	4.78E-05
I-LQSCNVL	1.47E-01	3.89E-01	2.83E-02	3.56E-04	5.64E-01
N-SSTRASH	2.26E-04	5.32E-04	3.84E-04	1.63E-04	1.31E-03
N-SSWASTE	7.77E-04	1.83E-03	1.33E-03	5.60E-04	4.49E-03
F-PROCESS	9.39E-04	4.11E-04	3.28E-04	7.86E-04	2.46E-03
U-PROCESS	1.47E-04	2.64E-05	4.65E-06	4.34E-04	6.12E-04
F-COTRASH	1.68E-04	6.83E-05	5.66E-05	1.08E-04	4.01E-04
N-NCTRASH	2.84E-05	1.15E-05	9.62E-06	1.83E-05	6.78E-05
C-SMOKDET	4.97E-02	5.17E-01	6.15E-01	1.98E-01	1.38E+00
C-TIMEPCS	5.86E+00	1.45E+00	0.00E+00	2.87E-25	7.31E+00
TOTALS	6.06E+00	2.36E+00	6.45E-01	2.00E-01	9.26E+00

* Includes the nine wastes expected to meet the proposed 4 millirem BRC criterion and the two consumer wastes.

** Year "zero" of the health risk analysis begins after 20 years of disposal and three years of site closure.

Table E-2

DISTRIBUTION OF NARM HEALTH EFFECTS OVER TIME
FOR THE TOTAL UNITED STATES

NARM Wastes Streams	0-100*** Years	101-500 Years	501-1,000 Years	1,001-10,000 Years	Radon *	Total
Unregulated Disposal:						
R-GLASDS1	3.86E-01	1.42E+00	1.71E+00	1.22E+00	NA	4.74E+00
R-GLASDS2	1.32E-04	1.76E+04	1.28E-04	5.48E-05	NA	4.91E-04
R-INSTDF1	1.81E-01	7.33E-01	6.78E-01	7.21E-01	NC	2.31E+00
R-INSTDF2	6.15E-05	2.49E-04	2.31E-04	2.45E-04	NC	7.86E-04
R-RASOURC	4.70E+00	2.07E+01	1.92E+01	2.23E+01	1.97E-01	6.68E+01
R-RAIXRSN	3.13E-01	1.08E+00	9.96E-01	1.36E+00	5.70E-02	3.74E+00
Regulated Disposal: **						
R-GLASDS1	4.44E-07	3.87E-02	8.30E-02	8.20E-01	NA	9.42E-01
R-GLASDS2	6.12E-11	1.41E-05	2.17E-05	6.36E-05	NA	9.94E-05
R-INSTDF1	6.30E-07	7.68E-02	1.40E-01	4.24E-01	NC	6.41E-01
R-INSTDF2	2.14E-10	2.61E-05	4.76E-05	1.44E-04	NC	2.18E-04
R-RASOURC	0.00E+00	6.20E-05	1.26E-04	3.35E-04	1.32E-01	1.33E-01
R-RAIXRSN	0.00E+00	3.67E-06	7.50E-06	1.99E-05	3.10E-02	3.10E-02

* The distribution of radon risk over time was not estimated. The total radon risk over 10,000 years is included in total health effects.

** Regulated disposal assumes that R-GLASDS1, R-GLASDS2, R-INSTDF1, and R-INSTDF2 are disposed of by shallow land disposal as generated, while R-RAIXRSN and R-RASOURC are disposed of by improved shallow disposal, solidified.

*** Year "zero" of the health risk analysis begins after 20 years of disposal and three years of site closure.

NA = Not applicable. These wastes do not contain radium and, hence, do not pose a radon risk.

NC = Not calculated. However, radon risk constitutes anywhere between two and 12 percent of the total health risk from these wastes streams.

Table E-3

DISTRIBUTION OF HEALTH EFFECTS OVER TIME
FOR SELECTED REGULATED DISPOSAL METHODS

	U.S. Totals By Time Period (Years)				
	0-100*	101-500	501-1,000	1,001-10,000	Total
SLF As Is					
Class A - BRC	16.8240	4.4549	1.2135	5.0780	27.5703
Class B	58.1280	26.8828	2.2122	4.4706	91.6936
Class C	4.4307	1.7569	0.5343	0.4126	7.1344
NARM	1.4482	17.8964	15.5599	25.8700	60.7746
TOTAL LLW	80.8309	50.9910	19.5198	35.8312	187.1729
SLD AS IS					
Class A - BRC	1.5651	8.6011	0.5189	4.7977	15.4827
Class B	0.7900	13.4259	0.7126	3.6353	18.5639
Class C	0.0009	0.0669	0.1454	0.2146	0.4278
NARM	0.0287	2.7047	4.7835	14.0295	21.5464
TOTAL LLW	2.3848	24.7986	6.1604	22.6771	56.0209
10 CFR 61					
Class A - BRC	1.5651	8.6011	0.5189	4.7977	15.4827
Class B	0.0538	1.9256	2.2257	8.4829	12.6879
Class C	0.0001	0.0010	0.0011	0.0085	0.0106
NARM	0.0163	0.0655	0.0819	0.0004	0.1640
TOTAL LLW	1.6353	10.5931	2.8275	13.2894	28.3453
A: IDD As Is; B, C, & NARM: IDD SOL					
Class A - BRC	0.7996	6.4645	1.6243	3.8708	12.7591
Class B	0.0379	0.5812	0.7028	4.0567	5.3785
Class C	0.0001	0.0010	0.0010	0.0071	0.0092
NARM	0.0157	0.0629	0.0787	0.0002	0.1576
TOTAL LLW	0.8533	7.1096	2.4068	7.9348	18.3044
CC					
Class A - BRC	0.0000	0.2433	0.3844	3.3587	3.9864
Class B	0.0000	0.2065	0.3393	2.8260	3.3718
Class C	0.0000	0.0003	0.0005	0.0047	0.0056
NARM	0.0006	0.0025	0.0031	0.0001	0.0063
TOTAL LLW	0.0006	0.4526	0.7273	6.1896	7.3700

* Year "zero" of the health risk analysis begins after 20 years of disposal and three years of site closure.

Table E-4

IMPACTS OF ALTERNATIVE LLW STANDARDS
AT DIFFERENT RATES OF DISCOUNT
UNDER NATIONAL-IMPLICIT IMPLEMENTATION

LLW Standard (Maximum CPG Dose in mrem per year)	Predicted Maximum CPG Dose	Predicted Maximum CPG Dose Doubled	Present Value Incremental Cost ($ Millions)			Present Value Avoided Health Effects			Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect)		
			Discount Rate			Discount Rate			Discount Rate		
			10%	5%	2%	0%	5%	2%	10%/0%	5%/5%	2%/2%
125	62	124	(590)	(860)	(1,100)	(160)	(5.1)	(22)			
									1.1	42	13
75	35	70	(450)	(650)	(860)	(28)	(0.0501)	(0.36)			
									16	13,000	2,400
25	9.1	18.2	(9.1)	(13)	(17)	(0.12)	(0.001)	(0.0036)			
									35	10,000	2,700
10	5	10	340	504	660	10	0.051	0.25			
									250	71,000	17,000
4	1.3	2.6	3,070	4,500	5,900	21	0.107	0.56			

(1) Incremental costs and avoided health effects are measured relative to current practice (10 CFR 61 for commercial waste; ISD Solidified for NARM).

(2) Costs (in 1985 dollars) are incurred annually from 1985 to 2004. Health effects (fatal cancers and genetic effects) occur over 10,000 years, beginning in 2008.

(3) Costs and health effects are discounted to 1985 at the rate indicated above each column. The procedure used to discount health effects is approximate and assumes a linear occurrence of health effects within the four discrete time intervals for which health effects were quantified.

(4) Costs and health effects include commercial LLW and two NARM wastes, and exclude BRC and DOE waste. The average annual waste volume is 108,750 cubic meters as generated.

(5) Compliance with the standard assumes that the same disposal technology is used everywhere, as determined by the CPG dose in the worst hydrogeologic region.

Table E-5

IMPACTS OF ALTERNATIVE BRC STANDARDS
AT DIFFERENT RATES OF DISCOUNT
UNDER NATIONAL IMPLICIT IMPLEMENTATION

BRC Standard (Maximum CPG Dose in mrem per year)	Predicted Maximum CPG Dose	Present Value BRC Savings Versus Current Practice* ($ Millions) Discount Rate			Present Value Additional Health Effects Versus Current Practice* Discount Rate			Marginal Cost-Effectiveness ($ Millions per Health Effect) Discount Rate		
		10%	5%	2%	0%	5%	2%	10%/0%	5%/5%	2%/2%
15	12.0	490	720	950	270	5.0	23			
								0.45	35	10
4	2.58	400	580	760	53	1.02	4.7			
								1.54	114	31
1	0.51	340	500	660	19	0.33	1.5			
								4.3	352	104
0.1	0.04	270	388	510	.5	.0096	.044			
								87	2,827	862
0.0	0.00	(1,500)	(2,200)	(2,910)	(20)	(.9)	(3.9)			

* Incremental costs and avoided health effects are measured relative to current practice (10 CFR 61). Under current practice, commercial LLW BRC candidates are disposed of at a SLD in the as generated form (except P-CONDRSN which is Solidified); consumer and biomedical wastes deregulated by 10 CFR 20.306 (the BIOMED rule, [NRC81a]) are unregulated. NARM and DOE wastes are not included.

NOTES:

(1) Costs (in 1985 dollars) are incurred annually from 1985 to 2004. Health effects (fatal cancers and genetic effects) occur over 10,000 years, beginning in 2008.

(2) Costs and health effects are discounted to 1985 at the rate indicated above each column. The procedure used to discount health effects is approximate and assumes a linear occurrence of health effects within the four discrete time intervals for which health effects were quantified.

Table E-6

DISCOUNTED COST AND HEALTH EFFECTS
FOR NARM WASTE STREAMS
(UNREGULATED DISPOSAL VERSUS 10 CFR 61 DISPOSAL)

NARM Waste	Present Value Incremental Cost ($ Millions)			Present Value Avoided Health Effects			Average Cost-Effectiveness ($ Millions per Avoided Health Effect)		
	Discount Rate			Discount Rate			Discount Rate		
	10%	5%	2%	0%	5%	2%	10%/0%	5%/5%	2%/2%
R-RAIXRSN	20.27	29.67	38.93	3.71	0.02	0.10	5.46	1,468.86	403.84
R-RASOURC	3.28	4.81	6.31	66.69	0.31	1.51	0.05	15.75	4.19
TOTAL	23.55	34.48	45.24	70.41	0.33	1.60	0.33	105.95	28.24

The purpose of this appendix is to provide additional backup tables associated with costs, health effects, and cost-effectiveness calculations. For each hydrogeologic region, Tables F-1 to F-3 present the incremental costs, avoided health effects, and the cost-effectiveness of regulating the BRC surrogate wastes, the two consumer wastes, NRC's unregulated biomedical waste, and the six NARM wastes. Table F-4 presents this information for the entire U.S. The information presented in these tables is used in the analysis of NARM in Chapter 6 and the analysis of BRC waste in Chapter 7.

The total health effects and costs occurring in each hydrogeologic region and in the total U.S. are presented in Tables F-5 to F-8 for the 17 regulated disposal methods considered in the analysis of the LLW standard in Chapter 8. Also included for purposes of comparison are the health effects and costs associated with regulated and unregulated disposal of the nine BRC wastes (those expected to meet the proposed 4 millirem BRC standard) which are excluded from the LLW analysis. The calculation of total health effects and costs (based on EPA assumptions highlighted in Appendix G) are shown for DOE waste as well.

Tables F-9 through F-13 introduce the unit health effects and unit costs associated with the five unregulated disposal options that were used to calculate a weighted average for unregulated disposal in Chapters 6 and 7. Table F-14 shows the estimated unit health effects and unit costs of regulated disposal, which are used for comparison to unregulated disposal in these two chapters.

Tables F-15 to F-17 present a summary of the accumulative fatal and genetic unit health effects occurring at four points in time (at 100-, 500-, 1,000-, and 10,000-year intervals) in the three hydrogeologic regions for all waste types and disposal technologies.

Finally, Table F-18 demonstrates the underlying nuclide concentrations (curies per cubic meter) and total nuclide inventories assumed for all waste streams in the Economic Impact Assessment.

TABLE F-1

COST EFFECTIVENESS OF REGULATION
HUMID IMPERMEABLE REGION
(Unregulated versus Regulated Disposal)

WASTE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
BRC "SURROGATES"			
P-COTRASH	19.05	0.2341	81.40
P-CONDRSN	3.74	0.0002	16,304.67
L-WASTOIL	4.84	0.0000	213,325.91
B-COTRASH	53.25	0.5425	98.16
I-COTRASH	36.76	0.5190	70.84
I-BIOWAST	3.27	0.0404	80.79
I-ABSLIQD	6.87	0.0644	106.75
I-LQSCNVL	9.29	0.0025	3,728.59
N-SSTRASH	62.44	0.0007	84,111.04
N-SSWASTE	11.02	0.0026	4,313.97
N-LOTRASH	10.62	0.0649	163.54
N-LOWASTE	6.31	0.0330	191.21
F-PROCESS	0.85	0.0003	3,199.46
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	2.55	0.0000	62,415.77
F-NCTRASH	0.66	0.0000	94,921.55
CONSUMER			
C-SMOKDET	163.10	1.1087	147.11
C-TIMEPCS	105.01	0.0882	1,190.62
BIOMED			
BIOMED	156.14	-0.2060	(757.96)
NARM			
R-GLASDS1	1293.55	1.2767	1,013.17
R-GLASDS2	0.00	0.0003	9.80
R-INSTDF1	142.78	1.5152	94.23
R-INSTDF2	0.01	0.0005	26.55
R-RAIXRSN	4.94	3.3885	1.46
R-RASOURC	1.40	64.2119	0.02
TOTAL	2,098.46	72.89	28.79

NOTES: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD, As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Unregulated disposal is represented by a weighted average of MD, SF, SI, UF and UI disposal practices (weighting depends on waste type). Unregulated disposal for BIOMED waste is represented by the LURO option. Note that consumer, BIOMED and NARM wastes are currently unregulated. N.A.= Waste not generated in this region.

September 1987

TABLE F-2

COST EFFECTIVENESS OF REGULATION
HUMID PERMEABLE REGION
(Unregulated versus Regulated Disposal)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
BRC "SURROGATES"			
P-COTRASH	52.48	1.7786	29.51
P-CONDRSN	11.48	0.0003	33,804.99
L-WASTOIL	9.22	0.0000	465,672.61
B-COTRASH	58.65	0.9922	59.11
I-COTRASH	36.74	164.8216	0.22
I-BIOWAST	3.26	8.2034	0.40
I-ABSLIQD	6.87	9.8090	0.70
I-LQSCNVL	9.29	0.4071	22.81
N-SSTRASH	38.95	0.0001	679,480.50
N-SSWASTE	6.87	0.0002	34,979.11
N-LOTRASH	18.00	19.1937	0.94
N-LOWASTE	10.70	6.2267	1.72
F-PROCESS	13.98	0.0010	13,502.29
U-PROCESS	7.42	0.0006	12,120.97
F-COTRASH	42.21	0.0001	287,303.83
F-NCTRASH	10.88	0.0000	438,715.53
CONSUMER			
C-SMOKDET	329.74	0.0078	42,533.16
C-TIMEPCS	212.28	7.1994	29.49
BIOMED			
BIOMED	156.14	12.291	12.70
NARM			
R-GLASDS1	2615.09	0.4294	6,089.58
R-GLASDS2	0.01	0.0001	104.29
R-INSTDF1	266.77	0.0697	3,828.77
R-INSTDF2	0.03	0.0000	1,081.88
R-RAIXRSN	9.99	0.1756	56.85
R-RASOURC	1.33	1.2283	1.08
TOTAL	3,928.35	232.84	16.87

NOTES: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD, As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Unregulated disposal is represented by a weighted average of MD, SF, SI, UF and UI disposal practices (weighting depends on waste type). Unregulated disposal for BIOMED waste is represented by the LURO option. Note that consumer, BIOMED and NARM wastes are currently unregulated. N.A.= Waste not generated in this region.

September 1987

TABLE F-3

COST EFFECTIVENESS OF REGULATION
ARID PERMEABLE REGION
(Unregulated versus Regulated Disposal)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
BRC "SURROGATES"			
P-COTRASH	20.47	0.4996	40.96
P-CONDRSN	4.19	0.0001	59,422.31
L-WASTOIL	1.41	0.0000	267,766.68
B-COTRASH	3.30	0.0518	63.69
I-COTRASH	24.18	52.5276	0.46
I-BIOWAST	2.15	2.6925	0.80
I-ABSLIQD	4.52	3.2217	1.40
I-LQSCNVL	6.11	0.1336	45.74
N-SSTRASH	23.27	0.0001	294,729.12
N-SSWASTE	4.11	0.0003	15,162.85
N-LOTRASH	6.57	2.2650	2.90
N-LOWASTE	3.90	0.7675	5.09
F-PROCESS	5.80	0.0008	6,898.82
U-PROCESS	0.00	0.0000	N.A.
F-COTRASH	17.49	0.0002	107,396.90
F-NCTRASH	4.51	0.0000	163,600.64
CONSUMER			
C-SMOKDET	176.48	0.0158	11,174.26
C-TIMEPCS	113.61	0.0010	112,500.38
BIOMED			
BIOMED	102.96	-0.6625	(155.41)
NARM			
R-GLASDS1	1399.62	2.0946	668.20
R-GLASDS2	0.00	0.0001	47.16
R-INSTDF1	131.95	0.0880	1,498.92
R-INSTDF2	0.01	0.0000	424.24
R-RAIXRSN	5.34	0.1444	37.01
R-RASOURC	0.55	1.2472	0.44
TOTAL	2,062.51	65.09	31.69

NOTES: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD, As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Unregulated disposal is represented by a weighted average of MD, SF, SI, UF and UI disposal practices (weighting depends on waste type). Unregulated disposal for BIOMED waste is represented by the LURO option. Note that consumer, BIOMED and NARM wastes are currently unregulated. N.A.= Waste not generated in this region.

September 1987

TABLE F-4

COST EFFECTIVENESS OF REGULATION
TOTAL U.S.
(Unregulated versus Regulated Disposal)

BRC CANDIDATE	INCREMENTAL COST ($ MILLIONS)	AVOIDED HEALTH EFFECTS	COST-EFFECTIVENESS RATIO ($ MILLIONS PER AVOIDED HEALTH EFFECT)
BRC "SURROGATES"			
P-COTRASH	92.00	2.5123	36.62
P-CONDRSN	19.40	0.0006	30,355.21
L-WASTOIL	15.47	0.0000	324,000.67
B-COTRASH	115.21	1.5865	72.62
I-COTRASH	97.69	217.8682	0.45
I-BIOWAST	8.68	10.9363	0.79
I-ABSLIQD	18.26	13.0951	1.39
I-LQSCNVL	24.69	0.5432	45.45
N-SSTRASH	124.66	0.0009	141,876.80
N-SSWASTE	22.00	0.0030	7,280.47
N-LOTRASH	35.19	21.5236	1.63
N-LOWASTE	20.91	7.0272	2.98
F-PROCESS	20.62	0.0021	9,637.63
U-PROCESS	7.42	0.0006	12,120.97
F-COTRASH	62.25	0.0004	177,518.38
F-NCTRASH	16.04	0.0001	270,639.87
CONSUMER			
C-SMOKDET	669.32	1.1323	591.14
C-TIMEPCS	430.91	7.2886	59.12
BIOMED			
BIOMED	415.24	11.4235	36.35
NARM			
R-GLASDS1	5308.26	3.8008	1,396.62
R-GLASDS2	0.01	0.0004	28.43
R-INSTDF1	541.50	1.6729	323.69
R-INSTDF2	0.05	0.0006	91.17
R-RAIXRSN	20.27	3.7085	5.47
R-RASOURC	3.28	66.6874	0.05
TOTAL	8,089.33	370.8151	21.82

NOTES: Costs represent present values at a 10 percent real discount rate, expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Regulated disposal is SLD, As Generated, except for P-CONDRSN (SLD Solidified) and R-RAIXRSN and R-RASOURC (both ISD Solidified). Unregulated disposal is represented by a weighted average of MD, SF, SI, UF and UI disposal practices (weighting depends on waste type). Unregulated disposal for BIOMED waste is represented by the LURO option. Note that consumer, BIOMED and NARM wastes are currently unregulated. N.A.= Waste not generated in this region.

September 1987

TABLE F-5

TOTAL HEALTH EFFECTS AND COSTS FOR ALTERNATIVE DISPOSAL METHODS
HUMID IMPERMEABLE REGION

TOTAL HEALTH EFFECTS

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-RAIKRSH	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	0.0132	0.0000	67.5900	4.3761	1.4397	0.4124
SLF	13.9025	77.8016	6.7655	98.4696	0.0415	NA	NA	59.2873	NA	NA	NA
SLD	3.6185	10.1444	0.4073	14.1702	0.0060	NA	NA	21.3325	NA	NA	NA
10CFR61	3.6185	7.2959	0.0011	10.9155	0.0046	0.0068	0.0000	0.0006	1.5834	0.2428	0.6184
IDO	1.9865	1.7075	0.0008	3.6948	0.0016	NA	NA	0.0004	NA	NA	NA
CC	0.3742	0.9693	0.0004	1.3439	0.0006	NA	NA	0.0002	NA	NA	NA
SLD1	3.6185	7.2959	0.0036	10.9180	0.0046	NA	NA	0.0767	NA	NA	NA
SLD/ISD	3.6185	10.1444	0.1180	13.8809	0.0058	NA	NA	6.8512	NA	NA	NA
SLD/ISD2	5.8484	16.5956	0.1075	22.5515	0.0095	NA	NA	6.6305	NA	NA	NA
SLD/ISD3	3.6185	16.5956	0.0011	20.2152	0.0085	NA	NA	0.0006	NA	NA	NA
SLD/ISD4	3.6185	6.6818	0.1180	10.4183	0.0044	NA	NA	6.8512	NA	NA	NA
SLD2	1.8270	1.8572	0.0033	3.6875	0.0016	NA	NA	20.1336	NA	NA	NA
SLD/ISD5	1.8270	1.8572	0.0009	3.6851	0.0016	NA	NA	6.4676	NA	NA	NA
ISD	2.3286	2.4171	0.0011	4.7468	0.0020	NA	NA	0.0006	NA	NA	NA
ENCB	1.6881	0.8357	0.0004	2.5242	0.0011	NA	NA	0.0220	NA	NA	NA
DWI (5)	3.4518	7.2959	0.0011	10.7488	0.0045	NA	NA	0.0006	NA	NA	NA
NF (5)	2.9020	5.5717	0.0011	8.4748	0.0036	NA	NA	0.0005	NA	NA	NA
DGD	0.0333	0.0870	0.0000	0.1203	0.0001	NA	NA	0.0000	NA	NA	NA

TOTAL COSTS DISCOUNTED @ 10%
(IN MILLIONS OF DOLLARS)

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-IXRESIN	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	1.54	0.00	0.01	0.10	0.16	0.66
SLF	249.84	76.85	1.24	327.93	0.08	NA	NA	1.58	NA	NA	NA
SLD	291.27	83.38	1.42	376.06	0.10	NA	NA	1.72	NA	NA	NA
10CFR61	291.27	255.13	6.47	552.87	0.16	96.93	0.03	6.36	1,436.40	268.28	156.80
IDO	381.89	282.77	6.07	670.73	0.21	NA	NA	6.03	NA	NA	NA
CC	1,262.23	267.12	5.63	1,534.98	0.54	NA	NA	5.68	NA	NA	NA
SLD1	291.27	255.13	5.30	551.70	0.16	NA	NA	5.41	NA	NA	NA
SLD/ISD	291.27	83.38	2.00	376.65	0.10	NA	NA	2.19	NA	NA	NA
SLD/ISD2	938.47	147.77	3.75	1,089.98	0.40	NA	NA	3.60	NA	NA	NA
SLD/ISD3	291.27	147.77	6.47	445.50	0.13	NA	NA	6.36	NA	NA	NA
SLD/ISD4	291.27	105.01	2.00	398.28	0.11	NA	NA	2.19	NA	NA	NA
SLD2	721.49	138.43	3.16	863.08	0.33	NA	NA	1.47	NA	NA	NA
SLD/ISD5	721.49	138.43	3.28	863.20	0.33	NA	NA	1.63	NA	NA	NA
ISD	428.66	297.02	6.47	732.16	0.23	NA	NA	6.36	NA	NA	NA
ENCB	1,251.75	552.36	13.62	1,817.73	0.66	NA	NA	12.12	NA	NA	NA
DWI (5)	0.00	0.00	0.00	711.57	0.24	NA	NA	5.76	NA	NA	NA
NF (5)	0.00	0.00	0.00	552.27	0.18	NA	NA	3.72	NA	NA	NA
DGD	1,819.17	526.54	8.54	2,354.25	0.88	NA	NA	10.92	NA	NA	NA

NOTES:

(1) Class A waste excludes L-WASTOIL
(2) Class B waste excludes P-CONDRSH
(3) LLW equals A + B + C
(4) Includes F-COTRASH, F-NCTRASH, F-PROCESS, U-PROCESS, N-SSTRASH, N-SSWASTE, I-LIQSCVL, L-WASTOIL, & P-CONDRSH
(5) Since this technology is applicable to the disposal of liquid wastes only, 10 CFR 61 disposal (i.e., current practice) is assumed for the other wastes.

KEY TO DISPOSAL METHODS:

	A	B	C & NARM
UNREGUL	(AVG OF 5 UNREGULATED OPTIONS)		
SLF	AG	AG	AG
SLD	AG	AG	AG
10CFR61	SLD:AG	SLD:S	ISD:S
IDO	AG	S	S
CC	S	S	S
SLD1	AG	S	S
SLD/ISD	SLD:AG	SLD:AG	ISD:AG
SLD/ISD2	SLD:HIC	SLD:HIC	ISD:HIC

	A	B	C & NARM
SLD/ISD3	SLD:AG	SLD:HIC	ISD:S
SLD/ISD4	SLD:AG	ISD:AG	ISD:AG
SLD2	I/AG	I/S	I/S*
SLD/ISD5	SLD:I/AG	SLD:I/S	ISD:I/S*
ISD	AG	S	S
ENCB	EN:S	CB:S	CB:S
DWI	AG	AG	AG
NF	AG	AG	AG
DGD	S	S	S

*NARM WASTE FORM IS ALWAYS AS IS

AG = AS GENERATED
S = SOLIDIFIED
HIC = HIGH INTEGRITY CONTAINER
I = INCINERATED

TABLE F-6

TOTAL HEALTH EFFECTS AND COSTS FOR ALTERNATIVE DISPOSAL METHODS
HUMID PERMEABLE REGION

TOTAL HEALTH EFFECTS

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-RAIXRSN	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	0.4205	0.0002	1.5650	0.4992	7.2331	13.7974
SLF	10.1240	11.8691	0.3202	22.3133	11.9993	NA	NA	1.3439	NA	NA	NA
SLD	8.6499	6.6001	0.0168	15.2668	8.2100	NA	NA	0.1865	NA	NA	NA
10CFR61	8.6499	4.6734	0.0084	13.3317	7.1693	0.0109	0.0059	0.1566	0.0000	0.0260	1.5064
IDD	8.1737	3.6710	0.0084	11.8531	6.3742	NA	NA	0.1515	NA	NA	NA
CC	3.3211	2.2501	0.0047	5.5759	2.9985	NA	NA	0.0055	NA	NA	NA
SLD1	8.6499	4.6734	0.0108	13.3341	7.1706	NA	NA	0.1761	NA	NA	NA
SLD/ISD	8.6499	6.6001	0.0150	15.2650	8.2090	NA	NA	0.1180	NA	NA	NA
SLD/ISD2	8.1972	6.3628	0.0140	14.5740	7.8374	NA	NA	0.1542	NA	NA	NA
SLD/ISD3	8.6499	6.3628	0.0084	15.0211	8.0778	NA	NA	0.1566	NA	NA	NA
SLD/ISD4	8.6499	6.4672	0.0150	15.1321	8.1375	NA	NA	0.1180	NA	NA	NA
SLD2	4.2142	1.2778	0.0097	5.5017	2.9586	NA	NA	0.1516	NA	NA	NA
SLD/ISD5	4.2142	1.2778	0.0074	5.4994	2.9574	NA	NA	0.0958	NA	NA	NA
ISD	8.2256	3.6644	0.0084	11.8984	6.3986	NA	NA	0.1566	NA	NA	NA
EMCB	6.4942	1.3473	0.0028	7.8443	4.2184	NA	NA	0.0726	NA	NA	NA
DWI (5)	8.3040	4.6734	0.0084	12.9858	6.9833	NA	NA	0.1566	NA	NA	NA
HF (5)	7.1798	0.8620	0.0084	8.0502	4.3291	NA	NA	0.1271	NA	NA	NA
DGD	0.0448	0.0327	0.0001	0.0776	0.0417	NA	NA	0.0000	NA	NA	NA

TOTAL COSTS DISCOUNTED @ 10%
(IN MILLIONS OF DOLLARS)

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-IXRESIN	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	2.33	1.26	0.02	0.20	0.33	0.66
SLF	434.98	88.30	2.22	525.51	166.48	NA	NA	2.86	NA	NA	NA
SLD	501.87	95.66	2.54	600.07	206.58	NA	NA	3.11	NA	NA	NA
10CFR61	501.87	293.91	11.65	807.43	289.35	152.63	65.27	11.34	2,882.10	542.35	156.80
IDD	648.20	326.02	10.93	985.14	384.92	NA	NA	10.78	NA	NA	NA
CC	2,100.10	307.84	10.13	2,418.07	1,071.57	NA	NA	10.16	NA	NA	NA
SLD1	501.87	293.91	9.53	805.31	288.21	NA	NA	9.69	NA	NA	NA
SLD/ISD	501.87	95.66	3.60	601.13	207.15	NA	NA	3.94	NA	NA	NA
SLD/ISD2	1,518.35	168.26	6.75	1,693.36	794.52	NA	NA	6.40	NA	NA	NA
SLD/ISD3	501.87	168.26	11.65	681.78	250.52	NA	NA	11.34	NA	NA	NA
SLD/ISD4	501.87	120.06	3.60	625.53	220.27	NA	NA	3.94	NA	NA	NA
SLD2	1,118.02	157.90	5.66	1,281.58	608.71	NA	NA	2.60	NA	NA	NA
SLD/ISD5	1,118.02	157.90	5.86	1,281.78	608.82	NA	NA	2.80	NA	NA	NA
ISD	723.72	342.60	11.65	1,077.97	434.84	NA	NA	11.34	NA	NA	NA
EMCB	2,083.02	639.35	24.55	2,746.92	1,248.41	NA	NA	21.41	NA	NA	NA
DWI (5)	0.00	0.00	0.00	1,202.62	530.61	NA	NA	10.18	NA	NA	NA
HF (5)	0.00	0.00	0.00	906 69	371.47	NA	NA	6.61	NA	NA	NA
DGD	3,128.53	613.84	15.30	3,757.68	1,791.97	NA	NA	19.89	NA	NA	NA

NOTES:

(1) Class A waste excludes L-WASTOIL
(2) Class B waste excludes P-CONDRSN
(3) LLW equals A + B + C
(4) Includes F-COTRASH, F-NCTRASH, F-PROCESS, U-PROCESS, N-SSTRASH, N-SSWASTE, I-LIQSCVL, L-WASTOIL, & P-CONDRSN
(5) Since this technology is applicable to the disposal of liquid wastes only, 10 CFR 61 disposal (i.e., current practice) is assumed for the other wastes.

KEY TO DISPOSAL METHODS:

	A	B	C & NARM
UNREGUL	(AVG OF 5 UNREGULATED OPTIONS)		
SLF	AG	AG	AG
SLD	AG	AG	AG
10CFR61	SLD:AG	SLD:S	ISD:S
IDD	AG	S	S
CC	S	S	S
SLD1	AG	S	S
SLD/ISD	SLD:AG	SLD:AG	ISD:AG
SLD/ISD2	SLD:HIC	SLD:HIC	ISD:HIC

	A	B	C & NARM
SLD/ISD3	SLD:AG	SLD:HIC	ISD:S
SLD/ISD4	SLD:AG	ISD:AG	ISD:AG
SLD2	I/AG	I/S	I/S*
SLD/ISD5	SLD:I/AG	SLD:I/S	ISD:I/S*
ISD	AG	S	S
EMCB	EM:S	CB:S	CB:S
DWI	AG	AG	AG
HF	AG	AG	AG
DGD	S	S	S

*NARM WASTE FORM IS ALWAYS AS IS

AG = AS GENERATED
S = SOLIDIFIED
HIC = HIGH INTEGRITY CONTAINER
I = INCINERATED

TABLE F-7

TOTAL HEALTH EFFECTS AND COSTS FOR ALTERNATIVE DISPOSAL METHODS
ARID PERMEABLE REGION

TOTAL HEALTH EFFECTS

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-RAIXRSN	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	0.1409	0.0001	1.3960	2.1827	0.0168	0.1374
SLF	3.5438	2.0229	0.0487	5.6154	11.8351	NA	NA	0.1434	NA	NA	NA
SLD	3.2144	1.8194	0.0037	5.0375	10.6171	NA	NA	0.0275	NA	NA	NA
10CFR61	3.2144	0.7185	0.0012	3.9341	8.2916	0.0058	0.0122	0.0069	0.0000	0.0000	0.7989
IDO	2.5989	0.0000	0.0000	2.5989	5.4775	NA	NA	0.0058	NA	NA	NA
CC	0.2911	0.1524	0.0005	0.4440	0.9358	NA	NA	0.0006	NA	NA	NA
SLD1	3.2144	0.7185	0.0022	3.9351	8.2937	NA	NA	0.0277	NA	NA	NA
SLD/ISD	3.2144	1.8194	0.0028	5.0366	10.6152	NA	NA	0.0066	NA	NA	NA
SLD/ISD2	3.1609	1.7944	0.0027	4.9580	10.4496	NA	NA	0.0064	NA	NA	NA
SLD/ISD3	3.2144	1.7944	0.0012	5.0100	10.5592	NA	NA	0.0069	NA	NA	NA
SLD/ISD4	3.2144	1.5864	0.0028	4.8036	10.1241	NA	NA	0.0066	NA	NA	NA
SLD2	0.8223	0.1903	0.0014	1.0140	2.1371	NA	NA	0.0212	NA	NA	NA
SLD/ISD5	0.8223	0.1903	0.0008	1.0134	2.1359	NA	NA	0.0051	NA	NA	NA
ISD	2.7180	0.3888	0.0012	3.1080	6.5505	NA	NA	0.0069	NA	NA	NA
EMCB	1.2889	0.0778	0.0002	1.3669	2.8809	NA	NA	0.0247	NA	NA	NA
DWI (5)	3.2166	0.7185	0.0012	3.9363	8.2962	NA	NA	0.0069	NA	NA	NA
HF (5)	2.8838	0.2654	0.0012	3.1506	6.6403	NA	NA	0.0053	NA	NA	NA
DGD	0.0214	0.0117	0.0000	0.0331	0.0698	NA	NA	0.0000	NA	NA	NA

TOTAL COSTS DISCOUNTED @ 10%
(IN MILLIONS OF DOLLARS)

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-IXRESIN	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	1.05	2.22	0.01	0.11	0.18	0.44
SLF	128.44	15.22	2.26	165.92	191.57	NA	NA	1.50	NA	NA	NA
SLD	149.02	16.50	2.61	168.13	238.36	NA	NA	1.63	NA	NA	NA
10CFR61	149.02	50.63	12.38	212.04	310.37	67.93	115.74	5.91	1,531.70	290.27	103.40
IDO	194.03	56.16	11.60	261.78	415.21	NA	NA	5.62	NA	NA	NA
CC	628.40	53.03	10.74	692.16	1,233.47	NA	NA	5.30	NA	NA	NA
SLD1	149.02	50.63	10.08	209.73	305.50	NA	NA	5.05	NA	NA	NA
SLD/ISD	149.02	16.50	3.76	169.28	240.79	NA	NA	2.06	NA	NA	NA
SLD/ISD2	518.54	29.07	7.20	554.80	1,053.32	NA	NA	3.33	NA	NA	NA
SLD/ISD3	149.02	29.07	12.38	190.47	284.13	NA	NA	5.91	NA	NA	NA
SLD/ISD4	149.02	20.72	3.76	173.50	249.70	NA	NA	2.06	NA	NA	NA
SLD2	389.89	25.01	5.88	420.78	807.97	NA	NA	1.36	NA	NA	NA
SLD/ISD5	389.89	25.01	6.00	420.90	808.22	NA	NA	1.45	NA	NA	NA
ISD	217.27	59.01	12.38	288.65	471.85	NA	NA	5.91	NA	NA	NA
EMCB	623.24	110.03	26.44	759.71	1,375.84	NA	NA	11.14	NA	NA	NA
DWI (5)	0.00	0.00	0.00	310.51	538.45	NA	NA	5.29	NA	NA	NA
HF (5)	0.00	0.00	0.00	244.85	400.07	NA	NA	3.45	NA	NA	NA
DGD	916.91	105.46	15.48	1,037.85	1,962.05	NA	NA	10.42	NA	NA	NA

NOTES:

(1) Class A waste excludes L-WASTOIL
(2) Class B waste excludes P-CONDRSN
(3) LLW equals A + B + C
(4) Includes F-COTRASH, F-NCTRASH, F-PROCESS, U-PROCESS, N-SSTRASH, N-SSWASTE, I-LIQSCVL, L-WASTOIL, & P-CONDRSN
(5) Since this technology is applicable to the disposal of liquid wastes only, 10 CFR 61 disposal (i.e., current practice) is assumed for the other wastes.

KEY TO DISPOSAL METHODS:

	A	B	C & NARM
UNREGUL	(AVG OF 5 UNREGULATED OPTIONS)		
SLF	AG	AG	AG
SLD	AG	AG	AG
10CFR61	SLD:AG	SLD:S	ISD:S
IDO	AG	S	S
CC	S	S	S
SLD1	AG	S	S
SLD/ISD	SLD:AG	SLD:AG	ISD:AG
SLD/ISD2	SLD:HIC	SLD:HIC	ISD:HIC
SLD/ISD3	SLD:AG	SLD:HIC	ISD:S
SLD/ISD4	SLD:AG	ISD:AG	ISD:AG
SLD2	I/AG	I/S	I/S*
SLD/ISD5	SLD:I/AG	SLD:I/S	ISD:I/S*
ISD	AG	S	S
EMCB	EM:S	CB:S	CB:S
DWI	AG	AG	AG
HF	AG	AG	AG
DGD	S	S	S

*NARM WASTE FORM IS ALWAYS AS IS

AG = AS GENERATED
S = SOLIDIFIED
HIC = HIGH INTEGRITY CONTAINER
I = INCINERATED

TABLE F 8

TOTAL HEALTH EFFECTS AND COSTS FOR ALTERNATIVE DISPOSAL METHODS
TOTAL U.S.

TOTAL HEALTH EFFECTS

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-RAIXRSN	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	0.5745	0.0002	70.5510	7.0580	8.6896	16.3472
SLF	27.5703	91.6936	7.1344	126.3983	23.8759	NA	NA	60.7746	NA	NA	NA
SLD	15.4828	18.5639	0.4278	34.4745	18.8331	NA	NA	21.5465	NA	NA	NA
10CFR61	15.4828	12.6878	0.0107	28.1813	15.4655	0.0235	0.0181	0.1641	1.5834	0.2688	2.9237
IDD	12.7591	5.3785	0.0092	18.1468	11.8532	NA	NA	0.1577	NA	NA	NA
CC	3.9864	3.3718	0.0056	7.3638	3.9349	NA	NA	0.0063	NA	NA	NA
SLD1	15.4828	12.6878	0.0166	28.1872	15.4689	NA	NA	0.2805	NA	NA	NA
SLD/ISD	15.4828	18.5639	0.1358	34.1825	18.8301	NA	NA	6.9758	NA	NA	NA
SLD/ISD2	17.2065	24.7528	0.1242	42.0835	18.2965	NA	NA	6.7911	NA	NA	NA
SLD/ISD3	15.4828	24.7528	0.0107	40.2463	18.6455	NA	NA	0.1641	NA	NA	NA
SLD/ISD4	15.4828	14.7354	0.1358	30.3540	18.2661	NA	NA	6.9758	NA	NA	NA
SLD2	6.8635	3.3253	0.0144	10.2032	5.0973	NA	NA	20.3062	NA	NA	NA
SLD/ISD5	6.8635	3.3253	0.0091	10.1979	5.0948	NA	NA	6.5685	NA	NA	NA
ISD	13.2722	6.4703	0.0107	19.7532	12.9518	NA	NA	0.1641	NA	NA	NA
EMCB	9.4712	2.2608	0.0034	11.7354	7.1006	NA	NA	0.1193	NA	NA	NA
DWI (5)	14.9726	12.6878	0.0107	27.6709	15.2841	NA	NA	0.1641	NA	NA	NA
HF (5)	12.9656	6.6993	0.0107	19.6756	10.9730	NA	NA	0.1329	NA	NA	NA
DGD	0.0995	0.1314	0.0001	0.2310	0.1115	NA	NA	0.0000	NA	NA	NA

TOTAL COSTS DISCOUNTED @ 10%
(IN MILLIONS OF DOLLARS)

	A (1)	B (2)	C	LLW (3)	DOE	BRC (4)	DOE/BRC	R-RASOURC R-IXRESIN	OTHER NARM	C-TIMEPCS C-SMOKDET	BIOMED WASTE
UNREGUL	NA	NA	NA	NA	NA	4.93	3.48	0.05	0.41	0.68	1.76
SLF	813.25	180.38	5.72	999.36	358.13	NA	NA	5.94	NA	NA	NA
SLD	942.16	195.54	6.57	1,144.26	445.05	NA	NA	6.46	NA	NA	NA
10CFR61	942.16	599.68	30.50	1,572.34	599.87	317.49	181.04	23.60	5,850.20	1,100.90	417.00
IDD	1,224.11	664.94	28.59	1,917.65	800.34	NA	NA	22.43	NA	NA	NA
CC	3,990.73	627.98	26.50	4,645.21	2,305.58	NA	NA	21.16	NA	NA	NA
SLD1	942.16	599.68	24.90	1,566.74	593.87	NA	NA	20.15	NA	NA	NA
SLD/ISD	942.16	195.54	9.37	1,147.06	448.05	NA	NA	8.19	NA	NA	NA
SLD/ISD2	2,975.36	345.09	17.69	3,338.15	1,848.25	NA	NA	13.33	NA	NA	NA
SLD/ISD3	942.16	345.09	30.50	1,317.75	534.78	NA	NA	23.60	NA	NA	NA
SLD/ISD4	942.16	245.79	9.37	1,197.32	470.08	NA	NA	8.19	NA	NA	NA
SLD2	2,229.40	321.34	14.69	2,565.44	1,417.01	NA	NA	5.43	NA	NA	NA
SLD/ISD5	2,229.40	321.34	15.14	2,565.88	1,417.38	NA	NA	5.87	NA	NA	NA
ISD	1,369.65	698.63	30.50	2,098.78	906.92	NA	NA	23.60	NA	NA	NA
EMCB	3,958.00	1,301.74	64.62	5,324.36	2,624.92	NA	NA	44.67	NA	NA	NA
DWI (5)	0.00	0.00	0.00	2,224.71	1,069.31	NA	NA	21.23	NA	NA	NA
HF (5)	0.00	0.00	0.00	1,703.81	771.72	NA	NA	13.78	NA	NA	NA
DGD	5,864.61	1,245.84	39.33	7,149.78	3,754.90	NA	NA	41.22	NA	NA	NA

NOTES:

(1) Class A waste excludes L-WASTOIL
(2) Class B waste excludes P-CONDRSN
(3) LLW equals A + B + C
(4) Includes F-COTRASH, F-NCTRASH, F-PROCESS, U-PROCESS, N-SSTRASH, N-SSWASTE, I-LIQSCVL, L-WASTOIL, & P-CONDRSN
(5) Since this technology is applicable to the disposal of liquid wastes only, 10 CFR 61 disposal (i.e., current practice) is assumed for the other wastes.

KEY TO DISPOSAL METHODS:

	A	B	C & NARM
UNREGUL	(AVG OF 5 UNREGULATED OPTIONS)		
SLF	AG	AG	AG
SLD	AG	AG	AG
10CFR61	SLD:AG	SLD:S	ISD:S
IDD	AG	S	S
CC	S	S	S
SLD1	AG	S	S
SLD/ISD	SLD:AG	SLD:AG	ISD:AG
SLD/ISD2	SLD:HIC	SLD:HIC	ISD:HIC

	A	B	C & NARM
SLD/ISD3	SLD:AG	SLD:HIC	ISD:S
SLD/ISD4	SLD:AG	ISD:AG	ISD:AG
SLD2	I/AG	I/S	I/S*
SLD/ISD5	SLD:I/AG	SLD:I/S	ISD:I/S*
ISD	AG	S	S
EMCB	EM:S	CB:S	CB:S
DWI	AG	AG	AG
HF	AG	AG	AG
DGD	S	S	S

*NARM WASTE FORM IS ALWAYS AS IS

AG = AS GENERATED
S = SOLIDIFIED

TABLE F-9

HEALTH EFFECTS AND DISPOSAL COSTS FOR
UNREGULATED SUBURBAN SANITARY LANDFILL, WITHOUT INCINERATION
(PER CUBIC METER)

WASTE	HUMID IMPERMEABLE UNIT HEALTH EFFECTS	HUMID IMPERMEABLE UNIT DISPOSAL COST	HUMID PERMEABLE UNIT HEALTH EFFECTS	HUMID PERMEABLE UNIT DISPOSAL COST	ARID PERMEABLE UNIT HEALTH EFFECTS	ARID PERMEABLE UNIT DISPOSAL COST
P-COTRASH	3.68E-06	14.78	1.20E-05	14.78	1.34E-06	14.78
P-CONDRSN	1.35E-07	14.78	6.37E-08	14.78	3.71E-11	14.78
L-WASTOIL	2.64E-09	14.78	9.42E-10	14.78	4.52E-15	14.78
B-COTRASH	2.91E-06	14.78	5.01E-06	14.78	8.50E-07	14.78
I-COTRASH	3.32E-05	14.78	1.47E-03	14.78	9.30E-06	14.78
I-BIOWAST	7.38E-05	14.78	2.45E-03	14.78	6.36E-06	14.78
I-ABSLIQD	6.28E-05	14.78	1.97E-03	14.78	5.13E-06	14.78
I-LQSCNVL	1.83E-06	14.78	6.08E-05	14.78	1.58E-07	14.78
N-SSTRASH	4.45E-09	14.78	3.06E-10	14.78	7.17E-10	14.78
N-SSWASTE	8.65E-08	14.78	5.93E-09	14.78	1.39E-08	14.78
N-LOTRASH	1.03E-05	14.78	4.60E-04	14.78	2.90E-06	14.78
N-LOWASTE	6.96E-06	14.78	2.27E-04	14.78	5.89E-07	14.78
F-PROCESS	2.48E-07	14.78	2.64E-08	14.78	2.55E-12	14.78
U-PROCESS	2.91E-07	14.78	3.12E-08	14.78	2.32E-12	14.78
F-COTRASH	1.28E-08	14.78	8.71E-10	14.78	2.72E-09	14.78
F-NCTRASH	1.22E-08	14.78	8.32E-10	14.78	2.59E-09	14.78
C-SMOKDET	3.82E-05	14.78	1.66E-07	14.78	3.12E-07	14.78
C-TIMEPCS	2.36E-05	14.78	1.40E-03	14.78	7.35E-09	14.78
R-GLASDS1	1.19E-04	14.78	6.02E-06	14.78	6.71E-05	14.78
R-GLASDS2	2.41E-05	14.78	1.66E-06	14.78	3.44E-06	14.78
R-INSTDF1	1.22E-03	14.78	2.52E-05	14.78	3.47E-05	14.78
R-INSTDF2	1.39E-05	14.78	2.87E-07	14.78	3.94E-07	14.78
R-RAIXRSN	1.86E-03	14.78	6.98E-05	14.78	7.58E-06	14.78
R-RASOURC	2.61E+02	14.78	9.09E+00	14.78	5.89E-01	14.78

September 1987

TABLE F-10

HEALTH EFFECTS AND DISPOSAL COSTS FOR
UNREGULATED SUBURBAN SANITARY LANDFILL, WITH INCINERATION
(PER CUBIC METER)

	HUMID IMPERMEABLE		HUMID PERMEABLE		ARID PERMEABLE	
WASTE	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST
P-COTRASH	3.80E-06	16.27	6.50E-06	16.27	2.09E-06	16.27
P-CONDRSN	1.34E-07	16.27	5.79E-08	16.27	3.95E-08	16.27
L-WASTOIL	2.97E-09	16.27	1.41E-09	16.27	2.97E-09	16.27
B-COTRASH	3.03E-06	16.27	4.30E-06	16.27	1.25E-06	16.27
I-COTRASH	9.84E-06	16.27	3.77E-04	16.27	3.45E-06	16.27
I-BIOWAST	1.87E-05	16.27	7.22E-04	16.27	5.97E-06	16.27
I-ABSLIQD	1.85E-05	16.27	5.85E-04	16.27	6.83E-06	16.27
I-LQSCNVL	4.53E-07	16.27	1.79E-05	16.27	1.17E-07	16.27
N-SSTRASH	4.59E-09	16.27	6.10E-10	16.27	1.01E-09	16.27
N-SSWASTE	8.94E-08	16.27	1.19E-08	16.27	1.96E-08	16.27
N-LOTRASH	3.07E-06	16.27	1.17E-04	16.27	1.08E-06	16.27
N-LOWASTE	1.86E-06	16.27	6.70E-05	16.27	6.28E-07	16.27
F-PROCESS	2.57E-07	16.27	3.56E-08	16.27	7.27E-08	16.27
U-PROCESS	3.01E-07	16.27	4.07E-08	16.27	7.39E-08	16.27
F-COTRASH	1.32E-08	16.27	1.83E-09	16.27	3.74E-09	16.27
F-NCTRASH	1.27E-08	16.27	1.75E-09	16.27	3.58E-09	16.27
C-SMOKDET	3.59E-05	16.27	2.65E-07	16.27	4.25E-07	16.27
C-TIMEPCS	6.64E-06	16.27	2.24E-04	16.27	4.48E-07	16.27
R-GLASDS1	1.23E-04	16.27	1.30E-05	16.27	8.46E-05	16.27
R-GLASDS2	2.49E-05	16.27	3.33E-06	16.27	4.94E-06	16.27
R-INSTDF1	1.15E-03	16.27	2.73E-05	16.27	4.37E-05	16.27
R-INSTDF2	1.31E-05	16.27	3.11E-07	16.27	4.97E-07	16.27
R-RAIXRSN	1.75E-03	16.27	5.74E-05	16.27	7.96E-05	16.27
R-RASOURC	2.47E+02	16.27	7.04E+00	16.27	1.17E+01	16.27

TABLE F-11

HEALTH EFFECTS AND DISPOSAL COSTS FOR
UNREGULATED URBAN SANITARY LANDFILL, WITHOUT INCINERATION
(PER CUBIC METER)

WASTE	HUMID IMPERMEABLE UNIT HEALTH EFFECTS	HUMID IMPERMEABLE UNIT DISPOSAL COST	HUMID PERMEABLE UNIT HEALTH EFFECTS	HUMID PERMEABLE UNIT DISPOSAL COST	ARID PERMEABLE UNIT HEALTH EFFECTS	ARID PERMEABLE UNIT DISPOSAL COST
P-COTRASH	5.35E-06	14.78	2.89E-05	14.78	3.40E-05	14.78
P-CONDRSH	1.72E-07	14.78	9.35E-08	14.78	1.09E-07	14.78
L-WASTOIL	3.55E-09	14.78	9.55E-10	14.78	4.81E-09	14.78
B-COTRASH	3.78E-06	14.78	1.11E-05	14.78	1.91E-05	14.78
I-COTRASH	3.66E-05	14.78	3.77E-03	14.78	2.63E-03	14.78
I-BIOWAST	6.75E-05	14.78	7.25E-03	14.78	5.07E-03	14.78
I-ABSLIQD	5.86E-05	14.78	5.86E-03	14.78	4.09E-03	14.78
I-LQSCNVL	1.88E-06	14.78	1.80E-04	14.78	1.26E-04	14.78
N-SSTRASH	1.39E-08	14.78	3.27E-10	14.78	2.04E-09	14.78
N-SSWASTE	2.71E-07	14.78	6.35E-09	14.78	3.96E-08	14.78
N-LOTRASH	1.14E-05	14.78	1.18E-03	14.78	8.21E-04	14.78
N-LOWASTE	6.44E-06	14.78	6.71E-04	14.78	4.70E-04	14.78
F-PROCESS	7.71E-07	14.78	1.83E-08	14.78	1.50E-07	14.78
U-PROCESS	9.08E-07	14.78	2.13E-08	14.78	1.50E-07	14.78
F-COTRASH	3.95E-08	14.78	9.40E-10	14.78	7.71E-09	14.78
F-NCTRASH	3.78E-08	14.78	8.98E-10	14.78	7.37E-09	14.78
C-SMOKDET	8.93E-05	14.78	1.74E-07	14.78	8.72E-07	14.78
C-TIMEPCS	8.84E-05	14.78	3.59E-03	14.78	1.53E-07	14.78
R-GLASDS1	2.01E-04	14.78	6.83E-06	14.78	1.92E-04	14.78
R-GLASDS2	7.55E-05	14.78	1.77E-06	14.78	9.78E-06	14.78
R-INSTDF1	2.19E-03	14.78	2.53E-05	14.78	9.85E-05	14.78
R-INSTDF2	2.50E-05	14.78	2.89E-07	14.78	1.12E-06	14.78
R-RAIXRSH	3.26E-03	14.78	4.34E-05	14.78	1.68E-04	14.78
R-RASOURC	4.47E+02	14.78	5.74E+00	14.78	2.55E+01	14.78

September 1987

TABLE F-12

HEALTH EFFECTS AND DISPOSAL COSTS FOR
UNREGULATED URBAN SANITARY LANDFILL, WITH INCINERATION
(PER CUBIC METER)

	HUMID IMPERMEABLE		HUMID PERMEABLE		ARID PERMEABLE	
WASTE	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST
P-COTRASH	5.80E-06	16.27	1.55E-05	16.27	2.56E-05	16.27
P-CONDRSN	1.75E-07	16.27	7.88E-08	16.27	1.11E-07	16.27
L-WASTOIL	4.50E-09	16.27	3.15E-09	16.27	7.57E-09	16.27
B-COTRASH	4.09E-06	16.27	9.60E-06	16.27	1.87E-05	16.27
I-COTRASH	1.15E-05	16.27	9.60E-04	16.27	6.64E-04	16.27
I-BIOWAST	2.18E-05	16.27	1.84E-03	16.27	1.27E-03	16.27
I-ABSLIQD	2.21E-05	16.27	1.50E-03	16.27	1.03E-03	16.27
I-LQSCNVL	7.25E-07	16.27	4.58E-05	16.27	3.15E-05	16.27
N-SSTRASH	1.37E-08	16.27	1.27E-09	16.27	2.51E-09	16.27
N-SSWASTE	2.68E-07	16.27	2.46E-08	16.27	4.89E-08	16.27
N-LOTRASH	3.58E-06	16.27	2.99E-04	16.27	2.07E-04	16.27
N-LOWASTE	2.22E-06	16.27	1.71E-04	16.27	1.18E-04	16.27
F-PROCESS	7.64E-07	16.27	7.69E-08	16.27	1.84E-07	16.27
U-PROCESS	8.97E-07	16.27	8.60E-08	16.27	1.86E-07	16.27
F-COTRASH	3.94E-08	16.27	3.97E-09	16.27	9.47E-09	16.27
F-NCTRASH	3.76E-08	16.27	3.79E-09	16.27	9.05E-09	16.27
C-SMOKDET	8.37E-05	16.27	5.05E-07	16.27	1.07E-06	16.27
C-TIMEPCS	2.44E-05	16.27	5.73E-04	16.27	9.40E-07	16.27
R-GLASDS1	2.08E-04	16.27	3.72E-05	16.27	2.30E-04	16.27
R-GLASDS2	7.47E-05	16.27	6.86E-06	16.27	1.21E-05	16.27
R-INSTDF1	2.05E-03	16.27	3.22E-05	16.27	1.18E-04	16.27
R-INSTDF2	2.35E-05	16.27	3.67E-07	16.27	1.35E-06	16.27
R-RAIXRSN	3.05E-03	16.27	5.98E-05	16.27	2.01E-04	16.27
R-RASOURC	4.18E+02	16.27	7.84E+00	16.27	3.06E+01	16.27

September 1987

TABLE F-13

HEALTH EFFECTS AND DISPOSAL COSTS FOR
UNREGULATED MUNICIPAL DUMP
(PER CUBIC METER)

	HUMID IMPERMEABLE		HUMID PERMEABLE		ARID PERMEABLE	
WASTE	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST	UNIT HEALTH EFFECTS	UNIT DISPOSAL COST
P-COTRASH	5.21E-06	14.78	7.22E-06	14.78	1.31E-06	14.78
P-CONDRSN	2.07E-07	14.78	1.06E-07	14.78	2.92E-08	14.78
L-WASTOIL	4.04E-09	14.78	1.85E-09	14.78	1.71E-09	14.78
B-COTRASH	4.48E-06	14.78	3.95E-06	14.78	8.51E-07	14.78
I-COTRASH	3.40E-05	14.78	6.84E-04	14.78	4.00E-06	14.78
I-BIOWAST	6.25E-05	14.78	1.32E-03	14.78	7.32E-06	14.78
I-ABSLIQD	5.54E-05	14.78	1.06E-03	14.78	7.18E-06	14.78
I-LQSCNVL	1.47E-06	14.78	3.26E-05	14.78	1.60E-07	14.78
N-SSTRASH	3.13E-09	14.78	3.27E-10	14.78	7.06E-10	14.78
N-SSWASTE	6.09E-08	14.78	6.36E-09	14.78	1.37E-08	14.78
N-LOTRASH	1.06E-05	14.78	2.14E-04	14.78	1.25E-06	14.78
N-LOWASTE	5.97E-06	14.78	1.22E-04	14.78	7.26E-07	14.78
F-PROCESS	1.75E-07	14.78	1.81E-08	14.78	5.19E-08	14.78
U-PROCESS	2.05E-07	14.78	2.13E-08	14.78	5.22E-08	14.78
F-COTRASH	8.99E-09	14.78	9.33E-10	14.78	2.67E-09	14.78
F-NCTRASH	8.60E-09	14.78	8.90E-10	14.78	2.56E-09	14.78
C-SMOKDET	3.17E-05	14.78	2.22E-07	14.78	3.13E-07	14.78
C-TIMEPCS	1.63E-05	14.78	6.64E-04	14.78	1.36E-08	14.78
R-GLASDS1	1.08E-04	14.78	6.84E-06	14.78	6.58E-05	14.78
R-GLASDS2	1.69E-05	14.78	1.78E-06	14.78	3.39E-06	14.78
R-INSTDF1	1.10E-03	14.78	3.98E-05	14.78	3.41E-05	14.78
R-INSTDF2	1.25E-05	14.78	4.55E-07	14.78	3.89E-07	14.78
R-RAIXRSN	1.68E-03	14.78	7.34E-05	14.78	6.40E-05	14.78
R-RASOURC	2.39E+02	14.78	9.44E+00	14.78	9.28E+00	14.78

September 1987

TABLE F-14

HEALTH EFFECTS AND DISPOSAL COSTS FOR
10 CFR 61 DISPOSAL TECHNOLOGY
(PER CUBIC METER)

WASTE	HUMID IMPERMEABLE UNIT HEALTH EFFECTS	HUMID IMPERMEABLE UNIT DISPOSAL COST	HUMID PERMEABLE UNIT HEALTH EFFECTS	HUMID PERMEABLE UNIT DISPOSAL COST	ARID PERMEABLE UNIT HEALTH EFFECTS	ARID PERMEABLE UNIT DISPOSAL COST
P-COTRASH	3.09E-07	830	2.22E-07	830	1.71E-07	830
P-CONDRSN	8.93E-10	6,202	4.55E-10	6,202	3.63E-10	6,202
L-WASTOIL	6.61E-12	1,726	9.37E-15	1,726	2.27E-15	1,726
B-COTRASH	5.32E-08	830	3.83E-08	830	2.42E-08	830
I-COTRASH	1.84E-05	830	4.07E-05	830	3.26E-05	830
I-BIOWAST	3.20E-05	2,726	7.80E-05	2,726	6.27E-05	2,726
I-ABSLIQD	2.59E-05	3,872	6.31E-05	3,872	5.07E-05	3,872
I-LQSCNVL	7.96E-07	3,872	1.93E-06	3,872	1.56E-06	3,872
N-SSTRASH	2.37E-09	830	3.30E-16	830	7.39E-16	830
N-SSWASTE	4.62E-08	830	6.42E-15	830	1.43E-14	830
N-LOTRASH	5.76E-06	830	1.27E-05	830	1.02E-05	830
N-LOWASTE	2.97E-06	830	7.23E-06	830	5.81E-06	830
F-PROCESS	1.33E-07	830	1.89E-14	830	5.44E-14	830
U-PROCESS	1.55E-07	830	2.19E-14	830	5.47E-14	830
F-COTRASH	6.86E-09	830	9.77E-16	830	2.80E-15	830
F-NCTRASH	6.55E-09	1,203	9.33E-16	1,203	2.68E-15	1,203
C-SMOKDET	1.08E-05	17,106	1.04E-07	17,106	3.74E-13	17,106
C-TIMEPCS	4.69E-10	97,351	4.16E-06	97,351	6.46E-14	97,351
R-GLASDS1	6.79E-05	218,913	1.26E-11	218,913	7.00E-11	218,913
R-GLASDS2	1.27E-05	830	1.79E-12	830	3.56E-12	830
R-INSTDF1	4.83E-04	252,918	1.51E-10	252,918	3.76E-11	252,918
R-INSTDF2	5.50E-06	830	1.73E-12	830	4.27E-13	830
R-RAIXRSN	1.93E-08	7,230	9.08E-06	7,230	9.08E-07	7,230
R-RASOURC	2.75E-03	5,962	7.06E-01	5,962	7.06E-02	5,962

September 1987

Table F-15

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
F-COTRASH	SLD, NIC	AS IS	0.00E+00	5.14E-10	2.08E-09	6.64E-09	0.00E+00	1.81E-11	7.57E-11	2.37E-10
F-COTRASH	SLD	AS IS	9.97E-16	9.40E-10	2.40E-09	6.62E-09	2.75E-17	3.34E-11	8.78E-11	2.37E-10
F-COTRASH	ISD, NIC	AS IS	0.00E+00	1.48E-10	6.55E-10	4.52E-09	0.00E+00	5.22E-12	2.38E-11	1.60E-10
F-COTRASH	ISD	AS IS	9.97E-16	2.18E-10	7.15E-10	4.49E-09	2.75E-17	7.70E-12	2.61E-11	1.59E-10
F-COTRASH	IDD	AS IS	9.97E-16	1.12E-10	4.42E-10	3.45E-09	2.75E-17	3.94E-12	1.61E-11	1.22E-10
F-COTRASH	SLF	AS IS	9.75E-10	4.73E-09	6.47E-09	7.23E-09	3.41E-11	1.71E-10	2.43E-10	2.70E-10
F-COTRASH	SLF	SOL	4.59E-13	3.96E-12	6.80E-12	2.05E-11	1.61E-14	1.42E-13	2.53E-13	7.38E-13
F-COTRASH	SLD	SOL	0.00E+00	2.65E-13	6.89E-13	2.47E-12	0.00E+00	9.41E-15	2.53E-14	8.83E-14
F-COTRASH	SLD, NIC	SOL	0.00E+00	1.32E-13	5.55E-13	2.34E-12	0.00E+00	4.64E-15	2.02E-14	8.32E-14
F-COTRASH	SLD	INC/SOL	0.00E+00	2.48E-13	6.45E-13	2.32E-12	0.00E+00	8.80E-15	2.36E-14	8.25E-14
F-COTRASH	EM	SOL	0.00E+00	9.33E-14	2.43E-13	8.74E-13	0.00E+00	3.32E-15	8.92E-15	3.12E-14
F-COTRASH	ISD, NIC	SOL	0.00E+00	1.51E-14	6.65E-14	4.67E-13	0.00E+00	5.42E-16	2.47E-15	1.66E-14
F-COTRASH	ISD	SOL	0.00E+00	2.66E-14	7.93E-14	4.80E-13	0.00E+00	9.42E-16	2.90E-15	1.70E-14
F-COTRASH	ISD	INC/SOL	0.00E+00	2.43E-14	7.25E-14	4.38E-13	0.00E+00	8.61E-16	2.65E-15	1.56E-14
F-COTRASH	IDD	SOL	0.00E+00	1.60E-14	5.01E-14	3.09E-13	0.00E+00	5.68E-16	1.83E-15	1.10E-14
F-COTRASH	CC	SOL	0.00E+00	6.76E-15	2.08E-14	1.76E-13	0.00E+00	2.40E-16	7.58E-16	6.24E-15
F-NCTRASH	SLD, NIC	AS IS	0.00E+00	4.91E-10	1.99E-09	6.34E-09	0.00E+00	1.73E-11	7.24E-11	2.26E-10
F-NCTRASH	SLD	AS IS	9.52E-16	8.98E-10	2.29E-09	6.32E-09	2.63E-17	3.19E-11	8.39E-11	2.26E-10
F-NCTRASH	ISD, NIC	AS IS	0.00E+00	1.41E-10	6.26E-10	4.31E-09	0.00E+00	4.99E-12	2.27E-11	1.53E-10
F-NCTRASH	ISD	AS IS	9.52E-16	2.08E-10	6.83E-10	4.29E-09	2.63E-17	7.36E-12	2.49E-11	1.52E-10
F-NCTRASH	IDD	AS IS	9.52E-16	1.07E-10	4.22E-10	3.30E-09	2.63E-17	3.77E-12	1.53E-11	1.17E-10
F-NCTRASH	SLF	AS IS	9.31E-10	4.52E-09	6.18E-09	6.91E-09	3.26E-11	1.63E-10	2.33E-10	2.59E-10
F-NCTRASH	SLF	SOL	4.38E-13	3.78E-12	6.50E-12	1.96E-11	1.54E-14	1.36E-13	2.42E-13	7.06E-13
F-NCTRASH	SLD	SOL	0.00E+00	2.53E-13	6.59E-13	2.36E-12	0.00E+00	8.99E-15	2.41E-14	8.43E-14
F-NCTRASH	SLD, NIC	SOL	0.00E+00	1.26E-13	5.30E-13	2.23E-12	0.00E+00	4.44E-15	1.93E-14	7.95E-14
F-NCTRASH	EM	SOL	0.00E+00	8.91E-14	2.33E-13	8.35E-13	0.00E+00	3.17E-15	8.52E-15	2.98E-14
F-NCTRASH	ISD	SOL	0.00E+00	2.54E-14	7.58E-14	4.59E-13	0.00E+00	9.01E-16	2.77E-15	1.63E-14
F-NCTRASH	ISD, NIC	SOL	0.00E+00	1.44E-14	6.35E-14	4.46E-13	0.00E+00	5.18E-16	2.36E-15	1.59E-14
F-NCTRASH	IDD	SOL	0.00E+00	1.53E-14	4.79E-14	2.96E-13	0.00E+00	5.43E-16	1.75E-15	1.05E-14
F-NCTRASH	CC	SOL	0.00E+00	6.46E-15	1.98E-14	1.68E-13	0.00E+00	2.29E-16	7.25E-16	5.96E-15

Table continued on next page

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
F-PROCESS	SLD, NIC	AS IS	0.00E+00	9.98E-09	4.05E-08	1.29E-07	0.00E+00	3.52E-10	1.47E-09	4.59E-09
F-PROCESS	SLD	AS IS	1.94E-14	1.85E-08	4.67E-08	1.28E-07	5.34E-16	6.57E-10	1.72E-09	4.61E-09
F-PROCESS	ISD, NIC	AS IS	0.00E+00	2.88E-09	1.27E-08	8.76E-08	0.00E+00	1.02E-10	4.63E-10	3.10E-09
F-PROCESS	ISD	AS IS	1.94E-14	4.44E-09	1.41E-08	8.74E-08	5.34E-16	1.57E-10	5.15E-10	3.10E-09
F-PROCESS	IDD	AS IS	1.94E-14	2.57E-09	8.98E-09	6.73E-08	5.34E-16	9.11E-11	3.27E-10	2.39E-09
F-PROCESS	SLF	AS IS	1.31E-08	8.97E-08	1.25E-07	1.40E-07	4.59E-10	3.23E-09	4.71E-09	5.26E-09
F-PROCESS	SLF	SOL	8.90E-12	7.69E-11	1.32E-10	3.99E-10	3.12E-13	2.77E-12	4.91E-12	1.43E-11
F-PROCESS	SLD	SOL	0.00E+00	5.14E-12	1.34E-11	4.80E-11	0.00E+00	1.83E-13	4.91E-13	1.71E-12
F-PROCESS	SLD, NIC	SOL	0.00E+00	2.56E-12	1.08E-11	4.54E-11	0.00E+00	9.02E-14	3.92E-13	1.61E-12
F-PROCESS	EM	SOL	0.00E+00	1.81E-12	4.72E-12	1.69E-11	0.00E+00	6.44E-14	1.73E-13	6.05E-13
F-PROCESS	ISD, NIC	SOL	0.00E+00	2.92E-13	1.29E-12	9.07E-12	0.00E+00	1.05E-14	4.80E-14	3.23E-13
F-PROCESS	ISD	SOL	0.00E+00	5.16E-13	1.54E-12	9.32E-12	0.00E+00	1.83E-14	5.63E-14	3.31E-13
F-PROCESS	IDD	SOL	0.00E+00	3.11E-13	9.73E-13	6.00E-12	0.00E+00	1.10E-14	3.55E-14	2.13E-13
F-PROCESS	CC	SOL	0.00E+00	1.31E-13	4.03E-13	3.42E-12	0.00E+00	4.66E-15	1.47E-14	1.21E-13
I-ABSLIQD	SLD	SOL	0.00E+00	3.47E-06	8.10E-06	2.35E-05	0.00E+00	4.30E-07	1.00E-06	2.91E-06
I-ABSLIQD	SLD, NIC	SOL	0.00E+00	1.58E-06	6.21E-06	2.16E-05	0.00E+00	1.96E-07	7.69E-07	2.68E-06
I-ABSLIQD	SLF	SOL	2.25E-06	1.56E-05	2.57E-05	3.92E-05	2.79E-07	1.93E-06	3.19E-06	4.87E-06
I-ABSLIQD	EM	SOL	0.00E+00	2.00E-06	4.79E-06	1.41E-05	0.00E+00	2.47E-07	5.92E-07	1.74E-06
I-ABSLIQD	ISD, NIC	SOL	0.00E+00	3.49E-07	1.46E-06	7.49E-06	0.00E+00	4.31E-08	1.81E-07	9.28E-07
I-ABSLIQD	ISD	SOL	0.00E+00	6.32E-07	1.75E-06	7.78E-06	0.00E+00	7.83E-08	2.16E-07	9.63E-07
I-ABSLIQD	IDD	SOL	0.00E+00	4.16E-07	1.21E-06	5.49E-06	0.00E+00	5.15E-08	1.49E-07	6.79E-07
I-ABSLIQD	CC	SOL	0.00E+00	1.87E-07	5.36E-07	3.12E-06	0.00E+00	2.32E-08	6.64E-08	3.85E-07
I-ABSLIQD	IDD	AS IS	3.54E-11	1.47E-05	1.51E-05	1.51E-05	8.33E-12	1.82E-06	1.87E-06	1.87E-06
I-ABSLIQD	ISD, NIC	AS IS	0.00E+00	3.65E-05	3.74E-05	3.74E-05	0.00E+00	4.52E-06	4.63E-06	4.63E-06
I-ABSLIQD	ISD	AS IS	3.54E-11	1.76E-05	1.76E-05	1.76E-05	8.33E-12	2.18E-06	2.18E-06	2.18E-06
I-ABSLIQD	SLF	AS IS	5.29E-05	5.41E-05	5.41E-05	5.41E-05	6.77E-06	7.07E-06	7.07E-06	7.07E-06
I-ABSLIQD	SLD, NIC	AS IS	0.00E+00	4.72E-05	4.72E-05	4.72E-05	0.00E+00	5.84E-06	5.84E-06	5.84E-06
I-ABSLIQD	SLD	AS IS	3.54E-11	2.30E-05	2.30E-05	2.30E-05	8.33E-12	2.85E-06	2.85E-06	2.85E-06
I-ABSLIQD	NF	SOL	0.00E+00	0.00E+00	0.00E+00	1.14E-06	0.00E+00	0.00E+00	0.00E+00	1.41E-07

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
I-BIOWAST	SLD	SOL	0.00E+00	4.29E-06	1.00E-05	2.91E-05	0.00E+00	5.32E-07	1.24E-06	3.60E-06
I-BIOWAST	SLD, NIC	SOL	0.00E+00	1.96E-06	7.69E-06	2.68E-05	0.00E+00	2.42E-07	9.51E-07	3.31E-06
I-BIOWAST	SLF	SOL	2.79E-06	1.93E-05	3.19E-05	4.87E-05	3.45E-07	2.39E-06	3.94E-06	6.01E-06
I-BIOWAST	SLD	INC/SOL	0.00E+00	3.14E-06	7.34E-06	2.13E-05	0.00E+00	3.89E-07	9.09E-07	2.64E-06
I-BIOWAST	EM	SOL	0.00E+00	2.47E-06	5.92E-06	1.74E-05	0.00E+00	3.06E-07	7.33E-07	2.15E-06
I-BIOWAST	ISD	SOL	0.00E+00	7.83E-07	2.16E-06	9.63E-06	0.00E+00	9.69E-08	2.67E-07	1.19E-06
I-BIOWAST	ISD, NIC	SOL	0.00E+00	4.31E-07	1.81E-06	9.28E-06	0.00E+00	5.34E-08	2.24E-07	1.15E-06
I-BIOWAST	IDD	SOL	0.00E+00	5.15E-07	1.49E-06	6.79E-06	0.00E+00	6.38E-08	1.85E-07	8.41E-07
I-BIOWAST	ISD	INC/SOL	0.00E+00	5.53E-07	1.53E-06	6.81E-06	0.00E+00	6.85E-08	1.89E-07	8.43E-07
I-BIOWAST	CC	SOL	0.00E+00	2.32E-07	6.64E-07	3.85E-06	0.00E+00	2.87E-08	8.22E-08	4.77E-07
I-BIOWAST	IDD	AS IS	2.59E-11	1.82E-05	1.87E-05	1.87E-05	5.69E-12	2.26E-06	2.31E-06	2.31E-06
I-BIOWAST	ISD, NIC	AS IS	0.00E+00	4.52E-05	4.63E-05	4.63E-05	0.00E+00	5.59E-06	5.73E-06	5.73E-06
I-BIOWAST	ISD	AS IS	2.59E-11	2.18E-05	2.18E-05	2.18E-05	5.69E-12	2.69E-06	2.70E-06	2.70E-06
I-BIOWAST	SLF	AS IS	6.45E-05	6.52E-05	6.52E-05	6.52E-05	8.12E-06	8.32E-06	8.32E-06	8.32E-06
I-BIOWAST	SLD, NIC	AS IS	0.00E+00	5.84E-05	5.84E-05	5.84E-05	0.00E+00	7.23E-06	7.23E-06	7.23E-06
I-BIOWAST	SLD	AS IS	2.59E-11	2.85E-05	2.85E-05	2.85E-05	5.69E-12	3.53E-06	3.53E-06	3.53E-06
I-COTRASH	SLD	SOL	0.00E+00	2.24E-06	5.22E-06	1.52E-05	0.00E+00	2.77E-07	6.46E-07	1.88E-06
I-COTRASH	SLD, NIC	SOL	0.00E+00	1.02E-06	4.00E-06	1.39E-05	0.00E+00	1.26E-07	4.96E-07	1.73E-06
I-COTRASH	SLF	SOL	1.45E-06	1.01E-05	1.66E-05	2.53E-05	1.80E-07	1.25E-06	2.05E-06	3.13E-06
I-COTRASH	SLD	INC/SOL	0.00E+00	1.64E-06	3.82E-06	1.11E-05	0.00E+00	2.02E-07	4.73E-07	1.37E-06
I-COTRASH	EM	SOL	0.00E+00	1.29E-06	3.08E-06	9.06E-06	0.00E+00	1.59E-07	3.82E-07	1.12E-06
I-COTRASH	ISD	SOL	0.00E+00	4.08E-07	1.13E-06	5.02E-06	0.00E+00	5.05E-08	1.39E-07	6.20E-07
I-COTRASH	ISD, NIC	SOL	0.00E+00	2.25E-07	9.42E-07	4.83E-06	0.00E+00	2.78E-08	1.17E-07	5.98E-07
I-COTRASH	IDD	SOL	0.00E+00	2.68E-07	7.78E-07	3.54E-06	0.00E+00	3.32E-08	9.63E-08	4.38E-07
I-COTRASH	ISD	INC/SOL	0.00E+00	2.88E-07	7.96E-07	3.55E-06	0.00E+00	3.57E-08	9.85E-08	4.39E-07
I-COTRASH	CC	SOL	0.00E+00	1.21E-07	3.46E-07	2.01E-06	0.00E+00	1.50E-08	4.28E-08	2.49E-07
I-COTRASH	SLF	AS IS	2.46E-05	2.50E-05	2.51E-05	2.51E-05	3.18E-06	3.29E-06	3.30E-06	3.30E-06
I-COTRASH	SLD	AS IS	1.35E-11	1.64E-05	1.64E-05	1.64E-05	2.99E-12	2.03E-06	2.03E-06	2.03E-06
I-COTRASH	SLD, NIC	AS IS	0.00E+00	3.04E-05	3.04E-05	3.04E-05	0.00E+00	3.76E-06	3.76E-06	3.76E-06
I-COTRASH	IDD	AS IS	1.35E-11	9.84E-06	1.10E-05	1.10E-05	2.99E-12	1.22E-06	1.36E-06	1.36E-06
I-COTRASH	ISD	AS IS	1.35E-11	1.22E-05	1.24E-05	1.24E-05	2.99E-12	1.51E-06	1.53E-06	1.53E-06
I-COTRASH	ISD, NIC	AS IS	0.00E+00	2.30E-05	2.41E-05	2.41E-05	0.00E+00	2.84E-06	2.98E-06	2.98E-06

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
I-LOSCNVL	SLD	SOL	0.00E+00	1.07E-07	2.49E-07	7.23E-07	0.00E+00	1.32E-08	3.08E-08	8.95E-08
I-LOSCNVL	SLD, HIC	SOL	0.00E+00	4.86E-08	1.91E-07	6.65E-07	0.00E+00	6.01E-09	2.36E-08	8.23E-08
I-LOSCNVL	SLF	SOL	6.93E-08	4.80E-07	7.92E-07	1.21E-06	8.58E-09	5.95E-08	9.80E-08	1.50E-07
I-LOSCNVL	SLD	INC/SOL	0.00E+00	7.80E-08	1.83E-07	5.31E-07	0.00E+00	9.66E-09	2.26E-08	6.56E-08
I-LOSCNVL	EM	SOL	0.00E+00	6.14E-08	1.47E-07	4.32E-07	0.00E+00	7.61E-09	1.82E-08	5.35E-08
I-LOSCNVL	ISD, HIC	SOL	0.00E+00	1.07E-08	4.50E-08	2.31E-07	0.00E+00	1.33E-09	5.57E-09	2.86E-08
I-LOSCNVL	ISD	SOL	0.00E+00	1.95E-08	5.37E-08	2.40E-07	0.00E+00	2.41E-09	6.65E-09	2.97E-08
I-LOSCNVL	IDD	SOL	0.00E+00	1.28E-08	3.71E-08	1.69E-07	0.00E+00	1.58E-09	4.59E-09	2.09E-08
I-LOSCNVL	ISD	INC/SOL	0.00E+00	1.38E-08	3.80E-08	1.69E-07	0.00E+00	1.70E-09	4.70E-09	2.10E-08
I-LOSCNVL	CC	SOL	0.00E+00	5.77E-09	1.65E-08	9.58E-08	0.00E+00	7.14E-10	2.04E-09	1.19E-08
I-LOSCNVL	IDD	AS IS	2.75E-13	4.53E-07	4.64E-07	4.64E-07	2.23E-14	5.61E-08	5.74E-08	5.74E-08
I-LOSCNVL	ISD, HIC	AS IS	0.00E+00	1.12E-06	1.15E-06	1.15E-06	0.00E+00	1.39E-07	1.42E-07	1.42E-07
I-LOSCNVL	ISD	AS IS	2.75E-13	5.41E-07	5.43E-07	5.43E-07	2.23E-14	6.69E-08	6.72E-08	6.72E-08
I-LOSCNVL	SLD, HIC	AS IS	0.00E+00	1.45E-06	1.45E-06	1.45E-06	0.00E+00	1.80E-07	1.80E-07	1.80E-07
I-LOSCNVL	SLD	AS IS	2.75E-13	7.08E-07	7.08E-07	7.08E-07	2.23E-14	8.76E-08	8.76E-08	8.76E-08
I-LOSCNVL	SLF	AS IS	1.61E-06	1.62E-06	1.62E-06	1.62E-06	1.95E-07	1.96E-07	1.96E-07	1.96E-07
L-CONCLIQ	SLF	AS IS	3.13E-05	5.40E-05	5.85E-05	6.33E-05	7.36E-06	1.27E-05	1.32E-05	1.38E-05
L-CONCLIQ	SLD, HIC	AS IS	0.00E+00	4.42E-06	5.47E-06	8.54E-06	0.00E+00	5.32E-07	6.72E-07	1.11E-06
L-CONCLIQ	SLD	AS IS	4.84E-10	2.74E-06	4.02E-06	7.08E-06	1.24E-10	3.65E-07	5.31E-07	9.66E-07
L-CONCLIQ	SLD	SOL	0.00E+00	3.14E-07	7.35E-07	2.15E-06	0.00E+00	3.74E-08	8.74E-08	2.53E-07
L-CONCLIQ	SLD, HIC	SOL	0.00E+00	1.43E-07	5.63E-07	1.97E-06	0.00E+00	1.70E-08	6.70E-08	2.33E-07
L-CONCLIQ	ISD	AS IS	4.84E-10	1.69E-06	2.06E-06	3.39E-06	1.24E-10	2.05E-07	2.53E-07	4.66E-07
L-CONCLIQ	ISD, HIC	AS IS	0.00E+00	3.35E-06	3.74E-06	5.06E-06	0.00E+00	4.00E-07	4.52E-07	6.65E-07
L-CONCLIQ	SLF	SOL	2.18E-07	1.44E-06	2.36E-06	3.60E-06	2.80E-08	1.75E-07	2.85E-07	4.32E-07
L-CONCLIQ	IDD	AS IS	4.84E-10	1.38E-06	1.64E-06	2.57E-06	1.24E-10	1.67E-07	2.00E-07	3.52E-07
L-CONCLIQ	EM	SOL	0.00E+00	1.81E-07	4.34E-07	1.28E-06	0.00E+00	2.15E-08	5.16E-08	1.52E-07
L-CONCLIQ	ISD, HIC	SOL	0.00E+00	3.16E-08	1.33E-07	6.90E-07	0.00E+00	3.76E-09	1.58E-08	8.09E-08
L-CONCLIQ	ISD	SOL	0.00E+00	5.73E-08	1.58E-07	7.15E-07	0.00E+00	6.82E-09	1.88E-08	8.39E-08
L-CONCLIQ	IDD	SOL	0.00E+00	3.77E-08	1.09E-07	5.04E-07	0.00E+00	4.49E-09	1.30E-08	5.92E-08
L-CONCLIQ	CC	SOL	0.00E+00	1.70E-08	4.86E-08	2.88E-07	0.00E+00	2.02E-09	5.78E-09	3.36E-08
L-CONCLIQ	HF	SOL	0.00E+00	0.00E+00	0.00E+00	1.11E-07	0.00E+00	0.00E+00	0.00E+00	1.23E-08

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-COTRASH	SLF	AS IS	1.40E-06	2.06E-06	2.15E-06	2.24E-06	3.50E-07	5.07E-07	5.19E-07	5.30E-07
L-COTRASH	SLD, HIC	AS IS	0.00E+00	8.85E-08	1.11E-07	1.66E-07	0.00E+00	1.07E-08	1.44E-08	2.55E-08
L-COTRASH	SLD	AS IS	1.35E-11	6.12E-08	8.82E-08	1.43E-07	3.47E-12	8.48E-09	1.26E-08	2.34E-08
L-COTRASH	SLD	SOL	0.00E+00	6.25E-09	1.46E-08	4.28E-08	0.00E+00	7.33E-10	1.71E-09	4.97E-09
L-COTRASH	SLD, HIC	SOL	0.00E+00	2.84E-09	1.12E-08	3.94E-08	0.00E+00	3.34E-10	1.31E-09	4.57E-09
L-COTRASH	SLF	SOL	4.45E-09	2.89E-08	4.72E-08	7.19E-08	5.79E-10	3.50E-09	5.64E-09	8.53E-09
L-COTRASH	ISD	AS IS	1.35E-11	3.63E-08	4.43E-08	6.86E-08	3.47E-12	4.42E-09	5.67E-09	1.16E-08
L-COTRASH	ISD, HIC	AS IS	0.00E+00	6.52E-08	7.51E-08	9.93E-08	0.00E+00	7.72E-09	9.20E-09	1.51E-08
L-COTRASH	SLD	INC/SOL	0.00E+00	4.65E-09	1.09E-08	3.21E-08	0.00E+00	5.37E-10	1.25E-09	3.64E-09
L-COTRASH	EM	SOL	0.00E+00	3.59E-09	8.62E-09	2.56E-08	0.00E+00	4.22E-10	1.01E-09	2.97E-09
L-COTRASH	IDD	AS IS	1.35E-11	2.83E-08	3.61E-08	5.31E-08	3.47E-12	3.39E-09	4.50E-09	8.78E-09
L-COTRASH	ISD, HIC	SOL	0.00E+00	6.27E-10	2.63E-09	1.37E-08	0.00E+00	7.36E-11	3.09E-10	1.58E-09
L-COTRASH	ISD	SOL	0.00E+00	1.14E-09	3.15E-09	1.43E-08	0.00E+00	1.34E-10	3.69E-10	1.64E-09
L-COTRASH	ISD	INC/SOL	0.00E+00	8.18E-10	2.26E-09	1.03E-08	0.00E+00	9.44E-11	2.61E-10	1.16E-09
L-COTRASH	IDD	SOL	0.00E+00	7.49E-10	2.17E-09	1.01E-08	0.00E+00	8.79E-11	2.55E-10	1.16E-09
L-COTRASH	CC	SOL	0.00E+00	3.37E-10	9.67E-10	5.75E-09	0.00E+00	3.96E-11	1.13E-10	6.57E-10
L-DECONRS	SLF	AS IS	4.49E-06	1.15E-05	1.38E-05	4.06E-05	1.20E-06	2.46E-06	2.71E-06	5.53E-06
L-DECONRS	SLD, HIC	AS IS	0.00E+00	1.63E-07	6.32E-07	8.67E-06	0.00E+00	3.02E-08	8.69E-08	9.35E-07
L-DECONRS	SLD	AS IS	2.32E-10	5.99E-07	1.14E-06	9.16E-06	7.16E-11	1.11E-07	1.74E-07	1.02E-06
L-DECONRS	ISD	AS IS	2.32E-10	1.05E-07	2.53E-07	2.80E-06	7.16E-11	1.94E-08	3.72E-08	3.06E-07
L-DECONRS	ISD, HIC	AS IS	0.00E+00	4.66E-08	1.81E-07	2.73E-06	0.00E+00	8.63E-09	2.50E-08	2.93E-07
L-DECONRS	IDD	AS IS	2.32E-10	5.37E-08	1.47E-07	1.82E-06	7.16E-11	9.96E-09	2.12E-08	1.97E-07
L-DECONRS	SLF	SOL	1.48E-09	6.48E-09	7.64E-09	4.61E-08	3.33E-10	1.27E-09	1.40E-09	5.46E-09
L-DECONRS	SLD	SOL	0.00E+00	1.67E-10	2.97E-10	9.26E-10	0.00E+00	3.12E-11	4.68E-11	1.13E-10
L-DECONRS	SLD, HIC	SOL	0.00E+00	4.14E-11	1.52E-10	7.74E-10	0.00E+00	7.69E-12	2.12E-11	8.68E-11
L-DECONRS	SLD	INC/SOL	0.00E+00	1.56E-10	2.78E-10	8.66E-10	0.00E+00	2.92E-11	4.38E-11	1.06E-10
L-DECONRS	ISD	SOL	0.00E+00	1.35E-11	2.86E-11	1.56E-10	0.00E+00	2.51E-12	4.33E-12	1.77E-11
L-DECONRS	ISD, HIC	SOL	0.00E+00	4.77E-12	1.79E-11	1.45E-10	0.00E+00	8.93E-13	2.53E-12	1.59E-11
L-DECONRS	ISD	INC/SOL	0.00E+00	1.23E-11	2.61E-11	1.43E-10	0.00E+00	2.29E-12	3.96E-12	1.63E-11
L-DECONRS	IDD	SOL	0.00E+00	7.46E-12	1.71E-11	9.95E-11	0.00E+00	1.39E-12	2.55E-12	1.12E-11
L-DECONRS	CC	SOL	0.00E+00	3.44E-12	7.38E-12	5.42E-11	0.00E+00	6.40E-13	1.12E-12	6.06E-12
L-DECONRS	CB	SOL	0.00E+00	2.91E-12	6.13E-12	5.24E-11	0.00E+00	5.42E-13	9.30E-13	5.81E-12
L-DECONRS	HF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-FSLUDGE	SLF	AS IS	1.76E-04	3.01E-04	3.07E-04	3.12E-04	4.43E-05	7.61E-05	7.70E-05	7.79E-05
L-FSLUDGE	SLD, NIC	AS IS	0.00E+00	6.09E-06	7.63E-06	1.28E-05	0.00E+00	6.74E-07	1.03E-06	2.38E-06
L-FSLUDGE	SLD	AS IS	3.11E-09	4.87E-06	6.60E-06	1.16E-05	7.98E-10	8.04E-07	1.18E-06	2.47E-06
L-FSLUDGE	ISD, NIC	AS IS	0.00E+00	4.56E-06	5.14E-06	7.83E-06	0.00E+00	4.83E-07	6.03E-07	1.41E-06
L-FSLUDGE	ISD	AS IS	3.11E-09	2.38E-06	2.90E-06	5.57E-06	7.98E-10	2.79E-07	3.93E-07	1.19E-06
L-FSLUDGE	SLD	SOL	0.00E+00	4.26E-07	9.99E-07	3.00E-06	0.00E+00	4.40E-08	1.03E-07	2.98E-07
L-FSLUDGE	SLD, NIC	SOL	0.00E+00	1.94E-07	7.67E-07	2.77E-06	0.00E+00	2.00E-08	7.85E-08	2.74E-07
L-FSLUDGE	IDD	AS IS	3.11E-09	1.92E-06	2.28E-06	4.22E-06	7.98E-10	2.14E-07	2.91E-07	8.77E-07
L-FSLUDGE	SLF	SOL	3.67E-07	2.08E-06	3.34E-06	5.07E-06	5.22E-08	2.41E-07	3.70E-07	5.44E-07
L-FSLUDGE	SLD	INC/SOL	0.00E+00	3.29E-07	7.73E-07	2.34E-06	0.00E+00	3.22E-08	7.53E-08	2.18E-07
L-FSLUDGE	ISD	SOL	0.00E+00	7.76E-08	2.15E-07	1.02E-06	0.00E+00	7.99E-09	2.21E-08	9.85E-08
L-FSLUDGE	ISD, NIC	SOL	0.00E+00	4.28E-08	1.80E-07	9.83E-07	0.00E+00	4.40E-09	1.85E-08	9.49E-08
L-FSLUDGE	ISD	INC/SOL	0.00E+00	5.78E-08	1.61E-07	7.72E-07	0.00E+00	5.66E-09	1.56E-08	6.98E-08
L-FSLUDGE	IDD	SOL	0.00E+00	5.11E-08	1.49E-07	7.19E-07	0.00E+00	5.26E-09	1.52E-08	6.94E-08
L-FSLUDGE	CC	SOL	0.00E+00	2.30E-08	6.61E-08	4.15E-07	0.00E+00	2.37E-09	6.78E-09	3.94E-08
L-FSLUDGE	CB	SOL	0.00E+00	1.72E-08	4.93E-08	3.61E-07	0.00E+00	1.77E-09	5.05E-09	3.40E-08
L-FSLUDGE	NF	SOL	0.00E+00	0.00E+00	0.00E+00	1.88E-07	0.00E+00	0.00E+00	0.00E+00	1.44E-08
L-IXRESIN	SLF	AS IS	5.57E-04	9.23E-04	9.60E-04	1.00E-03	1.31E-04	2.21E-04	2.25E-04	2.30E-04
L-IXRESIN	SLD	SOL	0.00E+00	5.66E-06	1.32E-05	3.87E-05	0.00E+00	6.75E-07	1.57E-06	4.57E-06
L-IXRESIN	SLD, NIC	SOL	0.00E+00	2.58E-06	1.02E-05	3.57E-05	0.00E+00	3.07E-07	1.21E-06	4.21E-06
L-IXRESIN	SLD	AS IS	8.61E-09	4.49E-05	5.53E-05	8.02E-05	2.20E-09	5.89E-06	7.15E-06	1.04E-05
L-IXRESIN	SLD, NIC	AS IS	0.00E+00	7.82E-05	8.68E-05	1.12E-04	0.00E+00	9.35E-06	1.04E-05	1.36E-05
L-IXRESIN	SLF	SOL	3.93E-06	2.60E-05	4.26E-05	6.49E-05	5.04E-07	3.16E-06	5.13E-06	7.77E-06
L-IXRESIN	SLD	INC/SOL	0.00E+00	4.19E-06	9.82E-06	2.88E-05	0.00E+00	4.94E-07	1.15E-06	3.35E-06
L-IXRESIN	ISD	AS IS	8.61E-09	2.96E-05	3.26E-05	4.31E-05	2.20E-09	3.57E-06	3.93E-06	5.38E-06
L-IXRESIN	ISD, NIC	AS IS	0.00E+00	5.99E-05	6.40E-05	7.44E-05	0.00E+00	7.14E-06	7.63E-06	9.07E-06
L-IXRESIN	ISD, NIC	SOL	0.00E+00	5.69E-07	2.39E-06	1.24E-05	0.00E+00	6.77E-08	2.84E-07	1.45E-06
L-IXRESIN	ISD	SOL	0.00E+00	1.03E-06	2.85E-06	1.29E-05	0.00E+00	1.23E-07	3.39E-07	1.51E-06
L-IXRESIN	IDD	AS IS	8.61E-09	2.45E-05	2.69E-05	3.41E-05	2.20E-09	2.93E-06	3.22E-06	4.24E-06
L-IXRESIN	ISD	INC/SOL	0.00E+00	7.39E-07	2.04E-06	9.27E-06	0.00E+00	8.69E-08	2.40E-07	1.07E-06
L-IXRESIN	IDD	SOL	0.00E+00	6.79E-07	1.97E-06	9.09E-06	0.00E+00	8.09E-08	2.34E-07	1.07E-06
L-IXRESIN	CC	SOL	0.00E+00	3.06E-07	8.76E-07	5.18E-06	0.00E+00	3.64E-08	1.04E-07	6.05E-07
L-IXRESIN	CB	SOL	0.00E+00	2.29E-07	6.53E-07	4.47E-06	0.00E+00	2.72E-08	7.77E-08	5.22E-07
L-IXRESIN	NF	SOL	0.00E+00	0.00E+00	[illegible]	2.00E-06	0.00E+00	0.00E+00	0.00E+00	[illegible]

Table continued on next page

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-FSLUDGE	SLF	AS IS	1.76E-04	3.01E-04	3.07E-04	3.12E-04	4.43E-05	7.61E-05	7.70E-05	7.79E-05
L-FSLUDGE	SLD, NIC	AS IS	0.00E+00	6.09E-06	7.63E-06	1.28E-05	0.00E+00	6.74E-07	1.03E-06	2.38E-06
L-FSLUDGE	SLD	AS IS	3.11E-09	4.87E-06	6.60E-06	1.16E-05	7.98E-10	8.04E-07	1.18E-06	2.47E-06
L-FSLUDGE	ISD, NIC	AS IS	0.00E+00	4.56E-06	5.14E-06	7.83E-06	0.00E+00	4.83E-07	6.03E-07	1.41E-06
L-FSLUDGE	ISD	AS IS	3.11E-09	2.38E-06	2.90E-06	5.57E-06	7.98E-10	2.79E-07	3.93E-07	1.19E-06
L-FSLUDGE	SLD	SOL	0.00E+00	4.26E-07	9.99E-07	3.00E-06	0.00E+00	4.40E-08	1.03E-07	2.98E-07
L-FSLUDGE	SLD, NIC	SOL	0.00E+00	1.94E-07	7.67E-07	2.77E-06	0.00E+00	2.00E-08	7.85E-08	2.74E-07
L-FSLUDGE	IDD	AS IS	3.11E-09	1.92E-06	2.28E-06	4.22E-06	7.98E-10	2.14E-07	2.91E-07	8.77E-07
L-FSLUDGE	SLF	SOL	3.67E-07	2.08E-06	3.34E-06	5.07E-06	5.22E-08	2.41E-07	3.70E-07	5.44E-07
L-FSLUDGE	SLD	INC/SOL	0.00E+00	3.29E-07	7.73E-07	2.34E-06	0.00E+00	3.22E-08	7.53E-08	2.18E-07
L-FSLUDGE	ISD	SOL	0.00E+00	7.76E-08	2.15E-07	1.02E-06	0.00E+00	7.99E-09	2.21E-08	9.85E-08
L-FSLUDGE	ISD, NIC	SOL	0.00E+00	4.28E-08	1.80E-07	9.83E-07	0.00E+00	4.40E-09	1.85E-08	9.49E-08
L-FSLUDGE	ISD	INC/SOL	0.00E+00	5.78E-08	1.61E-07	7.72E-07	0.00E+00	5.66E-09	1.56E-08	6.98E-08
L-FSLUDGE	IDD	SOL	0.00E+00	5.11E-08	1.49E-07	7.19E-07	0.00E+00	5.26E-09	1.52E-08	6.94E-08
L-FSLUDGE	CC	SOL	0.00E+00	2.30E-08	6.61E-08	4.15E-07	0.00E+00	2.37E-09	6.78E-09	3.94E-08
L-FSLUDGE	CB	SOL	0.00E+00	1.72E-08	4.93E-08	3.61E-07	0.00E+00	1.77E-09	5.05E-09	3.40E-08
L-FSLUDGE	HF	SOL	0.00E+00	0.00E+00	0.00E+00	1.88E-07	0.00E+00	0.00E+00	0.00E+00	1.44E-08
L-IXRESIN	SLF	AS IS	5.57E-04	9.23E-04	9.60E-04	1.00E-03	1.31E-04	2.21E-04	2.25E-04	2.30E-04
L-IXRESIN	SLD	SOL	0.00E+00	5.66E-06	1.32E-05	3.87E-05	0.00E+00	6.75E-07	1.57E-06	4.57E-06
L-IXRESIN	SLD, NIC	SOL	0.00E+00	2.58E-06	1.02E-05	3.57E-05	0.00E+00	3.07E-07	1.21E-06	4.21E-06
L-IXRESIN	SLD	AS IS	8.61E-09	4.49E-05	5.53E-05	8.02E-05	2.20E-09	5.89E-06	7.15E-06	1.04E-05
L-IXRESIN	SLD, NIC	AS IS	0.00E+00	7.82E-05	8.68E-05	1.12E-04	0.00E+00	9.35E-06	1.04E-05	1.36E-05
L:IXRESIN	SLF	SOL	3.93E-06	2.60E-05	4.26E-05	6.49E-05	5.04E-07	3.16E-06	5.13E-06	7.77E-06
L-IXRESIN	SLD	INC/SOL	0.00E+00	4.19E-06	9.82E-06	2.88E-05	0.00E+00	4.94E-07	1.15E-06	3.35E-06
L-IXRESIN	ISD	AS IS	8.61E-09	2.96E-05	3.26E-05	4.31E-05	2.20E-09	3.57E-06	3.93E-06	5.38E-06
L-IXRESIN	ISD, NIC	AS IS	0.00E+00	5.99E-05	6.40E-05	7.44E-05	0.00E+00	7.14E-06	7.63E-06	9.07E-06
L-IXRESIN,	ISD, NIC	SOL	0.00E+00	5.69E-07	2.39E-06	1.24E-05	0.00E+00	6.77E-08	2.84E-07	1.45E-06
L-IXRESIN	ISD	SOL	0.00E+00	1.03E-06	2.85E-06	1.29E-05	0.00E+00	1.23E-07	3.39E-07	1.51E-06
L-IXRESIN	IDD	AS IS	8.61E-09	2.45E-05	2.69E-05	3.41E-05	2.20E-09	2.93E-06	3.22E-06	4.24E-06
L-IXRESIN	ISD	INC/SOL	0.00E+00	7.39E-07	2.04E-06	9.27E-06	0.00E+00	8.69E-08	2.40E-07	1.07E-06
L-IXRESIN	IDD	SOL	0.00E+00	6.79E-07	1.97E-06	9.09E-06	0.00E+00	8.09E-08	2.34E-07	1.07E-06
L-IXRESIN	CC	SOL	0.00E+00	3.06E-07	8.76E-07	5.18E-06	0.00E+00	3.64E-08	1.04E-07	6.05E-07
L-IXRESIN	CB	SOL	0.00E+00	2.29E-07	6.53E-07	4.47E-06	0.00E+00	2.72E-08	7.77E-08	5.22E-07
L-IXRESIN	HF	SOL	0.00E+00	0.00E+00	0.00E+00	2.00E-06	0.00E+00	0.00E+00	0.00E+00	2.21E-07

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-NCTRASH	SLF	AS IS	8.49E-06	1.26E-05	1.35E-05	1.44E-05	2.09E-06	3.06E-06	3.17E-06	3.28E-06
L-NCTRASH	SLD, NIC	AS IS	0.00E+00	7.46E-07	9.53E-07	1.55E-06	0.00E+00	9.09E-08	1.23E-07	2.27E-07
L-NCTRASH	SLD	AS IS	8.03E-11	5.08E-07	7.54E-07	1.35E-06	2.06E-11	6.90E-08	1.05E-07	2.06E-07
L-NCTRASH	ISD	AS IS	8.03E-11	3.06E-07	3.78E-07	6.48E-07	2.06E-11	3.76E-08	4.84E-08	1.02E-07
L-NCTRASH	ISD, NIC	AS IS	0.00E+00	5.49E-07	6.37E-07	9.07E-07	0.00E+00	6.60E-08	7.88E-08	1.33E-07
L-NCTRASH	SLD, NIC	SOL	0.00E+00	2.40E-08	9.43E-08	3.31E-07	0.00E+00	2.86E-09	1.12E-08	3.91E-08
L-NCTRASH	SLD	SOL	0.00E+00	5.26E-08	1.23E-07	3.60E-07	0.00E+00	6.28E-09	1.47E-08	4.26E-08
L-NCTRASH	SLF	SOL	3.65E-08	2.42E-07	3.96E-07	6.04E-07	4.68E-09	2.94E-08	4.78E-08	7.25E-08
L-NCTRASH	IDD	AS IS	8.03E-11	2.39E-07	3.07E-07	4.97E-07	2.06E-11	2.89E-08	3.85E-08	7.76E-08
L-NCTRASH	EM	SOL	0.00E+00	3.03E-08	7.27E-08	2.16E-07	0.00E+00	3.61E-09	8.65E-09	2.55E-08
L-NCTRASH	ISD	SOL	0.00E+00	9.59E-09	2.65E-08	1.20E-07	0.00E+00	1.14E-09	3.16E-09	1.41E-08
L-NCTRASH	ISD, NIC	SOL	0.00E+00	5.29E-09	2.22E-08	1.15E-07	0.00E+00	6.30E-10	2.64E-09	1.35E-08
L-NCTRASH	IDD	SOL	0.00E+00	6.31E-09	1.83E-08	8.45E-08	0.00E+00	7.52E-10	2.18E-09	9.92E-09
L-NCTRASH	CC	SOL	0.00E+00	2.84E-09	8.14E-09	4.81E-08	0.00E+00	3.39E-10	9.69E-10	5.63E-09
L-NFRCOMP	SLD, NIC	SOL	0.00E+00	1.25E-06	4.89E-06	1.70E-05	0.00E+00	1.54E-07	6.06E-07	2.11E-06
L-NFRCOMP	SLD	SOL	0.00E+00	2.74E-06	6.38E-06	1.85E-05	0.00E+00	3.39E-07	7.91E-07	2.29E-06
L-NFRCOMP	SLF	SOL	1.78E-06	1.23E-05	2.03E-05	3.10E-05	2.21E-07	1.53E-06	2.52E-06	3.85E-06
L-NFRCOMP	SLD, NIC	AS IS	0.00E+00	1.44E-06	4.55E-06	1.50E-05	0.00E+00	1.78E-07	5.63E-07	1.84E-06
L-NFRCOMP	SLD	AS IS	0.00E+00	2.24E-06	5.35E-06	1.57E-05	0.00E+00	2.78E-07	6.63E-07	1.94E-06
L-NFRCOMP	SLF	AS IS	2.69E-06	1.27E-05	2.02E-05	3.03E-05	3.35E-07	1.57E-06	2.51E-06	3.77E-06
L-NFRCOMP	EM	SOL	0.00E+00	1.57E-06	3.77E-06	1.11E-05	0.00E+00	1.95E-07	4.67E-07	1.37E-06
L-NFRCOMP	ISD, NIC	SOL	0.00E+00	2.75E-07	1.15E-06	5.90E-06	0.00E+00	3.40E-08	1.43E-07	7.32E-07
L-NFRCOMP	ISD	SOL	0.00E+00	4.98E-07	1.38E-06	6.13E-06	0.00E+00	6.17E-08	1.70E-07	7.59E-07
L-NFRCOMP	IDD	SOL	0.00E+00	3.28E-07	9.51E-07	4.32E-06	0.00E+00	4.06E-08	1.18E-07	5.36E-07
L-NFRCOMP	ISD	AS IS	0.00E+00	2.86E-07	8.69E-07	4.03E-06	0.00E+00	3.55E-08	1.08E-07	4.99E-07
L-NFRCOMP	ISD, NIC	AS IS	0.00E+00	1.78E-07	7.61E-07	3.92E-06	0.00E+00	2.21E-08	9.43E-08	4.85E-07
L-NFRCOMP	IDD	AS IS	0.00E+00	1.70E-07	5.70E-07	2.74E-06	0.00E+00	2.10E-08	7.06E-08	3.40E-07
L-NFRCOMP	CC	SOL	0.00E+00	1.48E-07	4.23E-07	2.45E-06	0.00E+00	1.83E-08	5.23E-08	3.03E-07

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Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-ISOPROD	SLF	AS IS	2.12E-03	3.00E-03	3.28E-03	3.47E-03	2.80E-04	4.22E-04	4.52E-04	4.73E-04
N-ISOPROD	SLD	AS IS	1.20E-08	3.32E-05	1.09E-04	2.10E-04	2.66E-09	3.91E-06	1.22E-05	2.33E-05
N-ISOPROD	SLD, NIC	AS IS	0.00E+00	8.96E-06	7.05E-05	1.70E-04	0.00E+00	1.00E-06	7.75E-06	1.86E-05
N-ISOPROD	ISD	AS IS	1.20E-08	5.22E-06	2.63E-05	6.09E-05	2.66E-09	5.92E-07	2.90E-06	6.69E-06
N-ISOPROD	ISD, NIC	AS IS	0.00E+00	2.81E-06	2.14E-05	5.54E-05	0.00E+00	3.17E-07	2.35E-06	6.06E-06
N-ISOPROD	IDD	AS IS	1.20E-08	2.20E-06	1.49E-05	3.77E-05	2.66E-09	2.48E-07	1.64E-06	4.13E-06
N-ISOPROD	SLF	SOL	7.56E-07	1.49E-06	1.81E-06	2.13E-06	8.82E-08	1.93E-07	2.29E-07	2.66E-07
N-ISOPROD	SLD	SOL	0.00E+00	4.33E-08	1.09E-07	2.87E-07	0.00E+00	5.30E-09	1.31E-08	3.46E-08
N-ISOPROD	SLD, NIC	SOL	0.00E+00	1.74E-08	7.79E-08	2.54E-07	0.00E+00	2.12E-09	9.36E-09	3.07E-08
N-ISOPROD	SLD	INC/SOL	0.00E+00	3.38E-08	8.60E-08	2.23E-07	0.00E+00	4.12E-09	1.03E-08	2.68E-08
N-ISOPROD	ISD	SOL	0.00E+00	6.80E-09	1.98E-08	8.19E-08	0.00E+00	8.33E-10	2.41E-09	1.00E-08
N-ISOPROD	ISD, NIC	SOL	0.00E+00	3.59E-09	1.62E-08	7.81E-08	0.00E+00	4.41E-10	1.97E-09	9.56E-09
N-ISOPROD	ISD	INC/SOL	0.00E+00	4.96E-09	1.47E-08	5.96E-08	0.00E+00	6.07E-10	1.78E-09	7.26E-09
N-ISOPROD	IDD	SOL	0.00E+00	4.39E-09	1.34E-08	5.72E-08	0.00E+00	5.38E-10	1.64E-09	7.01E-09
N-ISOPROD	CC	SOL	0.00E+00	1.99E-09	5.94E-09	3.19E-08	0.00E+00	2.44E-10	7.24E-10	3.91E-09
N-ISOPROD	CB	SOL	0.00E+00	1.51E-09	4.49E-09	2.75E-08	0.00E+00	1.85E-10	5.47E-10	3.38E-09
N-LOTRASH	SLD, NIC	SOL	0.00E+00	3.17E-07	1.25E-06	4.35E-06	0.00E+00	3.93E-08	1.54E-07	5.37E-07
N-LOTRASH	SLD	SOL	0.00E+00	6.97E-07	1.63E-06	4.73E-06	0.00E+00	8.63E-08	2.02E-07	5.85E-07
N-LOTRASH	SLF	SOL	4.53E-07	3.14E-06	5.17E-06	7.89E-06	5.61E-08	3.88E-07	6.40E-07	9.77E-07
N-LOTRASH	SLD	INC/SOL	0.00E+00	5.10E-07	1.19E-06	3.46E-06	0.00E+00	6.31E-08	1.48E-07	4.29E-07
N-LOTRASH	EN	SOL	0.00E+00	4.01E-07	9.62E-07	2.82E-06	0.00E+00	4.97E-08	1.19E-07	3.50E-07
N-LOTRASH	ISD, NIC	SOL	0.00E+00	7.00E-08	2.94E-07	1.50E-06	0.00E+00	8.67E-09	3.64E-08	1.86E-07
N-LOTRASH	ISD	SOL	0.00E+00	1.27E-07	3.51E-07	1.56E-06	0.00E+00	1.57E-08	4.34E-08	1.93E-07
N-LOTRASH	IDD	SOL	0.00E+00	8.37E-08	2.42E-07	1.10E-06	0.00E+00	1.04E-08	3.00E-08	1.37E-07
N-LOTRASH	ISD	INC/SOL	0.00E+00	8.98E-08	2.48E-07	1.11E-06	0.00E+00	1.11E-08	3.07E-08	1.37E-07
N-LOTRASH	CC	SOL	0.00E+00	3.77E-08	1.08E-07	6.26E-07	0.00E+00	4.66E-09	1.33E-08	7.74E-08
N-LOTRASH	SLF	AS IS	7.67E-06	7.81E-06	7.82E-06	7.83E-06	9.92E-07	1.03E-06	1.03E-06	1.03E-06
N-LOTRASH	SLD	AS IS	4.21E-12	5.12E-06	5.12E-06	5.12E-06	9.31E-13	6.34E-07	6.34E-07	6.34E-07
N-LOTRASH	SLD, NIC	AS IS	0.00E+00	9.48E-06	9.48E-06	9.48E-06	0.00E+00	1.17E-06	1.17E-06	1.17E-06
N-LOTRASH	IDD	AS IS	4.21E-12	3.07E-06	3.42E-06	3.42E-06	9.31E-13	3.80E-07	4.23E-07	4.23E-07
N-LOTRASH	ISD	AS IS	4.21E-12	3.81E-06	3.86E-06	3.86E-06	9.31E-13	4.72E-07	4.78E-07	4.78E-07
N-LOTRASH	ISD, NIC	AS IS	0.00E+00	7.16E-06	7.51E-06	7.51E-06	0.00E+00	8.86E-07	9.30E-07	9.30E-07

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Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-LOWASTE	SLD	SOL	0.00E+00	3.98E-07	9.29E-07	2.70E-06	0.00E+00	4.93E-08	1.15E-07	3.34E-07
N-LOWASTE	SLD, NIC	SOL	0.00E+00	1.81E-07	7.12E-07	2.48E-06	0.00E+00	2.24E-08	8.82E-08	3.07E-07
N-LOWASTE	SLF	SOL	2.59E-07	1.79E-06	2.95E-06	4.50E-06	3.20E-08	2.22E-07	3.66E-07	5.58E-07
N-LOWASTE	SLD	INC/SOL	0.00E+00	2.91E-07	6.81E-07	1.98E-06	0.00E+00	3.60E-08	8.43E-08	2.44E-07
N-LOWASTE	EM	SOL	0.00E+00	2.29E-07	5.49E-07	1.61E-06	0.00E+00	2.84E-08	6.79E-08	2.00E-07
N-LOWASTE	ISD, NIC	SOL	0.00E+00	4.00E-08	1.68E-07	8.60E-07	0.00E+00	4.95E-09	2.08E-08	1.07E-07
N-LOWASTE	ISD	SOL	0.00E+00	7.26E-08	2.00E-07	8.92E-07	0.00E+00	8.98E-09	2.48E-08	1.11E-07
N-LOWASTE	IDD	SOL	0.00E+00	4.77E-08	1.38E-07	6.29E-07	0.00E+00	5.91E-09	1.71E-08	7.79E-08
N-LOWASTE	ISD	INC/SOL	0.00E+00	5.13E-08	1.42E-07	6.32E-07	0.00E+00	6.35E-09	1.75E-08	7.81E-08
N-LOWASTE	CC	SOL	0.00E+00	2.15E-08	6.15E-08	3.58E-07	0.00E+00	2.66E-09	7.62E-09	4.42E-08
N-LOWASTE	IDD	AS IS	2.91E-12	1.69E-06	1.73E-06	1.73E-06	6.56E-13	2.09E-07	2.14E-07	2.14E-07
N-LOWASTE	ISD, NIC	AS IS	0.00E+00	4.18E-06	4.29E-06	4.29E-06	0.00E+00	5.18E-07	5.31E-07	9.31E-07
N-LOWASTE	ISD	AS IS	2.91E-12	2.02E-06	2.02E-06	2.02E-06	6.56E-13	2.50E-07	2.50E-07	2.50E-07
N-LOWASTE	SLF	AS IS	6.01E-06	6.10E-06	6.10E-06	6.10E-06	7.60E-07	7.83E-07	7.83E-07	7.83E-07
N-LOWASTE	SLD, NIC	AS IS	0.00E+00	5.41E-06	5.41E-06	5.41E-06	0.00E+00	6.70E-07	6.70E-07	6.70E-07
N-LOWASTE	SLD	AS IS	2.91E-12	2.64E-06	2.64E-06	2.64E-06	6.56E-13	3.27E-07	3.27E-07	3.27E-07
N-SOURCES	SLF	SOL	3.13E-05	6.92E-05	8.18E-05	9.52E-05	7.77E-06	1.57E-05	1.71E-05	1.87E-05
N-SOURCES	SLF	AS IS	4.19E-05	7.08E-05	8.08E-05	9.19E-05	1.04E-05	1.62E-05	1.74E-05	1.87E-05
N-SOURCES	SLD	SOL	0.00E+00	2.30E-06	5.56E-06	1.50E-05	0.00E+00	3.00E-07	6.93E-07	1.85E-06
N-SOURCES	SLD, NIC	SOL	0.00E+00	9.50E-07	4.04E-06	1.35E-05	0.00E+00	1.17E-07	4.93E-07	1.64E-06
N-SOURCES	SLD	AS IS	0.00E+00	1.81E-06	4.45E-06	1.24E-05	0.00E+00	2.31E-07	5.52E-07	1.52E-06
N-SOURCES	SLD, NIC	AS IS	0.00E+00	1.10E-06	3.68E-06	1.16E-05	0.00E+00	1.36E-07	4.51E-07	1.42E-06
N-SOURCES	ISD	SOL	0.00E+00	3.79E-07	1.08E-06	4.57E-06	0.00E+00	4.73E-08	1.33E-07	5.63E-07
N-SOURCES	ISD, NIC	SOL	0.00E+00	2.03E-07	8.85E-07	4.37E-06	0.00E+00	2.51E-08	1.09E-07	5.39E-07
N-SOURCES	IDD	SOL	0.00E+00	2.46E-07	7.35E-07	3.21E-06	0.00E+00	3.06E-08	9.05E-08	3.96E-07
N-SOURCES	ISD, NIC	AS IS	0.00E+00	1.31E-07	5.79E-07	2.89E-06	0.00E+00	1.62E-08	7.12E-08	3.55E-07
N-SOURCES	ISD	AS IS	0.00E+00	2.13E-07	6.66E-07	2.98E-06	0.00E+00	2.64E-08	8.20E-08	3.67E-07
N-SOURCES	IDD	AS IS	0.00E+00	1.25E-07	4.33E-07	2.01E-06	0.00E+00	1.55E-08	5.33E-08	2.48E-07
N-SOURCES	CC	SOL	0.00E+00	1.11E-07	3.26E-07	1.80E-06	0.00E+00	1.39E-08	4.02E-08	2.22E-07
N-SOURCES	CB	SOL	0.00E+00	8.40E-08	2.45E-07	1.55E-06	0.00E+00	1.05E-08	3.02E-08	1.91E-07

Table continued on next page

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-SSTRASH	SLD, NIC	AS IS	0.00E+00	1.79E-10	7.23E-10	2.31E-09	0.00E+00	5.45E-12	2.24E-11	7.09E-11
N-SSTRASH	SLD	AS IS	3.42E-16	3.27E-10	8.31E-10	2.30E-09	8.10E-18	1.00E-11	2.58E-11	7.07E-11
N-SSTRASH	ISD, NIC	AS IS	0.00E+00	5.16E-11	2.27E-10	1.57E-09	0.00E+00	1.57E-12	7.02E-12	4.81E-11
N-SSTRASH	ISD	AS IS	3.42E-16	7.58E-11	2.48E-10	1.57E-09	8.10E-18	2.31E-12	7.68E-12	4.80E-11
N-SSTRASH	IDD	AS IS	3.42E-16	3.89E-11	1.53E-10	1.20E-09	8.10E-18	1.19E-12	4.74E-12	3.68E-11
N-SSTRASH	SLF	AS IS	3.40E-10	1.64E-09	2.24E-09	2.51E-09	1.03E-11	5.06E-11	7.03E-11	7.84E-11
N-SSTRASH	SLF	SOL	1.60E-13	1.38E-12	2.36E-12	7.15E-12	4.86E-15	4.23E-14	7.36E-14	2.20E-13
N-SSTRASH	SLD, NIC	SOL	0.00E+00	4.59E-14	1.93E-13	8.15E-13	0.00E+00	1.40E-15	5.96E-15	2.50E-14
N-SSTRASH	SLD	SOL	0.00E+00	9.21E-14	2.39E-13	8.61E-13	0.00E+00	2.82E-15	7.42E-15	2.64E-14
N-SSTRASH	SLD	INC/SOL	0.00E+00	8.61E-14	2.24E-13	8.06E-13	0.00E+00	2.63E-15	6.94E-15	2.47E-14
N-SSTRASH	EN	SOL	0.00E+00	3.25E-14	8.45E-14	3.05E-13	0.00E+00	9.93E-16	2.62E-15	9.34E-15
N-SSTRASH	ISD, NIC	SOL	0.00E+00	5.25E-15	2.31E-14	1.63E-13	0.00E+00	1.63E-16	7.29E-16	5.00E-15
N-SSTRASH	ISD	SOL	0.00E+00	9.25E-15	2.75E-14	1.68E-13	0.00E+00	2.83E-16	8.52E-16	5.12E-15
N-SSTRASH	ISD	INC/SOL	0.00E+00	8.46E-15	2.52E-14	1.53E-13	0.00E+00	2.58E-16	7.79E-16	4.68E-15
N-SSTRASH	IDD	SOL	0.00E+00	5.58E-15	1.74E-14	1.08E-13	0.00E+00	1.70E-16	5.39E-16	3.30E-15
N-SSTRASH	CC	SOL	0.00E+00	2.35E-15	7.21E-15	6.13E-14	0.00E+00	7.19E-17	2.23E-16	1.87E-15
N-SSWASTE	SLD, NIC	AS IS	0.00E+00	3.47E-09	1.41E-08	4.50E-08	0.00E+00	1.06E-10	4.34E-10	1.38E-09
N-SSWASTE	SLD	AS IS	6.65E-15	6.36E-09	1.62E-08	4.48E-08	1.57E-16	1.94E-10	5.01E-10	1.37E-09
N-SSWASTE	ISD, NIC	AS IS	0.00E+00	1.00E-09	4.42E-09	3.05E-08	0.00E+00	3.05E-11	1.37E-10	9.35E-10
N-SSWASTE	ISD	AS IS	6.65E-15	1.47E-09	4.82E-09	3.04E-08	1.57E-16	4.50E-11	1.49E-10	9.31E-10
N-SSWASTE	IDD	AS IS	6.65E-15	7.55E-10	2.98E-09	2.34E-08	1.57E-16	2.30E-11	9.21E-11	7.15E-10
N-SSWASTE	SLF	AS IS	6.60E-09	3.19E-08	4.35E-08	4.87E-08	2.00E-10	9.83E-10	1.37E-09	1.53E-09
N-SSWASTE	SLF	SOL	3.11E-12	2.68E-11	4.58E-11	1.39E-10	9.44E-14	8.23E-13	1.43E-12	4.27E-12
N-SSWASTE	SLD	SOL	0.00E+00	1.79E-12	4.65E-12	1.68E-11	0.00E+00	5.47E-14	1.44E-13	5.13E-13
N-SSWASTE	SLD, NIC	SOL	0.00E+00	8.92E-13	3.75E-12	1.59E-11	0.00E+00	2.72E-14	1.16E-13	4.85E-13
N-SSWASTE	EN	SOL	0.00E+00	6.31E-13	1.64E-12	5.91E-12	0.00E+00	1.93E-14	5.09E-14	1.82E-13
N-SSWASTE	ISD	SOL	0.00E+00	1.80E-13	5.35E-13	3.25E-12	0.00E+00	5.49E-15	1.66E-14	9.95E-14
N-SSWASTE	ISD, NIC	SOL	0.00E+00	1.02E-13	4.49E-13	3.16E-12	0.00E+00	3.17E-15	1.42E-14	9.71E-14
N-SSWASTE	IDD	SOL	0.00E+00	1.08E-13	3.38E-13	2.10E-12	0.00E+00	3.31E-15	1.05E-14	6.42E-14
N-SSWASTE	CC	SOL	0.00E+00	4.57E-14	1.40E-13	1.19E-12	0.00E+00	1.40E-15	4.34E-15	3.64E-14

Table continued on next page

Table F-15 (Continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-TARGETS	SLF	SOL	3.01E-06	3.12E-06	3.12E-06	3.12E-06	7.56E-07	7.84E-07	7.84E-07	7.84E-07
N-TARGETS	SLF	AS IS	1.15E-05	1.16E-05	1.16E-05	1.16E-05	2.89E-06	2.92E-06	2.92E-06	2.92E-06
N-TARGETS	SLD, NIC	SOL	0.00E+00	5.40E-14	5.40E-14	5.40E-14	0.00E+00	1.36E-14	1.36E-14	1.36E-14
N-TARGETS	SLD	SOL	0.00E+00	3.41E-10	3.41E-10	3.41E-10	0.00E+00	8.59E-11	8.59E-11	8.59E-11
N-TARGETS	SLD, NIC	AS IS	0.00E+00	2.50E-13	2.50E-13	2.50E-13	0.00E+00	6.28E-14	6.28E-14	6.28E-14
N-TARGETS	SLD	AS IS	0.00E+00	1.35E-10	1.35E-10	1.35E-10	0.00E+00	3.39E-11	3.39E-11	3.39E-11
N-TARGETS	ISD, NIC	SOL	0.00E+00	1.04E-14	1.04E-14	1.04E-14	0.00E+00	2.66E-15	2.66E-15	2.66E-15
N-TARGETS	ISD	SOL	0.00E+00	2.22E-12	2.22E-12	2.22E-12	0.00E+00	5.58E-13	5.58E-13	5.58E-13
N-TARGETS	IDD	SOL	0.00E+00	4.84E-13	4.84E-13	4.84E-13	0.00E+00	1.22E-13	1.22E-13	1.22E-13
N-TARGETS	ISD, NIC	AS IS	0.00E+00	6.27E-15	6.27E-15	6.27E-15	0.00E+00	1.58E-15	1.58E-15	1.58E-15
N-TARGETS	ISD	AS IS	0.00E+00	1.70E-13	1.70E-13	1.70E-13	0.00E+00	4.28E-14	4.28E-14	4.28E-14
N-TARGETS	IDD	AS IS	0.00E+00	2.27E-14	2.27E-14	2.27E-14	0.00E+00	5.72E-15	5.72E-15	5.72E-15
N-TARGETS	CC	SOL	0.00E+00	1.12E-12	1.12E-12	1.12E-12	0.00E+00	2.82E-13	2.82E-13	2.82E-13
N-TARGETS	CB	SOL	0.00E+00	1.57E-12	1.57E-12	1.57E-12	0.00E+00	3.94E-13	3.94E-13	3.94E-13
N-TRITIUM	SLD	SOL	0.00E+00	1.17E-04	2.74E-04	7.95E-04	0.00E+00	1.45E-05	3.39E-05	9.84E-05
N-TRITIUM	SLD, NIC	SOL	0.00E+00	5.34E-05	2.10E-04	7.31E-04	0.00E+00	6.61E-06	2.60E-05	9.05E-05
N-TRITIUM	SLF	SOL	7.70E-05	5.29E-04	8.72E-04	1.33E-03	9.65E-06	6.56E-05	1.08E-04	1.65E-04
N-TRITIUM	SLD	INC/SOL	0.00E+00	8.58E-05	2.01E-04	5.83E-04	0.00E+00	1.06E-05	2.48E-05	7.21E-05
N-TRITIUM	ISD, NIC	SOL	0.00E+00	1.18E-05	4.94E-05	2.53E-04	0.00E+00	1.46E-06	6.12E-06	3.14E-05
N-TRITIUM	ISD	SOL	0.00E+00	2.14E-05	5.90E-05	2.63E-04	0.00E+00	2.65E-06	7.31E-06	3.26E-05
N-TRITIUM	IDD	SOL	0.00E+00	1.41E-05	4.08E-05	1.86E-04	0.00E+00	1.74E-06	5.05E-06	2.30E-05
N-TRITIUM	ISD	INC/SOL	0.00E+00	1.51E-05	4.18E-05	1.86E-04	0.00E+00	1.87E-06	5.17E-06	2.31E-05
N-TRITIUM	CC	SOL	0.00E+00	6.34E-06	1.81E-05	1.05E-04	0.00E+00	7.85E-07	2.25E-06	1.31E-05
N-TRITIUM	CB	SOL	0.00E+00	4.74E-06	1.35E-05	9.07E-05	0.00E+00	5.87E-07	1.67E-06	1.12E-05
N-TRITIUM	IDD	AS IS	2.52E-10	5.16E-04	5.75E-04	5.75E-04	3.94E-11	6.39E-05	7.12E-05	7.12E-05
N-TRITIUM	ISD, NIC	AS IS	0.00E+00	1.20E-03	1.26E-03	1.26E-03	0.00E+00	1.49E-04	1.56E-04	1.56E-04
N-TRITIUM	ISD	AS IS	2.52E-10	6.42E-04	6.49E-04	6.49E-04	3.94E-11	7.94E-05	8.04E-05	8.04E-05
N-TRITIUM	SLD, NIC	AS IS	0.00E+00	1.60E-03	1.60E-03	1.60E-03	0.00E+00	1.97E-04	1.97E-04	1.97E-04
N-TRITIUM	SLD	AS IS	2.52E-10	8.61E-04	8.61E-04	8.61E-04	3.94E-11	1.07E-04	1.07E-04	1.07E-04
N-TRITIUM	SLF	AS IS	1.35E-03	1.35E-03	1.35E-03	1.35E-03	1.82E-04	1.82E-04	1.82E-04	1.82E-04

Table continued on next page

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
P-FCARTRG	SLF	AS IS	8.18E-06	2.38E-05	3.55E-05	4.78E-05	1.96E-06	4.70E-06	6.30E-06	7.87E-06
P-FCARTRG	SLD, NIC	AS IS	0.00E+00	1.06E-06	4.03E-06	1.24E-05	0.00E+00	1.63E-07	6.71E-07	2.32E-06
P-FCARTRG	SLD	AS IS	8.49E-11	1.74E-06	5.23E-06	1.35E-05	2.33E-11	2.98E-07	8.58E-07	2.46E-06
P-FCARTRG	ISD, NIC	AS IS	0.00E+00	5.89E-07	1.50E-06	5.36E-06	0.00E+00	8.09E-08	2.37E-07	1.14E-06
P-FCARTRG	ISD	AS IS	8.49E-11	4.96E-07	1.48E-06	5.34E-06	2.33E-11	7.73E-08	2.41E-07	1.14E-06
P-FCARTRG	IDD	AS IS	8.49E-11	3.04E-07	9.25E-07	3.66E-06	2.33E-11	4.46E-08	1.50E-07	8.05E-07
P-FCARTRG	SLD	SOL	0.00E+00	4.51E-08	1.06E-07	3.09E-07	0.00E+00	5.45E-09	1.28E-08	3.71E-08
P-FCARTRG	SLD, NIC	SOL	0.00E+00	2.05E-08	8.10E-08	2.84E-07	0.00E+00	2.47E-09	9.77E-09	3.41E-08
P-FCARTRG	SLF	SOL	3.14E-08	2.14E-07	3.54E-07	5.50E-07	4.06E-09	2.67E-08	4.37E-08	6.86E-08
P-FCARTRG	EM	SOL	0.00E+00	2.59E-08	6.22E-08	1.83E-07	0.00E+00	3.12E-09	7.49E-09	2.20E-08
P-FCARTRG	ISD, NIC	SOL	0.00E+00	4.51E-09	1.90E-08	9.82E-08	0.00E+00	5.42E-10	2.28E-09	1.17E-08
P-FCARTRG	ISD	SOL	0.00E+00	8.18E-09	2.27E-08	1.02E-07	0.00E+00	9.86E-10	2.73E-09	1.21E-08
P-FCARTRG	IDD	SOL	0.00E+00	5.38E-09	1.56E-08	7.18E-08	0.00E+00	6.48E-10	1.88E-09	8.56E-09
P-FCARTRG	CC	SOL	0.00E+00	2.42E-09	6.95E-09	4.08E-08	0.00E+00	2.92E-10	8.37E-10	4.86E-09
R-RAIXRSN	SLF	AS IS	3.77E-05	5.49E-04	9.91E-04	1.73E-03	7.14E-06	1.04E-04	1.88E-04	3.28E-04
R-RAIXRSN	SLD, NIC	AS IS	0.00E+00	3.34E-05	1.71E-04	5.89E-04	0.00E+00	6.32E-06	3.24E-05	1.12E-04
R-RAIXRSN	SLD	AS IS	2.85E-10	7.57E-05	2.12E-04	6.23E-04	5.39E-11	1.43E-05	4.01E-05	1.18E-04
R-RAIXRSN	ISD, NIC	AS IS	0.00E+00	9.44E-06	4.93E-05	1.93E-04	0.00E+00	1.79E-06	9.34E-06	3.67E-05
R-RAIXRSN	ISD	AS IS	2.85E-10	1.66E-05	5.65E-05	2.00E-04	5.39E-11	3.15E-06	1.07E-05	3.80E-05
R-RAIXRSN	IDD	AS IS	2.85E-10	9.28E-06	3.52E-05	1.31E-04	5.39E-11	1.76E-06	6.67E-06	2.49E-05
R-RAIXRSN	SLF	SOL	2.31E-08	3.33E-07	5.51E-07	1.29E-06	4.37E-09	6.30E-08	1.05E-07	2.46E-07
R-RAIXRSN	SLD, NIC	SOL	0.00E+00	8.29E-09	3.99E-08	1.01E-07	0.00E+00	1.57E-09	7.56E-09	1.92E-08
R-RAIXRSN	SLD	SOL	0.00E+00	1.98E-08	5.17E-08	1.13E-07	0.00E+00	3.76E-09	9.80E-09	2.14E-08
R-RAIXRSN	SLD	INC/SOL	0.00E+00	1.85E-08	4.84E-08	1.05E-07	0.00E+00	3.52E-09	9.17E-09	2.00E-08
R-RAIXRSN	ISD	SOL	0.00E+00	1.92E-09	5.84E-09	1.62E-08	0.00E+00	3.64E-10	1.11E-09	3.08E-09
R-RAIXRSN	ISD, NIC	SOL	0.00E+00	9.60E-10	4.83E-09	1.52E-08	0.00E+00	1.83E-10	9.21E-10	2.89E-09
R-RAIXRSN	ISD	INC/SOL	0.00E+00	1.76E-09	5.34E-09	1.48E-08	0.00E+00	3.33E-10	1.01E-09	2.81E-09
R-RAIXRSN	IDD	SOL	0.00E+00	1.14E-09	3.67E-09	1.04E-08	0.00E+00	2.16E-10	6.97E-10	1.97E-09
R-RAIXRSN	CC	SOL	0.00E+00	4.88E-10	1.52E-09	4.85E-09	0.00E+00	9.24E-11	2.89E-10	9.21E-10
R-RAIXRSN	CB	SOL	0.00E+00	4.02E-10	1.25E-09	4.28E-09	0.00E+00	7.63E-11	2.37E-10	8.13E-10
R-RAIXRSN	NF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-15 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID IMPERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
R-RASOURC	SLF	AS IS	5.41E+00	7.89E+01	1.42E+02	2.48E+02	9.83E-01	1.43E+01	2.59E+01	4.52E+01
R-RASOURC	SLD, NIC	AS IS	0.00E+00	4.79E+00	2.45E+01	8.46E+01	0.00E+00	8.70E-01	4.46E+00	1.54E+01
R-RASOURC	SLD	AS IS	4.09E-05	1.09E+01	3.04E+01	8.94E+01	7.43E-06	1.97E+00	5.52E+00	1.62E+01
R-RASOURC	ISD, NIC	AS IS	0.00E+00	1.36E+00	7.08E+00	2.79E+01	0.00E+00	2.46E-01	1.29E+00	5.07E+00
R-RASOURC	ISD	AS IS	4.09E-05	2.39E+00	8.11E+00	2.88E+01	7.43E-06	4.33E-01	1.47E+00	5.23E+00
R-RASOURC	IDD	AS IS	4.09E-05	1.33E+00	5.05E+00	1.89E+01	7.43E-06	2.42E-01	9.18E-01	3.43E+00
R-RASOURC	SLF	SOL	3.31E-03	4.78E-02	7.92E-02	1.86E-01	6.01E-04	8.68E-03	1.44E-02	3.38E-02
R-RASOURC	SLD	SOL	0.00E+00	2.85E-03	7.43E-03	1.62E-02	0.00E+00	5.17E-04	1.35E-03	2.94E-03
R-RASOURC	SLD, NIC	SOL	0.00E+00	1.19E-03	5.73E-03	1.45E-02	0.00E+00	2.16E-04	1.04E-03	2.63E-03
R-RASOURC	ISD, NIC	SOL	0.00E+00	1.38E-04	6.94E-04	2.18E-03	0.00E+00	2.52E-05	1.27E-04	3.98E-04
R-RASOURC	ISD	SOL	0.00E+00	2.76E-04	8.39E-04	2.33E-03	0.00E+00	5.01E-05	1.52E-04	4.23E-04
R-RASOURC	IDD	SOL	0.00E+00	1.64E-04	5.28E-04	1.49E-03	0.00E+00	2.97E-05	9.59E-05	2.72E-04
R-RASOURC	CC	SOL	0.00E+00	7.01E-05	2.19E-04	6.97E-04	0.00E+00	1.27E-05	3.98E-05	1.27E-04
R-RASOURC	CB	SOL	0.00E+00	5.78E-05	1.80E-04	6.16E-04	0.00E+00	1.05E-05	3.26E-05	1.12E-04
U-PROCESS	SLD, NIC	AS IS	0.00E+00	1.17E-08	4.73E-08	1.51E-07	0.00E+00	3.79E-10	1.57E-09	4.94E-09
U-PROCESS	SLD	AS IS	2.25E-14	2.16E-08	5.46E-08	1.50E-07	5.68E-16	7.06E-10	1.82E-09	4.93E-09
U-PROCESS	ISD, NIC	AS IS	0.00E+00	3.37E-09	1.49E-08	1.03E-07	0.00E+00	1.09E-10	4.93E-10	3.34E-09
U-PROCESS	ISD	AS IS	2.25E-14	5.20E-09	1.65E-08	1.02E-07	5.68E-16	1.69E-10	5.48E-10	3.34E-09
U-PROCESS	IDD	AS IS	2.25E-14	3.01E-09	1.05E-08	7.88E-08	5.68E-16	9.80E-11	3.48E-10	2.57E-09
U-PROCESS	SLF	AS IS	1.54E-08	1.05E-07	1.46E-07	1.64E-07	4.95E-10	3.45E-09	4.96E-09	5.55E-09
U-PROCESS	SLF	SOL	1.04E-11	8.99E-11	1.54E-10	4.66E-10	3.37E-13	2.96E-12	5.19E-12	1.54E-11
U-PROCESS	SLD	SOL	0.00E+00	6.01E-12	1.56E-11	5.62E-11	0.00E+00	1.96E-13	5.21E-13	1.84E-12
U-PROCESS	SLD, NIC	SOL	0.00E+00	2.99E-12	1.26E-11	5.32E-11	0.00E+00	9.72E-14	4.18E-13	1.74E-12
U-PROCESS	EM	SOL	0.00E+00	2.12E-12	5.52E-12	1.98E-11	0.00E+00	6.92E-14	1.84E-13	6.50E-13
U-PROCESS	ISD	SOL	0.00E+00	6.04E-13	1.80E-12	1.09E-11	0.00E+00	1.97E-14	5.98E-14	3.56E-13
U-PROCESS	ISD, NIC	SOL	0.00E+00	3.42E-13	1.51E-12	1.06E-11	0.00E+00	1.13E-14	5.11E-14	3.47E-13
U-PROCESS	IDD	SOL	0.00E+00	3.64E-13	1.14E-12	7.03E-12	0.00E+00	1.19E-14	3.78E-14	2.30E-13
U-PROCESS	CC	SOL	0.00E+00	1.54E-13	4.71E-13	4.00E-12	0.00E+00	5.01E-15	1.57E-14	1.31E-13

SOURCE: PUTNAM, HAYES, & BARTLETT, INC., 20-Aug 86

Table F-16

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
F-COTRASH	SLF	AS IS	5.90E-12	9.11E-12	9.50E-12	1.28E-09	9.55E-14	2.22E-13	2.62E-13	3.73E-11
F-COTRASH	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	2.22E-11	0.00E+00	0.00E+00	0.00E+00	6.47E-13
F-COTRASH	IDO	AS IS	5.90E-16	9.11E-16	9.50E-16	9.51E-16	9.55E-18	2.22E-17	2.62E-17	2.62E-17
F-COTRASH	SLD	AS IS	5.90E-16	9.11E-16	9.50E-16	9.51E-16	9.55E-18	2.22E-17	2.62E-17	2.62E-17
F-COTRASH	ISD	AS IS	5.90E-16	9.12E-16	9.50E-16	9.51E-16	9.55E-18	2.22E-17	2.62E-17	2.62E-17
F-COTRASH	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	IDO	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLF	AS IS	5.64E-12	8.71E-12	9.07E-12	1.23E-09	9.13E-14	2.13E-13	2.50E-13	3.57E-11
F-NCTRASH	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	2.12E-11	0.00E+00	0.00E+00	0.00E+00	6.18E-13
F-NCTRASH	ISD	AS IS	5.64E-16	8.71E-16	9.07E-16	9.08E-16	9.13E-18	2.13E-17	2.50E-17	2.50E-17
F-NCTRASH	SLD	AS IS	5.64E-16	8.71E-16	9.07E-16	9.08E-16	9.13E-18	2.13E-17	2.50E-17	2.50E-17
F-NCTRASH	IDO	AS IS	5.64E-16	8.71E-16	9.07E-16	9.08E-16	9.13E-18	2.13E-17	2.50E-17	2.50E-17
F-NCTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	IDO	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

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Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
F-PROCESS	SLF	AS IS	1.15E-10	1.77E-10	1.84E-10	2.49E-08	1.86E-12	4.32E-12	5.09E-12	7.24E-10
F-PROCESS	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	4.32E-10	0.00E+00	0.00E+00	0.00E+00	1.26E-11
F-PROCESS	SLD	AS IS	1.15E-14	1.77E-14	1.84E-14	1.84E-14	1.85E-16	4.32E-16	5.09E-16	5.10E-16
F-PROCESS	IDD	AS IS	1.15E-14	1.77E-14	1.84E-14	1.84E-14	1.85E-16	4.32E-16	5.09E-16	5.10E-16
F-PROCESS	ISD	AS IS	1.15E-14	1.77E-14	1.84E-14	1.84E-14	1.86E-16	4.32E-16	5.09E-16	5.10E-16
F-PROCESS	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-ABSLIQD	SLF	AS IS	4.80E-05	5.71E-05	5.71E-05	5.71E-05	5.97E-06	7.10E-06	7.10E-06	7.10E-06
I-ABSLIQD	SLD	AS IS	5.83E-06	5.59E-05	5.61E-05	5.61E-05	7.23E-07	6.93E-06	6.95E-06	6.95E-06
I-ABSLIQD	ISD	AS IS	3.99E-06	4.94E-05	5.51E-05	5.54E-05	4.95E-07	6.12E-06	6.83E-06	6.87E-06
I-ABSLIQD	IDD	AS IS	3.57E-06	4.50E-05	5.41E-05	5.51E-05	4.43E-07	5.58E-06	6.70E-06	6.82E-06
I-ABSLIQD	SLD, HIC	AS IS	0.00E+00	5.00E-05	5.46E-05	5.46E-05	0.00E+00	6.20E-06	6.76E-06	6.76E-06
I-ABSLIQD	ISD, HIC	AS IS	0.00E+00	2.99E-05	5.27E-05	5.38E-05	0.00E+00	3.71E-06	6.54E-06	6.68E-06
I-ABSLIQD	SLF	SOL	1.11E-06	1.82E-05	3.01E-05	4.80E-05	1.38E-07	2.25E-06	3.73E-06	5.94E-06
I-ABSLIQD	DWI	AS IS	NA	NA	5.74E-14	4.60E-05	NA	NA	1.64E-14	5.70E-06
I-ABSLIQD	SLD	SOL	4.98E-07	8.43E-06	1.56E-05	4.19E-05	6.17E-08	1.05E-06	1.93E-06	5.19E-06
I-ABSLIQD	EM	SOL	5.23E-07	8.19E-06	1.52E-05	4.06E-05	6.48E-08	1.02E-06	1.88E-06	5.03E-06
I-ABSLIQD	SLD, HIC	SOL	0.00E+00	2.15E-06	9.26E-06	3.56E-05	0.00E+00	2.68E-07	1.16E-06	4.42E-06
I-ABSLIQD	ISD	SOL	2.95E-07	4.47E-06	8.60E-06	3.30E-05	3.66E-08	5.54E-07	1.07E-06	4.09E-06
I-ABSLIQD	IDD	SOL	3.51E-07	4.52E-06	8.69E-06	3.30E-05	4.35E-08	5.60E-07	1.08E-06	4.09E-06
I-ABSLIQD	ISD, HIC	SOL	0.00E+00	1.21E-06	5.35E-06	2.98E-05	0.00E+00	1.50E-07	6.63E-07	3.68E-06
I-ABSLIQD	CC	SOL	0.00E+00	1.38E-06	3.52E-06	2.07E-05	0.00E+00	1.71E-07	4.36E-07	2.57E-06

Table continued on next pag

SOURCE: PUTNAM, HAYES, & [illegible]ETT, INC., 20 Aug 86

SOURCE: PUTNAM, HAYES, & BARTLETT, INC., 20 Aug 86

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
I-BIOWAST	SLF	AS IS	5.92E-05	7.06E-05	7.06E-05	7.06E-05	7.36E-06	8.77E-06	8.77E-06	8.77E-06
I-BIOWAST	SLD	AS IS	7.22E-06	6.92E-05	6.94E-05	6.94E-05	8.95E-07	8.58E-06	8.60E-06	8.60E-06
I-BIOWAST	ISD	AS IS	4.94E-06	6.11E-05	6.82E-05	6.86E-05	6.12E-07	7.58E-06	8.46E-06	8.50E-06
I-BIOWAST	IDD	AS IS	4.42E-06	5.57E-05	6.70E-05	6.82E-05	5.48E-07	6.90E-06	8.30E-06	8.45E-06
I-BIOWAST	SLD, NIC	AS IS	0.00E+00	6.19E-05	6.76E-05	6.76E-05	0.00E+00	7.67E-06	8.37E-06	8.37E-06
I-BIOWAST	ISD, NIC	AS IS	0.00E+00	3.70E-05	6.53E-05	6.67E-05	0.00E+00	4.59E-06	8.09E-06	8.26E-06
I-BIOWAST	SLF	SOL	1.37E-06	2.25E-05	3.72E-05	5.93E-05	1.70E-07	2.78E-06	4.61E-06	7.35E-06
I-BIOWAST	SLD	SOL	6.16E-07	1.04E-05	1.93E-05	5.18E-05	7.64E-08	1.29E-06	2.39E-06	6.42E-06
I-BIOWAST	EM	SOL	6.47E-07	1.01E-05	1.88E-05	5.02E-05	8.03E-08	1.26E-06	2.32E-06	6.21E-06
I-BIOWAST	SLD, NIC	SOL	0.00E+00	2.66E-06	1.15E-05	4.40E-05	0.00E+00	3.32E-07	1.43E-06	5.46E-06
I-BIOWAST	IDD	SOL	4.34E-07	5.59E-06	1.08E-05	4.09E-05	5.38E-08	6.93E-07	1.33E-06	5.06E-06
I-BIOWAST	ISD	SOL	3.65E-07	5.53E-06	1.06E-05	4.07E-05	4.53E-08	6.85E-07	1.32E-06	5.06E-06
I-BIOWAST	SLD	INC/SOL	4.62E-07	7.83E-06	1.45E-05	3.89E-05	5.73E-08	9.70E-07	1.79E-06	4.81E-06
I-BIOWAST	ISD, NIC	SOL	0.00E+00	1.50E-06	6.62E-06	3.67E-05	0.00E+00	1.86E-07	8.21E-07	4.56E-06
I-BIOWAST	ISD	INC/SOL	2.74E-07	4.14E-06	7.98E-06	3.06E-05	3.39E-08	5.14E-07	9.89E-07	3.79E-06
I-BIOWAST	CC	SOL	0.00E+00	1.71E-06	4.36E-06	2.57E-05	0.00E+00	2.12E-07	5.40E-07	3.18E-06
I-COTRASH	SLF	AS IS	3.60E-05	3.69E-05	3.69E-05	3.69E-05	4.47E-06	4.58E-06	4.58E-06	4.58E-06
I-COTRASH	SLD	AS IS	9.14E-06	3.61E-05	3.62E-05	3.62E-05	1.13E-06	4.48E-06	4.49E-06	4.49E-06
I-COTRASH	ISD	AS IS	5.53E-06	3.07E-05	3.53E-05	3.57E-05	6.87E-07	3.81E-06	4.38E-06	4.43E-06
I-COTRASH	IDD	AS IS	4.51E-06	2.76E-05	3.43E-05	3.54E-05	5.60E-07	3.42E-06	4.25E-06	4.39E-06
I-COTRASH	SLD, NIC	AS IS	0.00E+00	3.13E-05	3.52E-05	3.52E-05	0.00E+00	3.88E-06	4.36E-06	4.36E-06
I-COTRASH	ISD, NIC	AS IS	0.00E+00	1.71E-05	3.32E-05	3.46E-05	0.00E+00	2.12E-06	4.12E-06	4.29E-06
I-COTRASH	SLF	SOL	7.15E-07	1.17E-05	1.94E-05	3.09E-05	8.86E-08	1.45E-06	2.40E-06	3.83E-06
I-COTRASH	SLD	SOL	3.21E-07	5.44E-06	1.01E-05	2.70E-05	3.98E-08	6.74E-07	1.25E-06	3.35E-06
I-COTRASH	EM	SOL	3.37E-07	5.28E-06	9.77E-06	2.62E-05	4.18E-08	6.55E-07	1.21E-06	3.24E-06
I-COTRASH	SLD, NIC	SOL	0.00E+00	1.38E-06	5.97E-06	2.29E-05	0.00E+00	1.73E-07	7.46E-07	2.85E-06
I-COTRASH	IDD	SOL	2.26E-07	2.91E-06	5.60E-06	2.13E-05	2.80E-08	3.61E-07	6.94E-07	2.63E-06
I-COTRASH	ISD	SOL	1.90E-07	2.88E-06	5.55E-06	2.12E-05	2.36E-08	3.57E-07	6.87E-07	2.64E-06
I-COTRASH	SLD	INC/SOL	2.41E-07	4.08E-06	7.54E-06	2.02E-05	2.98E-08	5.05E-07	9.35E-07	2.51E-06
I-COTRASH	ISD, NIC	SOL	0.00E+00	7.81E-07	3.45E-06	1.91E-05	0.00E+00	9.68E-08	4.27E-07	2.38E-06
I-COTRASH	ISD	INC/SOL	1.43E-07	2.16E-06	4.16E-06	1.60E-05	1.77E-08	2.67E-07	5.15E-07	1.98E-06
I-COTRASH	CC	SOL	0.00E+00	8.89E-07	2.27E-06	1.34E-05	0.00E+00	1.10E-07	2.81E-07	1.65E-06

Table continued on next page

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	500 YRS	1000 YRS	10000 YRS	GENETIC RISK 100 YRS	500 YRS	1000 YRS	10000 YRS
I-LQSCNVL	SLF	AS IS	1.47E-06	1.75E-06	1.75E-06	1.75E-06	1.82E-07	2.17E-07	2.17E-07	2.17E-07
I-LQSCNVL	SLD	AS IS	1.79E-07	1.72E-06	1.72E-06	1.72E-06	2.22E-08	2.13E-07	2.14E-07	2.14E-07
I-LQSCNVL	ISD	AS IS	1.23E-07	1.52E-06	1.70E-06	1.71E-06	1.52E-08	1.88E-07	2.10E-07	2.11E-07
I-LQSCNVL	IDD	AS IS	1.10E-07	1.38E-06	1.66E-06	1.69E-06	1.36E-08	1.72E-07	2.06E-07	2.10E-07
I-LQSCNVL	SLD, HIC	AS IS	0.00E+00	1.54E-06	1.68E-06	1.68E-06	0.00E+00	1.91E-07	2.08E-07	2.08E-07
I-LQSCNVL	ISD, HIC	AS IS	0.00E+00	9.20E-07	1.62E-06	1.66E-06	0.00E+00	1.14E-07	2.01E-07	2.05E-07
I-LQSCNVL	SLF	SOL	3.41E-08	5.58E-07	9.25E-07	1.47E-06	4.23E-09	6.92E-08	1.15E-07	1.83E-07
I-LQSCNVL	SLD	SOL	1.53E-08	2.59E-07	4.80E-07	1.29E-06	1.90E-09	3.21E-08	5.95E-08	1.59E-07
I-LQSCNVL	EM	SOL	1.61E-08	2.52E-07	4.66E-07	1.25E-06	1.99E-09	3.12E-08	5.78E-08	1.55E-07
I-LQSCNVL	SLD, HIC	SOL	0.00E+00	6.61E-08	2.85E-07	1.09E-06	0.00E+00	8.25E-09	3.56E-08	1.36E-07
I-LQSCNVL	ISD	SOL	9.08E-09	1.37E-07	2.65E-07	1.01E-06	1.13E-09	1.70E-08	3.28E-08	1.26E-07
I-LQSCNVL	IDD	SOL	1.08E-08	1.39E-07	2.67E-07	1.01E-06	1.34E-09	1.72E-08	3.31E-08	1.26E-07
I-LQSCNVL	SLD	INC/SOL	1.15E-08	1.94E-07	3.60E-07	9.66E-07	1.42E-09	2.41E-08	4.46E-08	1.20E-07
I-LQSCNVL	ISD, HIC	SOL	0.00E+00	3.73E-08	1.65E-07	9.14E-07	0.00E+00	4.62E-09	2.04E-08	1.13E-07
I-LQSCNVL	ISD	INC/SOL	6.80E-09	1.03E-07	1.98E-07	7.59E-07	8.43E-10	1.28E-08	2.46E-08	9.42E-08
I-LQSCNVL	CC	SOL	0.00E+00	4.24E-08	1.08E-07	6.37E-07	0.00E+00	5.26E-09	1.34E-08	7.90E-08
L-CONCLIQ	SLF	AS IS	7.23E-06	8.04E-06	8.26E-06	8.77E-06	1.30E-06	1.40E-06	1.40E-06	1.42E-06
L-CONCLIQ	SLD	AS IS	5.08E-07	4.87E-06	4.99E-06	5.32E-06	6.30E-08	6.04E-07	6.05E-07	6.07E-07
L-CONCLIQ	ISD	AS IS	3.48E-07	4.30E-06	4.87E-06	5.22E-06	4.31E-08	5.33E-07	5.95E-07	6.00E-07
L-CONCLIQ	IDD	AS IS	3.11E-07	3.93E-06	4.77E-06	5.18E-06	3.86E-08	4.85E-07	5.84E-07	5.96E-07
L-CONCLIQ	SLD, HIC	AS IS	0.00E+00	4.35E-06	4.81E-06	5.14E-06	0.00E+00	5.39E-07	5.89E-07	5.91E-07
L-CONCLIQ	ISD, HIC	AS IS	0.00E+00	2.60E-06	4.63E-06	5.06E-06	0.00E+00	3.23E-07	5.69E-07	5.83E-07
L-CONCLIQ	SLF	SOL	9.65E-08	1.58E-06	2.64E-06	4.31E-06	1.20E-08	1.96E-07	3.24E-07	5.18E-07
L-CONCLIQ	DWI	AS IS	NA	NA	8.74E-13	4.00E-06	NA	NA	2.45E-13	4.96E-07
L-CONCLIQ	SLD	SOL	4.33E-08	7.34E-07	1.37E-06	3.77E-06	5.37E-09	9.09E-08	1.68E-07	4.52E-07
L-CONCLIQ	EM	SOL	4.55E-08	7.13E-07	1.32E-06	3.55E-06	5.64E-09	8.84E-08	1.63E-07	4.37E-07
L-CONCLIQ	SLD, HIC	SOL	0.00E+00	1.87E-07	8.11E-07	3.20E-06	0.00E+00	2.33E-08	1.01E-07	3.85E-07
L-CONCLIQ	ISD	SOL	2.57E-08	3.89E-07	7.56E-07	2.97E-06	3.18E-09	4.82E-08	9.28E-08	3.56E-07
L-CONCLIQ	IDD	SOL	3.05E-08	3.96E-07	7.65E-07	2.96E-06	3.79E-09	4.87E-08	9.38E-08	3.56E-07
L-CONCLIQ	ISD, HIC	SOL	0.00E+00	1.05E-07	4.68E-07	2.67E-06	0.00E+00	1.31E-08	5.77E-08	3.21E-07
L-CONCLIQ	CC	SOL	0.00E+00	1.20E-07	3.07E-07	1.82E-06	0.00E+00	1.49E-08	3.80E-08	2.24E-07

Table continued on next page

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-COTRASH	SLF	AS IS	1.81E-07	1.84E-07	1.89E-07	2.02E-07	3.38E-08	3.41E-08	3.41E-08	3.46E-08
L-COTRASH	SLD	AS IS	2.42E-08	9.55E-08	9.89E-08	1.08E-07	3.00E-09	1.18E-08	1.19E-08	1.19E-08
L-COTRASH	ISD	AS IS	1.46E-08	8.14E-08	9.52E-08	1.05E-07	1.82E-09	1.01E-08	1.16E-08	1.18E-08
L-COTRASH	IDD	AS IS	1.19E-08	7.34E-08	9.26E-08	1.04E-07	1.48E-09	9.04E-09	1.13E-08	1.17E-08
L-COTRASH	SLD, HIC	AS IS	0.00E+00	8.27E-08	9.47E-08	1.03E-07	0.00E+00	1.02E-08	1.15E-08	1.15E-08
L-COTRASH	ISD, HIC	AS IS	0.00E+00	4.51E-08	8.88E-08	1.01E-07	0.00E+00	5.59E-09	1.09E-08	1.14E-08
L-COTRASH	SLF	SOL	1.89E-09	3.09E-08	5.20E-08	8.56E-08	2.34E-10	3.83E-09	6.35E-09	1.02E-08
L-COTRASH	SLD	SOL	8.48E-10	1.44E-08	2.70E-08	7.49E-08	1.05E-10	1.78E-09	3.30E-09	8.86E-09
L-COTRASH	EM	SOL	8.91E-10	1.40E-08	2.59E-08	6.98E-08	1.10E-10	1.73E-09	3.20E-09	8.56E-09
L-COTRASH	SLD, HIC	SOL	0.00E+00	3.66E-09	1.59E-08	6.34E-08	0.00E+00	4.57E-10	1.97E-09	7.53E-09
L-COTRASH	IDD	SOL	5.98E-10	7.76E-09	1.51E-08	5.88E-08	7.41E-11	9.54E-10	1.84E-09	6.98E-09
L-COTRASH	ISD	SOL	5.03E-10	7.62E-09	1.49E-08	5.87E-08	6.23E-11	9.43E-10	1.82E-09	6.97E-09
L-COTRASH	SLD	INC/SOL	6.36E-10	1.08E-08	2.03E-08	5.68E-08	7.88E-11	1.34E-09	2.47E-09	6.64E-09
L-COTRASH	ISD, HIC	SOL	0.00E+00	2.06E-09	9.19E-09	5.28E-08	0.00E+00	2.56E-10	1.13E-09	6.28E-09
L-COTRASH	ISD	INC/SOL	3.77E-10	5.71E-09	1.12E-08	4.45E-08	4.67E-11	7.07E-10	1.36E-09	5.22E-09
L-COTRASH	CC	SOL	0.00E+00	2.35E-09	6.01E-09	3.57E-08	0.00E+00	2.91E-10	7.43E-10	4.37E-09
L-DECONRS	SLF	AS IS	1.13E-06	1.16E-06	1.17E-06	6.08E-06	3.60E-07	3.64E-07	3.65E-07	8.81E-07
L-DECONRS	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	9.56E-08	0.00E+00	0.00E+00	0.00E+00	1.00E-08
L-DECONRS	ISD	AS IS	1.13E-10	1.16E-10	1.17E-10	1.18E-10	3.60E-11	3.64E-11	3.65E-11	3.66E-11
L-DECONRS	SLD	AS IS	1.13E-10	1.16E-10	1.17E-10	1.18E-10	3.60E-11	3.64E-11	3.65E-11	3.66E-11
L-DECONRS	IDD	AS IS	1.13E-10	1.16E-10	1.17E-10	1.18E-10	3.60E-11	3.64E-11	3.65E-11	3.66E-11
L-DECONRS	DWI	AS IS	NA	NA	9.98E-12	9.98E-12	NA	NA	2.75E-12	2.75E-12
L-DECONRS	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	CB	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-FSLUDGE	SLF	AS IS	2.46E-05	2.56E-05	2.69E-05	2.90E-05	5.66E-06	5.78E-06	5.78E-06	5.81E-06
L-FSLUDGE	SLD	AS IS	5.94E-07	5.71E-06	6.38E-06	8.28E-06	7.40E-08	7.06E-07	7.08E-07	7.12E-07
L-FSLUDGE	ISD	AS IS	4.07E-07	5.04E-06	6.01E-06	7.94E-06	5.08E-08	6.23E-07	6.96E-07	7.03E-07
L-FSLUDGE	IDD	AS IS	3.65E-07	4.65E-06	5.90E-06	7.88E-06	4.55E-08	5.68E-07	6.83E-07	6.99E-07
L-FSLUDGE	SLD, NIC	AS IS	0.00E+00	5.09E-06	5.94E-06	7.84E-06	0.00E+00	6.30E-07	6.89E-07	6.93E-07
L-FSLUDGE	ISD, NIC	AS IS	0.00E+00	3.04E-06	5.59E-06	7.61E-06	0.00E+00	3.77E-07	6.65E-07	6.83E-07
L-FSLUDGE	SLF	SOL	1.13E-07	1.85E-06	3.22E-06	5.71E-06	1.40E-08	2.29E-07	3.79E-07	6.08E-07
L-FSLUDGE	SLD	SOL	5.06E-08	8.59E-07	1.67E-06	5.01E-06	6.27E-09	1.06E-07	1.97E-07	5.30E-07
L-FSLUDGE	SLD, NIC	SOL	0.00E+00	2.19E-07	9.68E-07	4.23E-06	0.00E+00	2.73E-08	1.18E-07	4.50E-07
L-FSLUDGE	SLD	INC/SOL	3.79E-08	6.45E-07	1.27E-06	3.91E-06	4.70E-09	7.97E-08	1.48E-07	3.98E-07
L-FSLUDGE	IDD	SOL	3.56E-08	4.74E-07	9.38E-07	3.91E-06	4.42E-09	5.70E-08	1.10E-07	4.17E-07
L-FSLUDGE	ISD	SOL	3.00E-08	4.56E-07	9.17E-07	3.90E-06	3.72E-09	5.63E-08	1.08E-07	4.16E-07
L-FSLUDGE	ISD, NIC	SOL	0.00E+00	1.23E-07	5.61E-07	3.50E-06	0.00E+00	1.53E-08	6.74E-08	3.75E-07
L-FSLUDGE	ISD	INC/SOL	2.25E-08	3.43E-07	6.95E-07	3.03E-06	2.78E-09	4.22E-08	8.13E-08	3.12E-07
L-FSLUDGE	CC	SOL	0.00E+00	1.40E-07	3.61E-07	2.20E-06	0.00E+00	1.74E-08	4.43E-08	2.61E-07
L-FSLUDGE	CB	SOL	0.00E+00	7.02E-08	1.83E-07	1.31E-06	0.00E+00	8.70E-09	2.25E-08	1.57E-07
L-IXRESIN	SLF	AS IS	1.30E-04	1.44E-04	1.48E-04	1.55E-04	2.33E-05	2.51E-05	2.51E-05	2.53E-05
L-IXRESIN	SLD	AS IS	9.16E-06	8.78E-05	9.00E-05	9.58E-05	1.14E-06	1.09E-05	1.09E-05	1.09E-05
L-IXRESIN	ISD	AS IS	6.27E-06	7.75E-05	8.77E-05	9.39E-05	7.78E-07	9.61E-06	1.07E-05	1.08E-05
L-IXRESIN	IDD	AS IS	5.61E-06	7.08E-05	8.60E-05	9.33E-05	6.96E-07	8.75E-06	1.05E-05	1.07E-05
L-IXRESIN	SLD, NIC	AS IS	0.00E+00	7.85E-05	8.68E-05	9.26E-05	0.00E+00	9.73E-06	1.06E-05	1.06E-05
L-IXRESIN	ISD, NIC	AS IS	0.00E+00	4.69E-05	8.34E-05	9.10E-05	0.00E+00	5.81E-06	1.03E-05	1.05E-05
L-IXRESIN	SLF	SOL	1.74E-06	2.85E-05	4.77E-05	7.78E-05	2.16E-07	3.53E-06	5.85E-06	9.33E-06
L-IXRESIN	SLD	SOL	7.81E-07	1.32E-05	2.47E-05	6.80E-05	9.69E-08	1.64E-06	3.03E-06	8.15E-06
L-IXRESIN	SLD, NIC	SOL	0.00E+00	3.37E-06	1.46E-05	5.76E-05	0.00E+00	4.21E-07	1.82E-06	6.94E-06
L-IXRESIN	IDD	SOL	5.50E-07	7.13E-06	1.38E-05	5.34E-05	6.82E-08	8.79E-07	1.69E-06	6.42E-06
L-IXRESIN	ISD	SOL	4.63E-07	7.01E-06	1.36E-05	5.33E-05	5.74E-08	8.68E-07	1.67E-06	6.41E-06
L-IXRESIN	SLD	INC/SOL	5.86E-07	9.92E-06	1.86E-05	5.15E-05	7.26E-08	1.23E-06	2.28E-06	6.12E-06
L-IXRESIN	ISD, NIC	SOL	0.00E+00	1.90E-06	8.44E-06	4.80E-05	0.00E+00	2.36E-07	1.04E-06	5.78E-06
L-IXRESIN	ISD	INC/SOL	3.47E-07	5.26E-06	1.02E-05	4.03E-05	4.30E-08	6.51E-07	1.25E-06	4.80E-06
L-IXRESIN	CC	SOL	0.00E+00	2.16E-06	5.53E-06	3.27E-05	0.00E+00	2.68E-07	6.84E-07	4.02E-06
L-IXRESIN	CB	SOL	0.00E+00	1.08E-06	2.81E-06	1.96E-05	0.00E+00	1.34E-07	3.48E-07	2.41E-06

Table continued on next page

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-NCTRASH	SLF	AS IS	1.32E-06	1.34E-06	1.38E-06	1.47E-06	2.31E-07	2.34E-07	2.34E-07	2.39E-07
L-NCTRASH	SLD	AS IS	2.07E-07	8.17E-07	8.39E-07	8.93E-07	2.57E-08	1.01E-07	1.02E-07	1.02E-07
L-NCTRASH	ISD	AS IS	1.25E-07	6.96E-07	8.11E-07	8.74E-07	1.56E-08	8.62E-08	9.91E-08	1.00E-07
L-NCTRASH	IDD	AS IS	1.02E-07	6.27E-07	7.88E-07	8.66E-07	1.27E-08	7.74E-08	9.63E-08	9.97E-08
L-NCTRASH	SLD, NIC	AS IS	0.00E+00	7.08E-07	8.06E-07	8.60E-07	0.00E+00	8.77E-08	9.86E-08	9.89E-08
L-NCTRASH	ISD, NIC	AS IS	0.00E+00	3.86E-07	7.58E-07	8.42E-07	0.00E+00	4.79E-08	9.32E-08	9.73E-08
L-NCTRASH	SLF	SOL	1.62E-08	2.65E-07	4.43E-07	7.23E-07	2.01E-09	3.28E-08	5.44E-08	8.70E-08
L-NCTRASH	SLD	SOL	7.26E-09	1.23E-07	2.30E-07	6.32E-07	9.01E-10	1.52E-08	2.82E-08	7.58E-08
L-NCTRASH	EM	SOL	7.63E-09	1.20E-07	2.22E-07	5.96E-07	9.46E-10	1.48E-08	2.74E-08	7.33E-08
L-NCTRASH	SLD, NIC	SOL	0.00E+00	3.13E-08	1.36E-07	5.36E-07	0.00E+00	3.91E-09	1.69E-08	6.45E-08
L-NCTRASH	ISD	SOL	4.30E-09	6.52E-08	1.27E-07	4.96E-07	5.34E-10	8.07E-09	1.56E-08	5.97E-08
L-NCTRASH	IDD	SOL	5.12E-09	6.63E-08	1.28E-07	4.96E-07	6.34E-10	8.17E-09	1.57E-08	5.97E-08
L-NCTRASH	ISD, NIC	SOL	0.00E+00	1.77E-08	7.85E-08	4.47E-07	0.00E+00	2.19E-09	9.67E-09	5.38E-08
L-NCTRASH	CC	SOL	0.00E+00	2.01E-08	5.14E-08	3.04E-07	0.00E+00	2.49E-09	6.36E-09	3.75E-08
L-NFRCOMP	SLF	AS IS	2.81E-06	1.62E-05	2.56E-05	3.97E-05	3.48E-07	2.01E-06	3.18E-06	4.93E-06
L-NFRCOMP	SLF	SOL	8.74E-07	1.43E-05	2.37E-05	3.78E-05	1.08E-07	1.77E-06	2.94E-06	4.69E-06
L-NFRCOMP	SLD	AS IS	1.18E-06	7.43E-06	1.31E-05	3.38E-05	1.46E-07	9.21E-07	1.62E-06	4.19E-06
L-NFRCOMP	SLD	SOL	3.92E-07	6.64E-06	1.23E-05	3.30E-05	4.86E-08	8.23E-07	1.52E-06	4.09E-06
L-NFRCOMP	EM	SOL	4.12E-07	6.46E-06	1.19E-05	3.19E-05	5.11E-08	8.00E-07	1.48E-06	3.96E-06
L-NFRCOMP	SLD, NIC	AS IS	0.00E+00	1.71E-06	7.36E-06	2.81E-05	0.00E+00	2.11E-07	9.12E-07	3.48E-06
L-NFRCOMP	SLD, NIC	SOL	0.00E+00	1.69E-06	7.30E-06	2.80E-05	0.00E+00	2.11E-07	9.12E-07	3.48E-06
L-NFRCOMP	IDD	AS IS	6.73E-07	3.96E-06	7.25E-06	2.64E-05	8.34E-08	4.91E-07	8.99E-07	3.27E-06
L-NFRCOMP	ISD	AS IS	6.28E-07	3.92E-06	7.18E-06	2.64E-05	7.79E-08	4.86E-07	8.90E-07	3.27E-06
L-NFRCOMP	ISD	SOL	2.32E-07	3.52E-06	6.78E-06	2.60E-05	2.88E-08	4.36E-07	8.40E-07	3.22E-06
L-NFRCOMP	IDD	SOL	2.76E-07	3.56E-06	6.85E-06	2.60E-05	3.43E-08	4.41E-07	8.49E-07	3.22E-06
L-NFRCOMP	ISD, NIC	SOL	0.00E+00	9.54E-07	4.22E-06	2.34E-05	0.00E+00	1.18E-07	5.22E-07	2.90E-06
L-NFRCOMP	ISD, NIC	AS IS	0.00E+00	9.55E-07	4.22E-06	2.34E-05	0.00E+00	1.18E-07	5.23E-07	2.90E-06
L-NFRCOMP	CC	SOL	0.00E+00	1.09E-06	2.77E-06	1.64E-05	0.00E+00	1.35E-07	3.44E-07	2.02E-06

Table continued on next page

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-ISOPROD	SLF	AS IS	7.46E-05	7.48E-05	7.50E-05	7.70E-05	1.67E-05	1.67E-05	1.68E-05	1.70E-05
N-ISOPROD	SLD	AS IS	1.48E-07	5.49E-07	5.76E-07	2.50E-06	1.97E-08	6.93E-08	7.22E-08	2.78E-07
N-ISOPROD	ISD	AS IS	9.27E-08	4.67E-07	5.64E-07	2.46E-06	1.27E-08	5.90E-08	7.05E-08	2.75E-07
N-ISOPROD	SLD, HIC	AS IS	0.00E+00	4.64E-07	5.23E-07	2.44E-06	0.00E+00	5.75E-08	6.46E-08	2.71E-07
N-ISOPROD	IDD	AS IS	7.77E-08	4.21E-07	5.61E-07	2.43E-06	1.08E-08	5.32E-08	6.98E-08	2.71E-07
N-ISOPROD	ISD, HIC	AS IS	0.00E+00	2.53E-07	4.94E-07	2.40E-06	0.00E+00	3.13E-08	6.11E-08	2.67E-07
N-ISOPROD	SLF	SOL	1.07E-08	1.74E-07	2.96E-07	9.41E-07	1.34E-09	2.15E-08	3.65E-08	1.09E-07
N-ISOPROD	SLD	SOL	4.80E-09	8.08E-08	1.55E-07	8.71E-07	6.00E-10	1.00E-08	1.90E-08	1.00E-07
N-ISOPROD	SLD	INC/SOL	3.57E-09	6.06E-08	1.17E-07	7.50E-07	4.43E-10	7.49E-09	1.44E-08	8.56E-08
N-ISOPROD	SLD, HIC	SOL	0.00E+00	2.05E-08	8.87E-08	7.50E-07	0.00E+00	2.56E-09	1.11E-08	8.63E-08
N-ISOPROD	IDD	SOL	3.39E-09	4.33E-08	8.89E-08	6.62E-07	4.25E-10	5.36E-09	1.09E-08	7.63E-08
N-ISOPROD	ISD	SOL	2.85E-09	4.28E-08	8.59E-08	6.57E-07	3.56E-10	5.30E-09	1.06E-08	7.58E-08
N-ISOPROD	ISD, HIC	SOL	0.00E+00	1.16E-08	5.12E-08	5.98E-07	0.00E+00	1.43E-09	6.33E-09	6.89E-08
N-ISOPROD	ISD	INC/SOL	2.11E-09	3.21E-08	6.51E-08	5.55E-07	2.62E-10	3.97E-09	7.99E-09	6.35E-08
N-ISOPROD	CC	SOL	0.00E+00	1.32E-08	3.37E-08	2.50E-07	0.00E+00	1.63E-09	4.17E-09	3.01E-08
N-ISOPROD	CB	SOL	0.00E+00	6.60E-09	1.71E-08	1.50E-07	0.00E+00	8.17E-10	2.12E-09	1.80E-08
N-LOTRASH	SLF	AS IS	1.12E-05	1.15E-05	1.15E-05	1.15E-05	1.39E-06	1.43E-06	1.43E-06	1.43E-06
N-LOTRASH	SLD	AS IS	2.85E-06	1.13E-05	1.13E-05	1.13E-05	3.54E-07	1.40E-06	1.40E-06	1.40E-06
N-LOTRASH	ISD	AS IS	1.73E-06	9.58E-06	1.10E-05	1.11E-05	2.14E-07	1.19E-06	1.37E-06	1.38E-06
N-LOTRASH	IDD	AS IS	1.41E-06	8.60E-06	1.07E-05	1.10E-05	1.75E-07	1.07E-06	1.33E-06	1.37E-06
N-LOTRASH	SLD, HIC	AS IS	0.00E+00	9.75E-06	1.10E-05	1.10E-05	0.00E+00	1.21E-06	1.36E-06	1.36E-06
N-LOTRASH	ISD, HIC	AS IS	0.00E+00	5.32E-06	1.04E-05	1.08E-05	0.00E+00	6.60E-07	1.28E-06	1.33E-06
N-LOTRASH	SLF	SOL	2.23E-07	3.65E-06	6.04E-06	9.63E-06	2.76E-08	4.52E-07	7.49E-07	1.19E-06
N-LOTRASH	SLD	SOL	1.00E-07	1.69E-06	3.14E-06	8.42E-06	1.24E-08	2.10E-07	3.89E-07	1.04E-06
N-LOTRASH	EM	SOL	1.05E-07	1.65E-06	3.05E-06	8.15E-06	1.30E-08	2.04E-07	3.77E-07	1.01E-06
N-LOTRASH	SLD, HIC	SOL	0.00E+00	4.32E-07	1.86E-06	7.14E-06	0.00E+00	5.39E-08	2.33E-07	8.88E-07
N-LOTRASH	IDD	SOL	7.05E-08	9.08E-07	1.75E-06	6.63E-06	8.74E-09	1.13E-07	2.17E-07	8.22E-07
N-LOTRASH	ISD	SOL	5.93E-08	8.98E-07	1.73E-06	6.62E-06	7.35E-09	1.11E-07	2.14E-07	8.21E-07
N-LOTRASH	SLD	INC/SOL	7.50E-08	1.27E-06	2.35E-06	6.31E-06	9.30E-09	1.57E-07	2.91E-07	7.82E-07
N-LOTRASH	ISD, HIC	SOL	0.00E+00	2.43E-07	1.08E-06	5.97E-06	0.00E+00	3.02E-08	1.33E-07	7.40E-07
N-LOTRASH	ISD	INC/SOL	4.44E-08	6.73E-07	1.30E-06	4.97E-06	5.51E-09	8.34E-08	1.61E-07	6.16E-07
N-LOTRASH	CC	SOL	0.00E+00	2.77E-07	7.07E-07	4.17E-06	0.00E+00	3.44E-08	8.77E-08	5.16E-07

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SOURCE: PUTNAM, HAYES & BARTLETT, INC. 20-Aug-86

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-LOWASTE	SLF	AS IS	5.49E-06	6.54E-06	6.54E-06	6.54E-06	6.83E-07	8.13E-07	8.13E-07	8.13E-07
N-LOWASTE	SLD	AS IS	6.69E-07	6.42E-06	6.43E-06	6.43E-06	8.29E-08	7.95E-07	7.97E-07	7.97E-07
N-LOWASTE	ISD	AS IS	4.58E-07	5.67E-06	6.32E-06	6.35E-06	5.67E-08	7.02E-07	7.84E-07	7.88E-07
N-LOWASTE	IDD	AS IS	4.10E-07	5.16E-06	6.20E-06	6.31E-06	5.08E-08	6.40E-07	7.69E-07	7.83E-07
N-LOWASTE	SLD, NIC	AS IS	0.00E+00	5.74E-06	6.26E-06	6.26E-06	0.00E+00	7.11E-07	7.76E-07	7.76E-07
N-LOWASTE	ISD, NIC	AS IS	0.00E+00	3.43E-06	6.05E-06	6.18E-06	0.00E+00	4.25E-07	7.50E-07	7.66E-07
N-LOWASTE	SLF	SOL	1.27E-07	2.08E-06	3.45E-06	5.50E-06	1.58E-08	2.58E-07	4.27E-07	6.81E-07
N-LOWASTE	SLD	SOL	5.71E-08	9.67E-07	1.79E-06	4.81E-06	7.08E-09	1.20E-07	2.22E-07	5.96E-07
N-LOWASTE	EM	SOL	6.00E-08	9.40E-07	1.74E-06	4.65E-06	7.44E-09	1.16E-07	2.15E-07	5.76E-07
N-LOWASTE	SLD, NIC	SOL	0.00E+00	2.46E-07	1.06E-06	4.08E-06	0.00E+00	3.08E-08	1.33E-07	5.07E-07
N-LOWASTE	IDD	SOL	4.02E-08	5.18E-07	9.97E-07	3.79E-06	4.99E-09	6.42E-08	1.24E-07	4.69E-07
N-LOWASTE	ISD	SOL	3.38E-08	5.12E-07	9.87E-07	3.78E-06	4.20E-09	6.35E-08	1.22E-07	4.68E-07
N-LOWASTE	SLD	INC/SOL	4.28E-08	7.25E-07	1.34E-06	3.60E-06	5.31E-09	8.99E-08	1.66E-07	4.46E-07
N-LOWASTE	ISD, NIC	SOL	0.00E+00	1.39E-07	6.14E-07	3.40E-06	0.00E+00	1.72E-08	7.60E-08	4.22E-07
N-LOWASTE	ISD	INC/SOL	2.54E-08	3.84E-07	7.40E-07	2.83E-06	3.14E-09	4.76E-08	9.17E-08	3.52E-07
N-LOWASTE	CC	SOL	0.00E+00	1.58E-07	4.04E-07	2.37E-06	0.00E+00	1.96E-08	5.00E-08	2.95E-07
N-SOURCES	SLF	AS IS	2.55E-06	1.21E-05	1.88E-05	2.89E-05	3.87E-07	1.57E-06	2.40E-06	3.65E-06
N-SOURCES	SLF	SOL	6.68E-07	1.02E-05	1.69E-05	2.70E-05	8.89E-08	1.28E-06	2.10E-06	3.35E-06
N-SOURCES	SLD	AS IS	1.09E-06	5.54E-06	9.56E-06	2.43E-05	1.68E-07	7.21E-07	1.22E-06	3.05E-06
N-SOURCES	SLD	SOL	3.02E-07	4.75E-06	8.77E-06	2.35E-05	4.03E-08	5.92E-07	1.09E-06	2.91E-06
N-SOURCES	SLD, NIC	AS IS	0.00E+00	1.21E-06	5.23E-06	1.99E-05	0.00E+00	1.50E-07	6.48E-07	2.48E-06
N-SOURCES	SLD, NIC	SOL	0.00E+00	1.20E-06	5.19E-06	1.99E-05	0.00E+00	1.50E-07	6.48E-07	2.47E-06
N-SOURCES	ISD	AS IS	6.08E-07	2.95E-06	5.27E-06	1.90E-05	9.60E-08	3.87E-07	6.74E-07	2.36E-06
N-SOURCES	IDD	AS IS	6.91E-07	3.03E-06	5.37E-06	1.90E-05	1.13E-07	4.03E-07	6.93E-07	2.38E-06
N-SOURCES	IDD	SOL	2.17E-07	2.55E-06	4.89E-06	1.85E-05	2.96E-08	3.20E-07	6.09E-07	2.30E-06
N-SOURCES	ISD	SOL	1.80E-07	2.52E-06	4.84E-06	1.84E-05	2.43E-08	3.15E-07	6.02E-07	2.29E-06
N-SOURCES	ISD, NIC	AS IS	0.00E+00	6.79E-07	3.00E-06	1.67E-05	0.00E+00	8.41E-08	3.72E-07	2.06E-06
N-SOURCES	ISD, NIC	SOL	0.00E+00	6.78E-07	3.00E-06	1.66E-05	0.00E+00	8.41E-08	3.71E-07	2.06E-06
N-SOURCES	CC	SOL	0.00E+00	7.73E-07	1.97E-06	1.16E-05	0.00E+00	9.57E-08	2.44E-07	1.43E-06
N-SOURCES	CB	SOL	0.00E+00	3.87E-07	1.00E-06	6.94E-06	0.00E+00	4.79E-08	1.24E-07	8.60E-07

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Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-SSTRASH	SLF	AS IS	2.01E-12	3.11E-12	3.22E-12	4.52E-10	3.03E-14	6.57E-14	7.26E-14	1.28E-11
N-SSTRASH	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	7.86E-12	0.00E+00	0.00E+00	0.00E+00	2.22E-13
N-SSTRASH	ISD	AS IS	2.01E-16	3.12E-16	3.23E-16	3.23E-16	3.03E-18	6.57E-18	7.26E-18	7.27E-18
N-SSTRASH	IDD	AS IS	2.01E-16	3.12E-16	3.22E-16	3.22E-16	3.03E-18	6.57E-18	7.26E-18	7.27E-18
N-SSTRASH	SLD	AS IS	2.01E-16	3.12E-16	3.22E-16	3.22E-16	3.03E-18	6.57E-18	7.26E-18	7.27E-18
N-SSTRASH	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	EN	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLF	AS IS	3.91E-11	6.05E-11	6.26E-11	8.79E-09	5.88E-13	1.28E-12	1.41E-12	2.48E-10
N-SSWASTE	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	1.53E-10	0.00E+00	0.00E+00	0.00E+00	4.31E-12
N-SSWASTE	SLD	AS IS	3.91E-15	6.05E-15	6.27E-15	6.28E-15	5.88E-17	1.28E-16	1.41E-16	1.41E-16
N-SSWASTE	ISD	AS IS	3.91E-15	6.05E-15	6.27E-15	6.28E-15	5.88E-17	1.28E-16	1.41E-16	1.41E-16
N-SSWASTE	IDD	AS IS	3.91E-15	6.05E-15	6.27E-15	6.28E-15	5.88E-17	1.28E-16	1.41E-16	1.41E-16
N-SSWASTE	EN	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-TARGETS	SLF	AS IS	1.50E-05	1.54E-05	1.54E-05	1.54E-05	3.78E-06	3.87E-06	3.87E-06	3.87E-06
N-TARGETS	SLD	AS IS	6.91E-06	7.07E-06	7.07E-06	7.07E-06	1.74E-06	1.78E-06	1.78E-06	1.78E-06
N-TARGETS	IDD	AS IS	5.77E-06	5.85E-06	5.85E-06	5.85E-06	1.46E-06	1.48E-06	1.48E-06	1.48E-06
N-TARGETS	ISD	AS IS	4.36E-06	4.44E-06	4.44E-06	4.44E-06	1.10E-06	1.12E-06	1.12E-06	1.12E-06
N-TARGETS	SLF	SOL	1.28E-06	1.65E-06	1.65E-06	1.65E-06	3.23E-07	4.15E-07	4.15E-07	4.15E-07
N-TARGETS	SLD	SOL	6.17E-07	7.74E-07	7.74E-07	7.74E-07	1.56E-07	1.95E-07	1.95E-07	1.95E-07
N-TARGETS	IDD	SOL	5.65E-07	6.45E-07	6.45E-07	6.45E-07	1.42E-07	1.63E-07	1.63E-07	1.63E-07
N-TARGETS	ISD	SOL	4.09E-07	4.89E-07	4.89E-07	4.89E-07	1.03E-07	1.23E-07	1.23E-07	1.23E-07
N-TARGETS	CC	SOL	0.00E+00	6.17E-10	6.17E-10	6.17E-10	0.00E+00	1.56E-10	1.56E-10	1.56E-10
N-TARGETS	CB	SOL	0.00E+00	2.49E-10	2.49E-10	2.49E-10	0.00E+00	6.29E-11	6.29E-11	6.29E-11
N-TARGETS	SLD, HIC	AS IS	0.00E+00	5.07E-14	5.08E-14	5.08E-14	0.00E+00	1.28E-14	1.28E-14	1.28E-14
N-TARGETS	SLD, HIC	SOL	0.00E+00	3.57E-14	3.57E-14	3.57E-14	0.00E+00	1.28E-14	1.28E-14	1.28E-14
N-TARGETS	ISD, HIC	AS IS	0.00E+00	3.40E-14	3.40E-14	3.40E-14	0.00E+00	8.57E-15	8.57E-15	8.57E-15
N-TARGETS	ISD, HIC	SOL	0.00E+00	3.39E-14	3.39E-14	3.39E-14	0.00E+00	8.56E-15	8.56E-15	8.56E-15
N-TRITIUM	SLF	AS IS	1.96E-03	2.01E-03	2.01E-03	2.01E-03	2.53E-04	2.59E-04	2.59E-04	2.59E-04
N-TRITIUM	SLD	AS IS	4.99E-04	1.91E-03	1.92E-03	1.92E-03	6.44E-05	2.40E-04	2.41E-04	2.41E-04
N-TRITIUM	ISD	AS IS	3.04E-04	1.63E-03	1.87E-03	1.89E-03	3.94E-05	2.03E-04	2.33E-04	2.36E-04
N-TRITIUM	IDD	AS IS	2.50E-04	1.46E-03	1.81E-03	1.87E-03	3.28E-05	1.83E-04	2.27E-04	2.34E-04
N-TRITIUM	SLD, HIC	AS IS	0.00E+00	1.64E-03	1.84E-03	1.84E-03	0.00E+00	2.03E-04	2.29E-04	2.29E-04
N-TRITIUM	ISD, HIC	AS IS	0.00E+00	8.96E-04	1.74E-03	1.81E-03	0.00E+00	1.11E-04	2.16E-04	2.25E-04
N-TRITIUM	SLF	SOL	3.79E-05	6.14E-04	1.02E-03	1.62E-03	4.74E-06	7.62E-05	1.26E-04	2.01E-04
N-TRITIUM	SLD	SOL	1.70E-05	2.85E-04	5.28E-04	1.42E-03	2.13E-06	3.54E-05	6.55E-05	1.76E-04
N-TRITIUM	SLD, HIC	SOL	0.00E+00	7.27E-05	3.13E-04	1.20E-03	0.00E+00	9.07E-06	3.91E-05	1.49E-04
N-TRITIUM	IDD	SOL	1.20E-05	1.53E-04	2.94E-04	1.12E-03	1.51E-06	1.90E-05	3.65E-05	1.39E-04
N-TRITIUM	ISD	SOL	1.01E-05	1.51E-04	2.91E-04	1.12E-03	1.27E-06	1.88E-05	3.61E-05	1.38E-04
N-TRITIUM	SLD	INC/SOL	1.26E-05	2.14E-04	3.96E-04	1.06E-03	1.57E-06	2.65E-05	4.91E-05	1.32E-04
N-TRITIUM	ISD, HIC	SOL	0.00E+00	4.10E-05	1.81E-04	1.01E-03	0.00E+00	5.08E-06	2.24E-05	1.24E-04
N-TRITIUM	ISD	INC/SOL	7.49E-06	1.13E-04	2.18E-04	8.35E-04	9.30E-07	1.40E-05	2.70E-05	1.04E-04
N-TRITIUM	CC	SOL	0.00E+00	4.67E-05	1.19E-04	7.01E-04	0.00E+00	5.78E-06	1.48E-05	8.69E-05
N-TRITIUM	CB	SOL	0.00E+00	2.34E-05	6.05E-05	4.20E-04	0.00E+00	2.89E-06	7.50E-06	5.20E-05

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
P-FCARTRG	SLF	AS IS	1.18E-06	1.20E-06	1.23E-06	1.90E-06	2.20E-07	2.23E-07	2.24E-07	2.94E-07
P-FCARTRG	SLD	AS IS	1.77E-07	7.01E-07	7.15E-07	7.66E-07	2.20E-08	8.68E-08	8.72E-08	8.91E-08
P-FCARTRG	ISD	AS IS	1.07E-07	5.96E-07	6.93E-07	7.52E-07	1.33E-08	7.39E-08	8.50E-08	8.78E-08
P-FCARTRG	IDD	AS IS	8.76E-08	5.37E-07	6.74E-07	7.46E-07	1.09E-08	6.64E-08	8.26E-08	8.71E-08
P-FCARTRG	SLD, HIC	AS IS	0.00E+00	6.07E-07	6.89E-07	7.41E-07	0.00E+00	7.52E-08	8.45E-08	8.64E-08
P-FCARTRG	ISD, HIC	AS IS	0.00E+00	3.31E-07	6.49E-07	7.27E-07	0.00E+00	4.10E-08	7.99E-08	8.50E-08
P-FCARTRG	SLF	SOL	1.39E-08	2.27E-07	3.79E-07	6.36E-07	1.72E-09	2.81E-08	4.66E-08	7.82E-08
P-FCARTRG	SLD	SOL	6.23E-09	1.05E-07	1.97E-07	5.42E-07	7.72E-10	1.31E-08	2.42E-08	6.54E-08
P-FCARTRG	EN	SOL	6.54E-09	1.02E-07	1.90E-07	5.11E-07	8.11E-10	1.27E-08	2.35E-08	6.29E-08
P-FCARTRG	SLD, HIC	SOL	0.00E+00	2.69E-08	1.16E-07	4.59E-07	0.00E+00	3.35E-09	1.45E-08	5.56E-08
P-FCARTRG	IDD	SOL	4.39E-09	5.67E-08	1.10E-07	4.26E-07	5.44E-10	7.00E-09	1.35E-08	5.15E-08
P-FCARTRG	ISD	SOL	3.69E-09	5.59E-08	1.08E-07	4.25E-07	4.57E-10	6.92E-09	1.33E-08	5.14E-08
P-FCARTRG	ISD, HIC	SOL	0.00E+00	1.51E-08	6.72E-08	3.83E-07	0.00E+00	1.88E-09	8.29E-09	4.63E-08
P-FCARTRG	CC	SOL	0.00E+00	1.72E-08	4.41E-08	2.61E-07	0.00E+00	2.14E-09	5.45E-09	3.22E-08
R-RAIXRSN	SLF	AS IS	1.69E-06	1.92E-06	1.92E-06	2.14E-05	3.07E-07	3.48E-07	3.49E-07	3.87E-06
R-RAIXRSN	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	1.27E-06	0.00E+00	0.00E+00	0.00E+00	2.30E-07
R-RAIXRSN	SLD	AS IS	1.69E-10	1.92E-10	1.92E-10	1.92E-10	3.07E-11	3.48E-11	3.49E-11	3.49E-11
R-RAIXRSN	IDD	AS IS	1.69E-10	1.92E-10	1.92E-10	1.92E-10	3.07E-11	3.48E-11	3.49E-11	3.49E-11
R-RAIXRSN	ISD	AS IS	1.69E-10	1.92E-10	1.92E-10	1.92E-10	3.07E-11	3.48E-11	3.49E-11	3.49E-11
R-RAIXRSN	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	CB	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-16 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR HUMID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
R-RASOURC	SLF	AS IS	2.39E-01	2.71E-01	2.71E-01	3.02E+00	4.07E-02	4.63E-02	4.63E-02	5.14E-01
R-RASOURC	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	1.80E-01	0.00E+00	0.00E+00	0.00E+00	3.06E-02
R-RASOURC	IDD	AS IS	2.39E-05	2.71E-05	2.71E-05	2.71E-05	4.07E-06	4.63E-06	4.64E-06	4.64E-06
R-RASOURC	SLD	AS IS	2.39E-05	2.71E-05	2.71E-05	2.71E-05	4.07E-06	4.63E-06	4.64E-06	4.64E-06
R-RASOURC	ISD	AS IS	2.39E-05	2.71E-05	2.71E-05	2.71E-05	4.07E-06	4.63E-06	4.64E-06	4.64E-06
R-RASOURC	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	CB	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLF	AS IS	1.33E-10	2.05E-10	2.13E-10	2.94E-08	2.06E-12	4.61E-12	5.24E-12	8.40E-10
U-PROCESS	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	5.10E-10	0.00E+00	0.00E+00	0.00E+00	1.46E-11
U-PROCESS	ISD	AS IS	1.33E-14	2.05E-14	2.13E-14	2.13E-14	2.06E-16	4.61E-16	5.24E-16	5.25E-16
U-PROCESS	IDD	AS IS	1.33E-14	2.05E-14	2.13E-14	2.13E-14	2.06E-16	4.61E-16	5.24E-16	5.25E-16
U-PROCESS	SLD	AS IS	1.33E-14	2.05E-14	2.13E-14	2.13E-14	2.06E-16	4.61E-16	5.24E-16	5.25E-16
U-PROCESS	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table F-17

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
F-COTRASH	SLF	AS IS	1.89E-11	2.20E-11	2.59E-11	2.59E-11	2.09E-13	1.03E-12	2.06E-12	2.06E-12
F-COTRASH	DGD	SOL	NA	NA	0.00E+00	4.51E-14	NA	NA	0.00E+00	8.09E-15
F-COTRASH	IDD	AS IS	1.89E-15	2.20E-15	2.59E-15	2.59E-15	2.08E-17	1.03E-16	2.06E-16	2.06E-16
F-COTRASH	SLD	AS IS	1.89E-15	2.20E-15	2.59E-15	2.59E-15	2.08E-17	1.03E-16	2.06E-16	2.06E-16
F-COTRASH	ISD	AS IS	1.89E-15	2.20E-15	2.59E-15	2.59E-15	2.08E-17	1.03E-16	2.06E-16	2.06E-16
F-COTRASH	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-COTRASH	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLF	AS IS	1.81E-11	2.11E-11	2.48E-11	2.48E-11	2.00E-13	9.87E-13	1.97E-12	1.97E-12
F-NCTRASH	DGD	SOL	NA	NA	0.00E+00	4.32E-14	NA	NA	0.00E+00	7.74E-15
F-NCTRASH	IDD	AS IS	1.81E-15	2.11E-15	2.48E-15	2.48E-15	2.00E-17	9.87E-17	1.97E-16	1.97E-16
F-NCTRASH	SLD	AS IS	1.81E-15	2.11E-15	2.48E-15	2.48E-15	2.00E-17	9.87E-17	1.97E-16	1.97E-16
F-NCTRASH	ISD	AS IS	1.81E-15	2.11E-15	2.48E-15	2.48E-15	2.00E-17	9.87E-17	1.97E-16	1.97E-16
F-NCTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-NCTRASH	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
F-PROCESS	SLF	AS IS	3.68E-10	4.28E-10	5.04E-10	5.04E-10	4.06E-12	2.01E-11	4.01E-11	4.01E-11
F-PROCESS	DGD	SOL	NA	NA	0.00E+00	8.78E-13	NA	NA	0.00E+00	1.58E-13
F-PROCESS	IDO	AS IS	3.68E-14	4.28E-14	5.04E-14	5.04E-14	4.06E-16	2.01E-15	4.01E-15	4.01E-15
F-PROCESS	SLD	AS IS	3.68E-14	4.28E-14	5.04E-14	5.04E-14	4.06E-16	2.01E-15	4.01E-15	4.01E-15
F-PROCESS	ISD	AS IS	3.68E-14	4.28E-14	5.04E-14	5.04E-14	4.06E-16	2.01E-15	4.01E-15	4.01E-15
F-PROCESS	EN	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	IDO	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
F-PROCESS	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-ABSLIQD	SLF	AS IS	6.05E-08	6.88E-08	7.17E-08	4.74E-05	1.08E-08	1.20E-08	1.24E-08	5.87E-06
I-ABSLIQD	SLD	AS IS	6.05E-12	6.88E-12	6.88E-12	4.51E-05	1.08E-12	1.20E-12	1.20E-12	5.59E-06
I-ABSLIQD	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	4.44E-05	0.00E+00	0.00E+00	0.00E+00	5.51E-06
I-ABSLIQD	ISD	AS IS	6.05E-12	6.88E-12	6.88E-12	3.94E-05	1.08E-12	1.20E-12	1.20E-12	4.88E-06
I-ABSLIQD	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	3.88E-05	0.00E+00	0.00E+00	0.00E+00	4.81E-06
I-ABSLIQD	IDO	AS IS	6.05E-12	6.88E-12	6.88E-12	3.85E-05	1.08E-12	1.20E-12	1.20E-12	4.77E-06
I-ABSLIQD	SLF	SOL	0.00E+00	0.00E+00	1.40E-10	3.24E-05	0.00E+00	0.00E+00	1.74E-11	4.02E-06
I-ABSLIQD	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	1.77E-05	0.00E+00	0.00E+00	0.00E+00	2.20E-06
I-ABSLIQD	EN	SOL	0.00E+00	0.00E+00	0.00E+00	1.67E-05	0.00E+00	0.00E+00	0.00E+00	2.08E-06
I-ABSLIQD	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.66E-05	0.00E+00	0.00E+00	0.00E+00	2.06E-06
I-ABSLIQD	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	9.59E-06	0.00E+00	0.00E+00	0.00E+00	1.19E-06
I-ABSLIQD,	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	9.06E-06	0.00E+00	0.00E+00	0.00E+00	1.12E-06
I-ABSLIQD	CC	SOL	0.00E+00	0.00E+00	0.00E+00	3.78E-06	0.00E+00	0.00E+00	0.00E+00	4.69E-07
I-ABSLIQD	DGD	SOL	NA	NA	1.55E-08	2.77E-07	NA	NA	1.92E-09	3.43E-08
I-ABSLIQD	IDO	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
I-BIOWAST	SLF	AS IS	5.89E-08	6.86E-08	7.22E-08	5.86E-05	8.86E-09	1.02E-08	1.06E-08	7.26E-06
I-BIOWAST	SLD	AS IS	5.89E-12	6.86E-12	6.86E-12	5.58E-05	8.86E-13	1.02E-12	1.02E-12	6.92E-06
I-BIOWAST	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	5.50E-05	0.00E+00	0.00E+00	0.00E+00	6.81E-06
I-BIOWAST	ISD	AS IS	5.89E-12	6.86E-12	6.86E-12	4.88E-05	8.86E-13	1.02E-12	1.02E-12	6.04E-06
I-BIOWAST	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	4.81E-05	0.00E+00	0.00E+00	0.00E+00	5.96E-06
I-BIOWAST	IDD	AS IS	5.89E-12	6.86E-12	6.86E-12	4.77E-05	8.86E-13	1.02E-12	1.02E-12	5.91E-06
I-BIOWAST	SLF	SOL	0.00E+00	0.00E+00	1.73E-10	4.01E-05	0.00E+00	0.00E+00	2.15E-11	4.97E-06
I-BIOWAST	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	2.19E-05	0.00E+00	0.00E+00	0.00E+00	2.72E-06
I-BIOWAST	EM	SOL	0.00E+00	0.00E+00	0.00E+00	2.07E-05	0.00E+00	0.00E+00	0.00E+00	2.57E-06
I-BIOWAST	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	2.06E-05	0.00E+00	0.00E+00	0.00E+00	2.55E-06
I-BIOWAST	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	1.64E-05	0.00E+00	0.00E+00	0.00E+00	2.04E-06
I-BIOWAST	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.19E-05	0.00E+00	0.00E+00	0.00E+00	1.47E-06
I-BIOWAST	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.12E-05	0.00E+00	0.00E+00	0.00E+00	1.39E-06
I-BIOWAST	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	8.89E-06	0.00E+00	0.00E+00	0.00E+00	1.10E-06
I-BIOWAST	CC	SOL	0.00E+00	0.00E+00	0.00E+00	4.68E-06	0.00E+00	0.00E+00	0.00E+00	5.80E-07
I-BIOWAST	DGD	SOL	NA	NA	1.92E-08	3.43E-07	NA	NA	2.38E-09	4.25E-08
I-BIOWAST	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-COTRASH	SLF	AS IS	3.24E-08	3.75E-08	3.93E-08	3.05E-05	5.12E-09	5.81E-09	6.04E-09	3.79E-06
I-COTRASH	SLD	AS IS	3.24E-12	3.75E-12	3.75E-12	2.90E-05	5.12E-13	5.81E-13	5.81E-13	3.59E-06
I-COTRASH	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	2.86E-05	0.00E+00	0.00E+00	0.00E+00	3.54E-06
I-COTRASH	ISD	AS IS	3.24E-12	3.75E-12	3.75E-12	2.49E-05	5.12E-13	5.81E-13	5.81E-13	3.09E-06
I-COTRASH	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	2.46E-05	0.00E+00	0.00E+00	0.00E+00	3.05E-06
I-COTRASH	IDD	AS IS	3.24E-12	3.75E-12	3.75E-12	2.42E-05	5.12E-13	5.81E-13	5.81E-13	3.01E-06
I-COTRASH	SLF	SOL	0.00E+00	0.00E+00	9.02E-11	2.09E-05	0.00E+00	0.00E+00	1.12E-11	2.59E-06
I-COTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	1.14E-05	0.00E+00	0.00E+00	0.00E+00	1.42E-06
I-COTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	1.08E-05	0.00E+00	0.00E+00	0.00E+00	1.34E-06
I-COTRASH	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.07E-05	0.00E+00	0.00E+00	0.00E+00	1.33E-06
I-COTRASH	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	8.57E-06	0.00E+00	0.00E+00	0.00E+00	1.06E-06
I-COTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	6.18E-06	0.00E+00	0.00E+00	0.00E+00	7.66E-07
I-COTRASH	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	5.84E-06	0.00E+00	0.00E+00	0.00E+00	7.24E-07
I-COTRASH	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	4.63E-06	0.00E+00	0.00E+00	0.00E+00	5.74E-07
I-COTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	2.44E-06	0.00E+00	0.00E+00	0.00E+00	3.02E-07
I-COTRASH	DGD	SOL	NA	NA	9.98E-09	1.78E-07	NA	NA	1.24E-09	2.21E-08
I-COTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
I-LQSCNVL	SLF	AS IS	1.27E-09	1.50E-09	1.59E-09	1.45E-06	1.51E-10	1.78E-10	1.89E-10	1.80E-07
I-LQSCNVL	SLD	AS IS	1.27E-13	1.50E-13	1.50E-13	1.39E-06	1.51E-14	1.78E-14	1.78E-14	1.72E-07
I-LQSCNVL	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	1.37E-06	0.00E+00	0.00E+00	0.00E+00	1.69E-07
I-LQSCNVL	ISD	AS IS	1.27E-13	1.50E-13	1.50E-13	1.21E-06	1.51E-14	1.78E-14	1.78E-14	1.50E-07
I-LQSCNVL	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	1.19E-06	0.00E+00	0.00E+00	0.00E+00	1.48E-07
I-LQSCNVL	IDD	AS IS	1.27E-13	1.50E-13	1.50E-13	1.18E-06	1.51E-14	1.78E-14	1.78E-14	1.47E-07
I-LQSCNVL	SLF	SOL	0.00E+00	0.00E+00	4.30E-12	9.97E-07	0.00E+00	0.00E+00	5.34E-13	1.24E-07
I-LQSCNVL	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	5.45E-07	0.00E+00	0.00E+00	0.00E+00	6.76E-08
I-LQSCNVL	EM	SOL	0.00E+00	0.00E+00	0.00E+00	5.15E-07	0.00E+00	0.00E+00	0.00E+00	6.39E-08
I-LQSCNVL	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	5.11E-07	0.00E+00	0.00E+00	0.00E+00	6.33E-08
I-LQSCNVL	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	4.09E-07	0.00E+00	0.00E+00	0.00E+00	5.07E-08
I-LQSCNVL	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	2.95E-07	0.00E+00	0.00E+00	0.00E+00	3.66E-08
I-LQSCNVL	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	2.79E-07	0.00E+00	0.00E+00	0.00E+00	3.45E-08
I-LQSCNVL	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	2.21E-07	0.00E+00	0.00E+00	0.00E+00	2.74E-08
I-LQSCNVL	CC	SOL	0.00E+00	0.00E+00	0.00E+00	1.16E-07	0.00E+00	0.00E+00	0.00E+00	1.44E-08
I-LQSCNVL	DGD	SOL	NA	NA	4.76E-10	8.51E-09	NA	NA	5.90E-11	1.06E-09
I-LQSCNVL	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-CONCLIQ	SLF	AS IS	3.30E-07	3.48E-07	3.49E-07	4.56E-06	9.14E-08	9.64E-08	9.65E-08	6.08E-07
L-CONCLIQ	SLD	AS IS	3.30E-11	3.48E-11	3.48E-11	4.02E-06	9.14E-12	9.64E-12	9.65E-12	4.87E-07
L-CONCLIQ	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	3.96E-06	0.00E+00	0.00E+00	0.00E+00	4.80E-07
L-CONCLIQ	ISD	AS IS	3.30E-11	3.48E-11	3.48E-11	3.52E-06	9.14E-12	9.64E-12	9.65E-12	4.26E-07
L-CONCLIQ	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	3.47E-06	0.00E+00	0.00E+00	0.00E+00	4.20E-07
L-CONCLIQ	IDD	AS IS	3.30E-11	3.48E-11	3.48E-11	3.45E-06	9.14E-12	9.64E-12	9.65E-12	4.17E-07
L-CONCLIQ	SLF	SOL	0.00E+00	0.00E+00	1.22E-11	2.90E-06	0.00E+00	0.00E+00	1.51E-12	3.51E-07
L-CONCLIQ	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	1.59E-06	0.00E+00	0.00E+00	0.00E+00	1.92E-07
L-CONCLIQ	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.49E-06	0.00E+00	0.00E+00	0.00E+00	1.80E-07
L-CONCLIQ	EM	SOL	0.00E+00	0.00E+00	0.00E+00	1.49E-06	0.00E+00	0.00E+00	0.00E+00	1.81E-07
L-CONCLIQ	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	8.58E-07	0.00E+00	0.00E+00	0.00E+00	1.04E-07
L-CONCLIQ	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	8.10E-07	0.00E+00	0.00E+00	0.00E+00	9.80E-08
L-CONCLIQ	CC	SOL	0.00E+00	0.00E+00	0.00E+00	3.36E-07	0.00E+00	0.00E+00	0.00E+00	4.09E-08
L-CONCLIQ	DGD	SOL	NA	NA	1.36E-09	2.63E-08	NA	NA	1.67E-10	3.09E-09
L-CONCLIQ	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-COTRASH	SLF	AS IS	1.07E-08	1.12E-08	1.12E-08	9.45E-08	2.98E-09	3.12E-09	3.12E-09	1.31E-08
L-COTRASH	SLD	AS IS	1.07E-12	1.12E-12	1.12E-12	7.92E-08	2.98E-13	3.12E-13	3.12E-13	9.53E-09
L-COTRASH	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	7.81E-08	0.00E+00	0.00E+00	0.00E+00	9.39E-09
L-COTRASH	ISD	AS IS	1.07E-12	1.12E-12	1.12E-12	6.85E-08	2.98E-13	3.12E-13	3.12E-13	8.20E-09
L-COTRASH	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	6.76E-08	0.00E+00	0.00E+00	0.00E+00	8.09E-09
L-COTRASH	IDD	AS IS	1.07E-12	1.12E-12	1.12E-12	6.66E-08	2.98E-13	3.12E-13	3.12E-13	7.97E-09
L-COTRASH	SLF	SOL	0.00E+00	0.00E+00	2.38E-13	5.74E-08	0.00E+00	0.00E+00	2.96E-14	6.87E-09
L-COTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	3.15E-08	0.00E+00	0.00E+00	0.00E+00	3.76E-09
L-COTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	2.95E-08	0.00E+00	0.00E+00	0.00E+00	3.55E-09
L-COTRASH	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	2.95E-08	0.00E+00	0.00E+00	0.00E+00	3.52E-09
L-COTRASH	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	2.39E-08	0.00E+00	0.00E+00	0.00E+00	2.82E-09
L-COTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.70E-08	0.00E+00	0.00E+00	0.00E+00	2.03E-09
L-COTRASH	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.60E-08	0.00E+00	0.00E+00	0.00E+00	1.92E-09
L-COTRASH	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	1.29E-08	0.00E+00	0.00E+00	0.00E+00	1.53E-09
L-COTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	6.62E-09	0.00E+00	0.00E+00	0.00E+00	8.00E-10
L-COTRASH	DGD	SOL	NA	NA	2.68E-11	5.31E-10	NA	NA	3.28E-12	6.13E-11
L-COTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLF	AS IS	4.03E-06	4.03E-06	4.03E-06	4.03E-06	1.17E-06	1.17E-06	1.17E-06	1.17E-06
L-DECONRS	SLD	AS IS	4.03E-10	4.03E-10	4.03E-10	4.03E-10	1.17E-10	1.17E-10	1.17E-10	1.17E-10
L-DECONRS	ISD	AS IS	4.03E-10	4.03E-10	4.03E-10	4.03E-10	1.17E-10	1.17E-10	1.17E-10	1.17E-10
L-DECONRS	IDD	AS IS	4.03E-10	4.03E-10	4.03E-10	4.03E-10	1.17E-10	1.17E-10	1.17E-10	1.17E-10
L-DECONRS	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	CB	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	DGD	SOL	NA	NA	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00
L-DECONRS	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-DECONRS	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

SOURCE: PUTNAM, HAYES & BARTLETT, INC. 30-Aug-86

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-FSLUDGE	SLF	AS IS	2.16E-06	2.27E-06	2.28E-06	7.66E-06	6.05E-07	6.36E-07	6.37E-07	1.24E-06
L-FSLUDGE	SLD	AS IS	2.16E-10	2.27E-10	2.28E-10	5.15E-06	6.05E-11	6.36E-11	6.37E-11	5.75E-07
L-FSLUDGE	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	5.09E-06	0.00E+00	0.00E+00	0.00E+00	5.67E-07
L-FSLUDGE	ISD	AS IS	2.16E-10	2.27E-10	2.28E-10	4.58E-06	6.05E-11	6.36E-11	6.37E-11	5.04E-07
L-FSLUDGE	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	4.52E-06	0.00E+00	0.00E+00	0.00E+00	4.97E-07
L-FSLUDGE	IDD	AS IS	2.16E-10	2.27E-10	2.28E-10	4.48E-06	6.05E-11	6.36E-11	6.37E-11	4.92E-07
L-FSLUDGE	SLF	SOL	0.00E+00	0.00E+00	1.42E-11	3.77E-06	0.00E+00	0.00E+00	1.76E-12	4.14E-07
L-FSLUDGE	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	2.08E-06	0.00E+00	0.00E+00	0.00E+00	2.27E-07
L-FSLUDGE	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.96E-06	0.00E+00	0.00E+00	0.00E+00	2.13E-07
L-FSLUDGE	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	1.63E-06	0.00E+00	0.00E+00	0.00E+00	1.71E-07
L-FSLUDGE	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.11E-06	0.00E+00	0.00E+00	0.00E+00	1.23E-07
L-FSLUDGE	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.05E-06	0.00E+00	0.00E+00	0.00E+00	1.16E-07
L-FSLUDGE	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	8.68E-07	0.00E+00	0.00E+00	0.00E+00	9.23E-08
L-FSLUDGE	CC	SOL	0.00E+00	0.00E+00	0.00E+00	4.24E-07	0.00E+00	0.00E+00	0.00E+00	4.81E-08
L-FSLUDGE	CB	SOL	0.00E+00	0.00E+00	0.00E+00	2.16E-07	0.00E+00	0.00E+00	0.00E+00	2.46E-08
L-FSLUDGE	DGD	SOL	NA	NA	1.68E-09	4.14E-08	NA	NA	1.96E-10	4.12E-09
L-FSLUDGE	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-IXRESIN	SLF	AS IS	4.84E-06	5.16E-06	5.16E-06	8.10E-05	1.33E-06	1.42E-06	1.42E-06	1.06E-05
L-IXRESIN	SLD	AS IS	4.84E-10	5.16E-10	5.16E-10	7.24E-05	1.33E-10	1.42E-10	1.42E-10	8.79E-06
L-IXRESIN	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	7.14E-05	0.00E+00	0.00E+00	0.00E+00	8.66E-06
L-IXRESIN	ISD	AS IS	4.84E-10	5.16E-10	5.16E-10	6.35E-05	1.33E-10	1.42E-10	1.42E-10	7.68E-06
L-IXRESIN	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	6.26E-05	0.00E+00	0.00E+00	0.00E+00	7.57E-06
L-IXRESIN	IDD	AS IS	4.84E-10	5.16E-10	5.16E-10	6.21E-05	1.33E-10	1.42E-10	1.42E-10	7.51E-06
L-IXRESIN	SLF	SOL	0.00E+00	0.00E+00	2.19E-10	5.23E-05	0.00E+00	0.00E+00	2.72E-11	6.32E-06
L-IXRESIN	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	2.86E-05	0.00E+00	0.00E+00	0.00E+00	3.46E-06
L-IXRESIN	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	2.69E-05	0.00E+00	0.00E+00	0.00E+00	3.24E-06
L-IXRESIN	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	2.17E-05	0.00E+00	0.00E+00	0.00E+00	2.59E-06
L-IXRESIN	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.55E-05	0.00E+00	0.00E+00	0.00E+00	1.87E-06
L-IXRESIN	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.46E-05	0.00E+00	0.00E+00	0.00E+00	1.77E-06
L-IXRESIN	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	1.17E-05	0.00E+00	0.00E+00	0.00E+00	1.40E-06
L-IXRESIN	CC	SOL	0.00E+00	0.00E+00	0.00E+00	6.05E-06	0.00E+00	0.00E+00	0.00E+00	7.36E-07
L-IXRESIN	CB	SOL	0.00E+00	0.00E+00	0.00E+00	3.09E-06	0.00E+00	0.00E+00	0.00E+00	3.76E-07
L-IXRESIN	DGD	SOL	NA	NA	2.46E-08	4.73E-07	NA	NA	3.01E-09	5.57E-08
L-IXRESIN	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
L-NCTRASH	SLF	AS IS	6.95E-08	7.25E-08	7.26E-08	7.79E-07	1.94E-08	2.03E-08	2.03E-08	1.06E-07
L-NCTRASH	SLD	AS IS	6.95E-12	7.25E-12	7.26E-12	6.72E-07	1.94E-12	2.03E-12	2.03E-12	8.15E-08
L-NCTRASH	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	6.62E-07	0.00E+00	0.00E+00	0.00E+00	8.03E-08
L-NCTRASH	ISD	AS IS	6.95E-12	7.25E-12	7.26E-12	5.80E-07	1.94E-12	2.03E-12	2.03E-12	7.01E-08
L-NCTRASH	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	5.72E-07	0.00E+00	0.00E+00	0.00E+00	6.91E-08
L-NCTRASH	IDD	AS IS	6.95E-12	7.25E-12	7.26E-12	5.64E-07	1.94E-12	2.03E-12	2.03E-12	6.82E-08
L-NCTRASH	SLF	SOL	0.00E+00	0.00E+00	2.04E-12	4.86E-07	0.00E+00	0.00E+00	2.53E-13	5.88E-08
L-NCTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	2.66E-07	0.00E+00	0.00E+00	0.00E+00	3.21E-08
L-NCTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	2.50E-07	0.00E+00	0.00E+00	0.00E+00	3.03E-08
L-NCTRASH	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	2.50E-07	0.00E+00	0.00E+00	0.00E+00	3.01E-08
L-NCTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.44E-07	0.00E+00	0.00E+00	0.00E+00	1.74E-08
L-NCTRASH	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.36E-07	0.00E+00	0.00E+00	0.00E+00	1.64E-08
L-NCTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	5.62E-08	0.00E+00	0.00E+00	0.00E+00	6.85E-09
L-NCTRASH	DGD	SOL	NA	NA	2.29E-10	4.39E-09	NA	NA	2.80E-11	5.18E-10
L-NCTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
L-NFRCOMP	SLF	AS IS	0.00E+00	0.00E+00	1.40E-10	2.60E-05	0.00E+00	0.00E+00	1.73E-11	3.23E-06
L-NFRCOMP	SLF	SOL	0.00E+00	0.00E+00	1.10E-10	2.55E-05	0.00E+00	0.00E+00	1.37E-11	3.17E-06
L-NFRCOMP	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	1.40E-05	0.00E+00	0.00E+00	0.00E+00	1.73E-06
L-NFRCOMP	SLD	AS IS	0.00E+00	0.00E+00	0.00E+00	1.40E-05	0.00E+00	0.00E+00	0.00E+00	1.73E-06
L-NFRCOMP	EM	SOL	0.00E+00	0.00E+00	0.00E+00	1.32E-05	0.00E+00	0.00E+00	0.00E+00	1.64E-06
L-NFRCOMP	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.31E-05	0.00E+00	0.00E+00	0.00E+00	1.62E-06
L-NFRCOMP	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	1.31E-05	0.00E+00	0.00E+00	0.00E+00	1.62E-06
L-NFRCOMP	ISD	AS IS	0.00E+00	0.00E+00	0.00E+00	7.57E-06	0.00E+00	0.00E+00	0.00E+00	9.38E-07
L-NFRCOMP	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	7.56E-06	0.00E+00	0.00E+00	0.00E+00	9.37E-07
L-NFRCOMP	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	7.15E-06	0.00E+00	0.00E+00	0.00E+00	8.86E-07
L-NFRCOMP	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	7.14E-06	0.00E+00	0.00E+00	0.00E+00	8.85E-07
L-NFRCOMP	IDD	AS IS	0.00E+00	0.00E+00	0.00E+00	3.37E-06	0.00E+00	0.00E+00	0.00E+00	4.18E-07
L-NFRCOMP	CC	SOL	0.00E+00	0.00E+00	0.00E+00	2.98E-06	0.00E+00	0.00E+00	0.00E+00	3.69E-07
L-NFRCOMP	DGD	SOL	NA	NA	1.22E-08	2.18E-07	NA	NA	1.51E-09	2.70E-08
L-NFRCOMP	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-ISOPROD	SLF	AS IS	6.47E-06	6.91E-06	6.92E-06	7.37E-06	1.52E-06	1.63E-06	1.63E-06	1.69E-06
N-ISOPROD	SLD	AS IS	6.47E-10	6.91E-10	6.92E-10	4.33E-07	1.52E-10	1.63E-10	1.64E-10	5.35E-08
N-ISOPROD	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	4.26E-07	0.00E+00	0.00E+00	0.00E+00	5.25E-08
N-ISOPROD	ISD	AS IS	6.47E-10	6.91E-10	6.92E-10	3.73E-07	1.52E-10	1.63E-10	1.64E-10	4.61E-08
N-ISOPROD	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	3.67E-07	0.00E+00	0.00E+00	0.00E+00	4.52E-08
N-ISOPROD	IDD	AS IS	6.47E-10	6.91E-10	6.92E-10	3.63E-07	1.52E-10	1.63E-10	1.64E-10	4.48E-08
N-ISOPROD	SLF	SOL	0.00E+00	0.00E+00	1.34E-12	3.12E-07	0.00E+00	0.00E+00	1.66E-13	3.84E-08
N-ISOPROD	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	1.71E-07	0.00E+00	0.00E+00	0.00E+00	2.10E-08
N-ISOPROD	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.60E-07	0.00E+00	0.00E+00	0.00E+00	1.97E-08
N-ISOPROD	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	1.28E-07	0.00E+00	0.00E+00	0.00E+00	1.58E-08
N-ISOPROD	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	9.22E-08	0.00E+00	0.00E+00	0.00E+00	1.14E-08
N-ISOPROD	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	8.71E-08	0.00E+00	0.00E+00	0.00E+00	1.07E-08
N-ISOPROD	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	6.93E-08	0.00E+00	0.00E+00	0.00E+00	8.53E-09
N-ISOPROD	CC	SOL	0.00E+00	0.00E+00	0.00E+00	3.63E-08	0.00E+00	0.00E+00	0.00E+00	4.48E-09
N-ISOPROD	CB	SOL	0.00E+00	0.00E+00	0.00E+00	1.85E-08	0.00E+00	0.00E+00	0.00E+00	2.29E-09
N-ISOPROD	DGD	SOL	NA	NA	1.48E-10	3.18E-09	NA	NA	1.83E-11	3.69E-10
N-ISOPROD	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-LOTRASH	SLF	AS IS	1.01E-08	1.17E-08	1.23E-08	9.53E-06	1.60E-09	1.81E-09	1.88E-09	1.18E-06
N-LOTRASH	SLD	AS IS	1.01E-12	1.17E-12	1.17E-12	9.04E-06	1.60E-13	1.81E-13	1.81E-13	1.12E-06
N-LOTRASH	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	8.91E-06	0.00E+00	0.00E+00	0.00E+00	1.10E-06
N-LOTRASH	ISD	AS IS	1.01E-12	1.17E-12	1.17E-12	7.78E-06	1.60E-13	1.81E-13	1.81E-13	9.64E-07
N-LOTRASH	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	7.67E-06	0.00E+00	0.00E+00	0.00E+00	9.50E-07
N-LOTRASH	IDD	AS IS	1.01E-12	1.17E-12	1.17E-12	7.56E-06	1.60E-13	1.81E-13	1.81E-13	9.37E-07
N-LOTRASH	SLF	SOL	0.00E+00	0.00E+00	2.81E-11	6.51E-06	0.00E+00	0.00E+00	3.49E-12	8.07E-07
N-LOTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	3.56E-06	0.00E+00	0.00E+00	0.00E+00	4.42E-07
N-LOTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	3.37E-06	0.00E+00	0.00E+00	0.00E+00	4.17E-07
N-LOTRASH	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	3.34E-06	0.00E+00	0.00E+00	0.00E+00	4.14E-07
N-LOTRASH	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	2.67E-06	0.00E+00	0.00E+00	0.00E+00	3.31E-07
N-LOTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.93E-06	0.00E+00	0.00E+00	0.00E+00	2.39E-07
N-LOTRASH	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.82E-06	0.00E+00	0.00E+00	0.00E+00	2.26E-07
N-LOTRASH	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	1.44E-06	0.00E+00	0.00E+00	0.00E+00	1.79E-07
N-LOTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	7.60E-07	0.00E+00	0.00E+00	0.00E+00	9.42E-08
N-LOTRASH	DGD	SOL	NA	NA	3.11E-09	5.56E-08	NA	NA	3.86E-10	6.90E-09
N-LOTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-LOWASTE	SLF	AS IS	5.94E-09	6.86E-09	7.19E-09	5.43E-06	9.56E-10	1.08E-09	1.12E-09	6.73E-07
N-LOWASTE	SLD	AS IS	5.94E-13	6.86E-13	6.86E-13	5.17E-06	9.56E-14	1.08E-13	1.08E-13	6.41E-07
N-LOWASTE	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	5.09E-06	0.00E+00	0.00E+00	0.00E+00	6.31E-07
N-LOWASTE	ISD	AS IS	5.94E-13	6.86E-13	6.86E-13	4.52E-06	9.56E-14	1.08E-13	1.08E-13	5.60E-07
N-LOWASTE	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	4.46E-06	0.00E+00	0.00E+00	0.00E+00	5.52E-07
N-LOWASTE	IDD	AS IS	5.94E-13	6.86E-13	6.86E-13	4.42E-06	9.56E-14	1.08E-13	1.08E-13	5.48E-07
N-LOWASTE	SLF	SOL	0.00E+00	0.00E+00	1.61E-11	3.72E-06	0.00E+00	0.00E+00	1.99E-12	4.61E-07
N-LOWASTE	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	2.03E-06	0.00E+00	0.00E+00	0.00E+00	2.52E-07
N-LOWASTE	EM	SOL	0.00E+00	0.00E+00	0.00E+00	1.92E-06	0.00E+00	0.00E+00	0.00E+00	2.38E-07
N-LOWASTE	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.91E-06	0.00E+00	0.00E+00	0.00E+00	2.36E-07
N-LOWASTE	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	1.52E-06	0.00E+00	0.00E+00	0.00E+00	1.89E-07
N-LOWASTE	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.10E-06	0.00E+00	0.00E+00	0.00E+00	1.36E-07
N-LOWASTE	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.04E-06	0.00E+00	0.00E+00	0.00E+00	1.29E-07
N-LOWASTE	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	8.24E-07	0.00E+00	0.00E+00	0.00E+00	1.02E-07
N-LOWASTE	CC	SOL	0.00E+00	0.00E+00	0.00E+00	4.34E-07	0.00E+00	0.00E+00	0.00E+00	5.37E-08
N-LOWASTE	DGD	SOL	NA	NA	1.78E-09	3.18E-08	NA	NA	2.20E-10	3.94E-09
N-LOWASTE	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SOURCES	SLF	AS IS	0.00E+00	0.00E+00	9.92E-11	1.85E-05	0.00E+00	0.00E+00	1.23E-11	2.29E-06
N-SOURCES	SLF	SOL	0.00E+00	0.00E+00	7.84E-11	1.81E-05	0.00E+00	0.00E+00	9.72E-12	2.25E-06
N-SOURCES	SLD	AS IS	0.00E+00	0.00E+00	0.00E+00	9.93E-06	0.00E+00	0.00E+00	0.00E+00	1.23E-06
N-SOURCES	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	9.93E-06	0.00E+00	0.00E+00	0.00E+00	1.23E-06
N-SOURCES	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	9.30E-06	0.00E+00	0.00E+00	0.00E+00	1.15E-06
N-SOURCES	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	9.30E-06	0.00E+00	0.00E+00	0.00E+00	1.15E-06
N-SOURCES	ISD	AS IS	0.00E+00	0.00E+00	0.00E+00	5.38E-06	0.00E+00	0.00E+00	0.00E+00	6.66E-07
N-SOURCES	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	5.37E-06	0.00E+00	0.00E+00	0.00E+00	6.66E-07
N-SOURCES	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	5.08E-06	0.00E+00	0.00E+00	0.00E+00	6.29E-07
N-SOURCES	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	5.07E-06	0.00E+00	0.00E+00	0.00E+00	6.29E-07
N-SOURCES	IDD	AS IS	0.00E+00	0.00E+00	0.00E+00	2.39E-06	0.00E+00	0.00E+00	0.00E+00	2.97E-07
N-SOURCES	CC	SOL	0.00E+00	0.00E+00	0.00E+00	2.12E-06	0.00E+00	0.00E+00	0.00E+00	2.62E-07
N-SOURCES	CB	SOL	0.00E+00	0.00E+00	0.00E+00	1.08E-06	0.00E+00	0.00E+00	0.00E+00	1.34E-07
N-SOURCES	DGD	SOL	NA	NA	8.67E-09	1.55E-07	NA	NA	1.07E-09	1.92E-08
N-SOURCES	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

SOURCE: PUTNAM, HAYES & BARTLETT, INC. 20-Aug-86

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
N-SSTRASH	SLF	AS IS	6.14E-12	6.58E-12	7.12E-12	7.12E-12	2.82E-14	1.37E-13	2.74E-13	2.74E-13
N-SSTRASH	DGD	SOL	NA	NA	0.00E+00	9.82E-15	NA	NA	0.00E+00	1.17E-15
N-SSTRASH	IDD	AS IS	6.14E-16	6.58E-16	7.12E-16	7.12E-16	2.82E-18	1.37E-17	2.74E-17	2.74E-17
N-SSTRASH	SLD	AS IS	6.14E-16	6.58E-16	7.12E-16	7.12E-16	2.82E-18	1.37E-17	2.74E-17	2.74E-17
N-SSTRASH	ISD	AS IS	6.14E-16	6.58E-16	7.12E-16	7.12E-16	2.82E-18	1.37E-17	2.74E-17	2.74E-17
N-SSTRASH	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSTRASH	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLF	AS IS	1.19E-10	1.28E-10	1.38E-10	1.38E-10	5.50E-13	2.68E-12	5.33E-12	5.33E-12
N-SSWASTE	DGD	SOL	NA	NA	0.00E+00	1.91E-13	NA	NA	0.00E+00	2.28E-14
N-SSWASTE	ISD	AS IS	1.19E-14	1.28E-14	1.38E-14	1.38E-14	5.50E-17	2.68E-16	5.33E-16	5.33E-16
N-SSWASTE	IDD	AS IS	1.19E-14	1.28E-14	1.38E-14	1.38E-14	5.50E-17	2.68E-16	5.33E-16	5.33E-16
N-SSWASTE	SLD	AS IS	1.19E-14	1.28E-14	1.38E-14	1.38E-14	5.50E-17	2.68E-16	5.33E-16	5.33E-16
N-SSWASTE	EM	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-SSWASTE	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

			FATAL RISK				GENETIC RISK			
WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	100 YRS	500 YRS	1000 YRS	10000 YRS	100 YRS	500 YRS	1000 YRS	10000 YRS
N-TARGETS	DGD	SOL	NA	NA	4.61E-20	4.61E-20	NA	NA	1.16E-20	1.16E-20
N-TARGETS	SLF	AS IS	0.00E+00	0.00E+00	2.13E-25	2.13E-25	0.00E+00	0.00E+00	5.38E-26	5.38E-26
N-TARGETS	SLF	SOL	0.00E+00	0.00E+00	2.48E-26	2.48E-26	0.00E+00	0.00E+00	6.26E-27	6.26E-27
N-TARGETS	SLD	AS IS	0.00E+00	0.00E+00	0.00E+00	1.84E-38	0.00E+00	0.00E+00	0.00E+00	4.63E-39
N-TARGETS	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	1.84E-38	0.00E+00	0.00E+00	0.00E+00	4.63E-39
N-TARGETS	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	4.12E-44	0.00E+00	0.00E+00	0.00E+00	1.04E-44
N-TARGETS	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	4.12E-44	0.00E+00	0.00E+00	0.00E+00	1.04E-44
N-TARGETS	IDD	AS IS	0.00E+00	0.00E+00	0.00E+00	5.69E-52	0.00E+00	0.00E+00	0.00E+00	1.43E-52
N-TARGETS	ISD	AS IS	0.00E+00	0.00E+00	0.00E+00	6.04E-53	0.00E+00	0.00E+00	0.00E+00	1.52E-53
N-TARGETS	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	6.03E-53	0.00E+00	0.00E+00	0.00E+00	1.52E-53
N-TARGETS	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	1.37E-58	0.00E+00	0.00E+00	0.00E+00	3.45E-59
N-TARGETS	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.37E-58	0.00E+00	0.00E+00	0.00E+00	3.45E-59
N-TARGETS	CC	SOL	0.00E+00	0.00E+00	0.00E+00	3.88E-62	0.00E+00	0.00E+00	0.00E+00	9.78E-63
N-TARGETS	CB	SOL	0.00E+00	0.00E+00	0.00E+00	5.56E-64	0.00E+00	0.00E+00	0.00E+00	1.40E-64
N-TARGETS	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-TRITIUM	SLF	AS IS	1.33E-06	1.58E-06	1.68E-06	1.60E-03	1.66E-07	1.96E-07	2.08E-07	1.99E-04
N-TRITIUM	SLD	AS IS	1.33E-10	1.58E-10	1.58E-10	1.52E-03	1.66E-11	1.96E-11	1.96E-11	1.89E-04
N-TRITIUM	SLD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	1.50E-03	0.00E+00	0.00E+00	0.00E+00	1.86E-04
N-TRITIUM	ISD	AS IS	1.33E-10	1.58E-10	1.58E-10	1.31E-03	1.66E-11	1.96E-11	1.96E-11	1.62E-04
N-TRITIUM	ISD, NIC	AS IS	0.00E+00	0.00E+00	0.00E+00	1.29E-03	0.00E+00	0.00E+00	0.00E+00	1.60E-04
N-TRITIUM	IDD	AS IS	1.33E-10	1.58E-10	1.58E-10	1.27E-03	1.66E-11	1.96E-11	1.96E-11	1.58E-04
N-TRITIUM	SLF	SOL	0.00E+00	0.00E+00	4.73E-09	1.10E-03	0.00E+00	0.00E+00	5.87E-10	1.36E-04
N-TRITIUM	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	6.00E-04	0.00E+00	0.00E+00	0.00E+00	7.43E-05
N-TRITIUM	SLD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	5.62E-04	0.00E+00	0.00E+00	0.00E+00	6.96E-05
N-TRITIUM	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	4.49E-04	0.00E+00	0.00E+00	0.00E+00	5.57E-05
N-TRITIUM	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	3.24E-04	0.00E+00	0.00E+00	0.00E+00	4.02E-05
N-TRITIUM	ISD, NIC	SOL	0.00E+00	0.00E+00	0.00E+00	3.06E-04	0.00E+00	0.00E+00	0.00E+00	3.80E-05
N-TRITIUM	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	2.43E-04	0.00E+00	0.00E+00	0.00E+00	3.01E-05
N-TRITIUM	CC	SOL	0.00E+00	0.00E+00	0.00E+00	1.28E-04	0.00E+00	0.00E+00	0.00E+00	1.58E-05
N-TRITIUM	CB	SOL	0.00E+00	0.00E+00	0.00E+00	6.53E-05	0.00E+00	0.00E+00	0.00E+00	8.09E-06
N-TRITIUM	DGD	SOL	NA	NA	5.24E-07	9.36E-06	NA	NA	6.49E-08	1.16E-06
N-TRITIUM	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table continued on next page

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
P-FCARTRG	SLF	AS IS	5.79E-07	5.82E-07	5.84E-07	1.19E-06	1.67E-07	1.68E-07	1.68E-07	2.41E-07
P-FCARTRG	SLD	AS IS	5.79E-11	5.82E-11	5.84E-11	5.73E-07	1.67E-11	1.68E-11	1.68E-11	6.98E-08
P-FCARTRG	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	5.65E-07	0.00E+00	0.00E+00	0.00E+00	6.88E-08
P-FCARTRG	ISD	AS IS	5.79E-11	5.82E-11	5.84E-11	4.94E-07	1.67E-11	1.68E-11	1.68E-11	6.01E-08
P-FCARTRG	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	4.87E-07	0.00E+00	0.00E+00	0.00E+00	5.92E-08
P-FCARTRG	IDD	AS IS	5.79E-11	5.82E-11	5.84E-11	4.80E-07	1.67E-11	1.68E-11	1.68E-11	5.84E-08
P-FCARTRG	SLF	SOL	0.00E+00	0.00E+00	1.75E-12	4.14E-07	0.00E+00	0.00E+00	2.17E-13	5.03E-08
P-FCARTRG	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	2.27E-07	0.00E+00	0.00E+00	0.00E+00	2.75E-08
P-FCARTRG	EM	SOL	0.00E+00	0.00E+00	0.00E+00	2.13E-07	0.00E+00	0.00E+00	0.00E+00	2.60E-08
P-FCARTRG	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	2.13E-07	0.00E+00	0.00E+00	0.00E+00	2.58E-08
P-FCARTRG	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	1.22E-07	0.00E+00	0.00E+00	0.00E+00	1.49E-08
P-FCARTRG	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	1.16E-07	0.00E+00	0.00E+00	0.00E+00	1.41E-08
P-FCARTRG	CC	SOL	0.00E+00	0.00E+00	0.00E+00	4.80E-08	0.00E+00	0.00E+00	0.00E+00	5.87E-09
P-FCARTRG	DGD	SOL	NA	NA	1.95E-10	3.70E-09	NA	NA	2.40E-11	4.41E-10
P-FCARTRG	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLF	AS IS	6.87E-08	2.72E-07	4.81E-07	4.81E-07	1.77E-08	7.51E-08	1.34E-07	1.34E-07
R-RAIXRSN	IDD	AS IS	6.87E-12	2.72E-11	4.81E-11	4.81E-11	1.77E-12	7.51E-12	1.34E-11	1.34E-11
R-RAIXRSN	SLD	AS IS	6.87E-12	2.72E-11	4.81E-11	4.81E-11	1.77E-12	7.51E-12	1.34E-11	1.34E-11
R-RAIXRSN	ISD	AS IS	6.87E-12	2.72E-11	4.81E-11	4.81E-11	1.77E-12	7.51E-12	1.34E-11	1.34E-11
R-RAIXRSN	DGD	SOL	NA	NA	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00
R-RAIXRSN	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	ISD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLD	INC/SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	CB	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RAIXRSN	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table F-17 (continued)

SUMMARY OF UNIT VOLUME HEALTH EFFECTS FOR ARID PERMEABLE REGION

WASTE STREAM	DISPOSAL ALTERNATIVE	WASTE FORM	FATAL RISK 100 YRS	FATAL RISK 500 YRS	FATAL RISK 1000 YRS	FATAL RISK 10000 YRS	GENETIC RISK 100 YRS	GENETIC RISK 500 YRS	GENETIC RISK 1000 YRS	GENETIC RISK 10000 YRS
R-RASOURC	SLF	AS IS	1.03E-02	4.17E-02	7.41E-02	7.41E-02	2.68E-03	1.16E-02	2.07E-02	2.07E-02
R-RASOURC	IDA	AS IS	1.03E-06	4.17E-06	7.41E-06	7.41E-06	2.68E-07	1.16E-06	2.07E-06	2.07E-06
R-RASOURC	ISD	AS IS	1.03E-06	4.17E-06	7.41E-06	7.41E-06	2.68E-07	1.16E-06	2.07E-06	2.07E-06
R-RASOURC	SLD	AS IS	1.03E-06	4.17E-06	7.41E-06	7.41E-06	2.68E-07	1.16E-06	2.07E-06	2.07E-06
R-RASOURC	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	DGD	SOL	NA	NA	0.00E+00	0.00E+00	NA	NA	0.00E+00	0.00E+00
R-RASOURC	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	CB	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
R-RASOURC	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLF	AS IS	4.14E-10	4.60E-10	5.17E-10	5.17E-10	3.04E-12	1.49E-11	2.98E-11	2.98E-11
U-PROCESS	DGD	SOL	NA	NA	0.00E+00	8.00E-13	NA	NA	0.00E+00	1.21E-13
U-PROCESS	IDD	AS IS	4.14E-14	4.60E-14	5.17E-14	5.17E-14	3.04E-16	1.49E-15	2.98E-15	2.98E-15
U-PROCESS	ISD	AS IS	4.14E-14	4.60E-14	5.17E-14	5.17E-14	3.04E-16	1.49E-15	2.98E-15	2.98E-15
U-PROCESS	SLD	AS IS	4.14E-14	4.60E-14	5.17E-14	5.17E-14	3.04E-16	1.49E-15	2.98E-15	2.98E-15
U-PROCESS	IDD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLF	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	ISD, HIC	AS IS	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	ISD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	CC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	EN	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	SLD	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-PROCESS	ISD, HIC	SOL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table F-18

LLW AND BRC WASTE NUCLIDE CONCENTRATION MATRIX

	LLW NAME:	L-IXRESIN	L-CONCLIQ	L-FSLUDGE	P-FCARTRG	L-DECONRS	L-NFRCOMP	F-PROCESS	U-PROCESS	L-COTRASH	L NCTRASH	F-COTRASH	F-NCTRASH	I-COTRASH	N-LOTRASH
	EPA VOLUME:	99100	331000	131000	12800	2240	64500	59500	21400	598000	478000	179000	31700	282000	101000
	NUCLIDE CONCENTRATION (Ci/m^3):														
1	H-3	3.42E-01	1.89E-02	1.36E-02	2.77E-03					3.56E 04	3.17E-03			9.13E 02	2.85E-02
2	C-14	1.20E-02	7.10E-04	8.29E-04	1.02E-04		6.43E-03			1.39E-05	1.19E 04			5.26E-03	1.64E-03
3	FE-55	8.19E-01	1.95E-01	1.56E+00	1.34E+00	2.63E+00	5.54E+01			9.19E-03	6.87E-02				
4	NI-59	8.89E-04	2.20E-04	1.62E-03	1.59E-03		3.45E 02			1.05E 05	8.09E-05				
5	CO-60	1.44E+00	3.58E-01	2.62E+00	2.58E+00	1.89E+01	3.98E+01			1.71E-02	1.31E-01			1.04E-02	3.25E-03
6															
7	NI-63	1.19E-01	6.59E-02	5.32E-02	4.91E-01	9.96E 01	4.76E+00			2.41E-03	2.24E-02				
8	SR-90	2.62E-02	1.45E-03	2.50E-03	2.02E-04					2.96E-05	2.43E-04			1.45E-03	4.53E-04
9	NB-94	2.82E-05	6.98E-06	5.10E-05	5.03E 05		2.04E-04			3.33E-07	2.56E-06				
10	TC-99	1.45E-04	8.12E-06	5.36E-05	8.62E 07					2.26E 07	1.32E-06			3.39E-09	1.06E-09
11	RU-106	3.87E-03	2.16E-04	1.39E-03	2.30E-05	8.46E-01				6.01E-06	3.54E-05				
12															
13	SB-125	1.16E-02	2.86E-03	2.09E-02	2.06E-02	1.88E-03				1.36E-04	1.05E-03				
14	I-129	4.18E-04	2.33E-05	1.39E-04	2.55E-06					6.32E 07	3.82E-06				
15	CS-134	3.87E+00	2.16E-01	1.39E+00	2.30E-02					6.01E-03	3.54E-02				
16	CS-135	1.45E-04	8.12E-06	5.24E-05	8.62E-07					2.26E-07	1.33E-06				
17	CS-137	3.87E+00	2.16E-01	1.39E+00	2.30E-02					6.01E-03	3.54E 02			4.56E-03	1.42E-03
18															
19	BA-137M	3.87E+00	2.16E-01	1.39E+00	2.30E-02					6.01E-03	3.54E-02			4.56E-03	1.42E-03
20	EU-154	1.16E-03	2.87E-04	2.10E-03	2.07E-03	3.76E 05				1.37E-05	1.05E-04				
21	U-234	1.59E-04	9.62E-06	9.95E-06	2.36E-05			5.20E-04	3.64E-04	2.43E 07	2.19E 06	2.68E 05	2.56E 05		
22	U 235	2.55E-06	1.56E-07	1.60E 07	3.79E 07			2.30E-05	1.65E-05	3.89E 09	3.52E 08	1.18E-06	1.13E 06		
23	NP-237	1.16E-09	6.89E-11	7.14E-11	1.69E-10					1.74E 12	1.57E-11				
24															
25	U-238	4.65E-05	2.82E-06	2.92E-06	4.91E-06			8.54E-05	3.64E-04	7.11E 08	6.43E-07	4.40E-06	4.20E 06		
26	PU-238	3.29E-03	4.66E-04	4.95E-04	6.05E-04	1.13E-02				7.46E 06	6.39E 05				
27	PU 239	2.30E 03	2.68E-04	2.72E 04	9.15E-04	7.52E 03				6.49E 06	5.75E 05				
28	PU 241	1.01E-01	1.21E-02	1.32E 02	4.00E 02					2.85E 04	2.52E 03				
29	AM-241	2.35E-03	2.76E 04	2.08E-04	3.95E-04					4.69E 06	4.14E-05			4.82E 06	1.51E-06
30															
31	PU 242	5.04E-06	5.76E-07	5.41E-07	2.01E-06					1.41E-08	1.26E 07				
32	AM 243	1.58E-04	1.86E 05	1.40E-05	2.65E-05					3.33E 08	2.80E 06				
33	CM 243	1.25E-06	3.16E-07	3.62E 07	4.65E-07	1.13E-02				3.84E 09	3.04E 08				
34	CM-244	1.73E-03	3.03E-04	2.63E-04	2.65E-04	3.76E-03				3.50E 06	2.84E 05				
35															
36	PO-210														
37	PB 210														
38	BI 214														
39	PB 214														
40	RA 226														
41	TH 232														
42															
	TOTAL	1.450E+01	1.285E+00	8.461E+00	4.550E+00	2.341E+01	1.000E+02	6.284E 04	7.445E 04	4.760E 02	3.358E 01	3.238E 05	3.093E 05	1.175E 01	3.668E 02

Table continued on next page

Table F-18 (continued)

LLW NAME:	L-IXRESIN	L-CONCLIQ	L-FSLUDGE	P-FCARTRG	L-DECONRS	L-NFRCOMP	F-PROCESS	U-PROCESS	L-COTRASH	L-NCTRASH	F-COTRASH	F-NCTRASH	I-COTRASH	N LOTRASH
EPA VOLUME:	99100	331000	131000	12800	2240	64500	59500	21400	598000	478000	179000	31700	282000	101000
US TOTAL NUCLIDES (CI):														
H-3	3.39E+04	6.26E+03	1.78E+03	3.55E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.13E+02	1.52E+03	0.00E+00	0.00E+00	2.57E+04	2.88E+03
C-14	1.27E+03	2.35E+02	1.09E+02	1.31E+00	0.00E+00	4.15E+02	0.00E+00	0.00E+00	8.31E+00	5.69E+01	0.00E+00	0.00E+00	1.48E+03	1.66E+02
FE-55	8.12E+04	6.45E+04	2.04E+05	1.72E+04	5.89E+03	3.57E+06	0.00E+00	0.00E+00	5.50E+03	3.28E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI-59	8.81E+01	7.28E+01	2.12E+02	2.04E+01	0.00E+00	2.23E+03	0.00E+00	0.00E+00	6.28E+00	3.87E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO-60	1.43E+05	1.18E+05	3.43E+05	3.30E+04	4.23E+04	2.57E+06	0.00E+00	0.00E+00	1.02E+04	6.26E+04	0.00E+00	0.00E+00	2.93E+03	3.28E+02
NI-63	1.18E+04	1.52E+04	6.97E+03	6.28E+03	2.23E+03	3.07E+05	0.00E+00	0.00E+00	1.44E+03	1.07E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR-90	2.60E+03	4.80E+02	3.28E+02	2.59E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.77E+01	1.16E+02	0.00E+00	0.00E+00	4.09E+02	4.58E+01
NB-94	2.79E+00	2.31E+00	6.68E+00	6.44E-01	0.00E+00	1.32E+01	0.00E+00	0.00E+00	1.99E-01	1.22E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TC-99	1.44E+01	2.69E+00	7.02E+00	1.10E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-01	6.31E-01	0.00E+00	0.00E+00	9.56E-04	1.07E-04
RU 106	3.84E+02	7.15E+01	1.82E+02	2.94E-01	1.90E+03	0.00E+00	0.00E+00	0.00E+00	3.59E+00	1.69E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB-125	1.15E+03	9.47E+02	2.74E+03	2.64E+02	4.21E+00	0.00E+00	0.00E+00	0.00E+00	8.13E+01	5.02E+02	0.00E+00	0.00E+00	0.00E+00	0 00E+00
I-129	4.14E+01	7.71E+00	1.82E+01	3.26E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.78E-01	1.83E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS-134	3.84E+05	7.15E+04	1.82E+05	2.94E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E+03	1.69E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS-135	1.44E+01	2.69E+00	6.86E+00	1.10E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-01	6.36E 01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS-137	3.84E+05	7.15E+04	1.82E+05	2.94E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E+03	1.69E+04	0.00E+00	0.00E+00	1.29E+03	1.43E+02
BA-137M	3.84E+05	7.15E+04	1.82E+05	2.94E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E+03	1.69E+04	0.00E+00	0.00E+00	1.29E+03	1.43E+02
EU-154	1.15E+02	9.50E+01	2.75E+02	2.65E+01	8.42E-02	0.00E+00	0.00E+00	0.00E+00	8.19E+00	5.02E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-234	1.58E+01	3.18E+00	1.30E+00	3.02E-01	0.00E+00	0.00E+00	3.09E+01	7.79E+00	1.45E 01	1.05E+00	4.80E+00	8.12E-01	0.00E+00	0.00E+00
U-235	2.53E-01	5.10E-02	2.10E-02	4.85E-03	0.00E+00	0.00E+00	1.37E+00	3.53E-01	2.33E-03	1.68E-02	2.11E-01	3.58E-02	0.00E+00	0.00E+00
NP-237	1.13E-04	2.28E-05	9.35E-06	2.16E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-06	7.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
U-238	4.61E+00	9.33E-01	3.83E-01	8.84E-02	0.00E+00	0.00E+00	5.08E+00	7.79E+00	4.25E-02	3.07E-01	7.88E-01	1.33E-01	0.00E+00	0.00E+00
PU-238	3.26E+02	1.54E+02	6.48E+01	7.74E+00	2.53E+01	0.00E+00	0.00E+00	0.00E+00	4.46E+00	3.05E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU-239	2.28E+02	8.87E+01	3.56E+01	1.17E+01	1.68E+01	0.00E+00	0.00E+00	0.00E+00	3.88E+00	2.75E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU-241	1.00E+04	4.01E+03	1.73E+03	5.12E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E+02	1.20E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM-241	2.33E+02	9.14E+01	2.72E+01	5.06E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E+00	1.98E+01	0.00E+00	0.00E+00	1.36E+00	1.53E-01
PU-242	4.99E-01	1.91E-01	7.09E-02	2.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.43E-03	6.02E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AM-243	1.57E+01	6.16E+00	1.83E+00	3.39E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.99E-02	1.34E+00	0.00E+00	0.00E+00	0.00E+00	0 00E+00
CM-243	1.24E-01	1.05E-01	4.74E-02	5.95E-03	2.53E+01	0.00E+00	0.00E+00	0.00E+00	2.30E-03	1.45E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CM-244	1.71E+02	1.00E+02	3.45E+01	3.39E+00	8.42E+00	0.00E+00	0.00E+00	0.00E+00	2.09E+00	1.36E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB 210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI-214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB-214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0 00E+00
RA-226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH-232	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ALL NUCLIDES	1.637E+06	4.253E+05	1.108E+06	5.824E+04	5.243E+04	6.450E+06	3.739E+01	1.593E+01	2.847E+04	1.605E+05	5.796E+00	9 805E 01	3.314E+04	3.705E+03

Table continued on next page

Table F-18 (continued)

Page 3 | LLW AND BRC WASTE NUCLIDE CONCENTRATION MATRIX | 14 May 86

	LLW NAME:	N-SSTRASH	N-SSWASTE	I-LQSCHVL	I-ABSLIQD	I-BIOWAST	N-LOWASTE	N-ISOPROD	N-SOURCES	N-TRITIUM	N-TARGETS	R-RAIXRSH	R-RASOURC	LLW-TOTAL	B-COTRASH
	EPA VOLUME:	359000	63400	15000	11100	7520	60300	9970	582	6940	223	6600	0.445	2931875.445	332000
	NUCLIDE CONCENT														
1	H-3			5.01E-03	1.42E-01	1.75E-01	1.63E-02	5.52E-02	2.80E+01	2.21E+02	7.80E+02			NA	5.67E-05
2	C-14			2.51E-04	8.16E-03	1.01E-02	9.36E-04	7.79E-05	4.57E-03	2.76E 01				NA	3.50E-06
3	FE-55							9.64E-01						NA	5.03E-03
4	NI-59													NA	5.21E-06
5	CO-60				3.12E-02	3.99E-03	1.47E-03	1.48E+00	2.24E+01					NA	8.47E 03
6														NA	
7	NI-63							1.48E-02	1.56E-02					NA	1.16E-04
8	SR-90			4.34E-03	4.34E-03	8.33E-03	1.31E-03	7.09E+01	3.77E+01					NA	1.06E-05
9	NB-94													NA	1.64E-07
10	TC-99				1.02E-08	6.51E-09	7.76E-10	5.10E-06						NA	2.25E 07
11	RU-106							1.46E-01						NA	5.99E-06
12														NA	
13	SB-125													NA	6.78E-05
14	I-129							4.24E-08						NA	5.99E-07
15	CS-134							4.70E-01						NA	5.99E 03
16	CS-135							5.10E-06						NA	2.25E-07
17	CS-137				1.37E-02	8.76E-03	1.04E-03	4.78E+00	4.45E+02					NA	5.99E-03
18														NA	
19	BA-137M				1.37E-02	8.76E-03	1.04E-03	4.78E+00	4.45E+02					NA	5.99E-03
20	EU-154													NA	6.79E 06
21	U-234	2.56E-06	4.97E-05					1.20E-03						NA	2.74E 08
22	U-235	1.42E-07	2.77E-06					3.15E-05						NA	4.41E 10
23	NP-237							6.20E-15						NA	1.97E-13
24														NA	
25	U-238	8.80E-06	1.71E-04					3.47E-07						NA	8.04E-09
26	PU-238							2.29E-06	8.89E-01					NA	1.92E 06
27	PU-239							6.45E-07						NA	9.72E-07
28	PU-241							8.25E-05						NA	4.72E 05
29	AM-241							4.50E-02	1.47E+00					NA	8.11E 07
30														NA	
31	PU-242							1.11E-09						NA	2.12E 09
32	AM-243							1.46E-08						NA	5.47E-08
33	CM-243							3.35E-09						NA	1.62E 09
34	CM-244							1.93E-06						NA	1.26E 06
35														NA	
36	PO-210											9.00E-03	1.40E+03	NA	
37	PB-210											9.00E-03	1.40E+03	NA	
38	BI-214											9.00E-03	1.40E+03	NA	
39	PB-214											9.00E 03	1.40E+03	NA	
40	RA-226											1.80E-02	1.40E+03	NA	
41	TH 232													NA	
42															
	TOTAL	1.150E-05	2.235E 04	9.601E-03	2.131E-01	2.149E 01	2.210E 02	8 364E+01	9.813E+02	2.213E+02	7.800E+02	5.400E-02	7.000E+03		3.179E 02

Table continued on next page

Table F-18 (continued)

LLW AND BRC WASTE NUCLIDE CONCENTRATION MATRIX

	LLW NAME:	N-SSTRASH	N-SSWASTE	I-LOSCHVL	I-ABSLIQD	I-BIOWAST	N-LOWASTE	N ISOPROD	N-SOURCES	N-TRITIUM	N TARGETS	R-RAIXRSN	R-RASOURC	LLW-TOTAL	B-COTRASH
	EPA VOLUME:	359000	63400	15000	11100	7520	60300	9970	582	6940	223	6600	0.445	2931875.445	332000
	US TOTAL NUCLID													2931875.445	
1	H-3	0.00E+00	0.00E+00	7.51E+01	1.58E+03	1.32E+03	9.83E+02	5.50E+02	1.68E+04	1.53E+06	1.74E+05	0.00E+00	0.00E+00	1.8013E+06	1.88E+01
2	C-14	0.00E+00	0.00E+00	3.76E+00	9.06E+01	7.60E+01	5.64E+01	7.77E-01	2.66E+00	1.92E+03	0.00E+00	0.00E+00	0.00E+00	5.8879E+03	1.16E+00
3	FE-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.61E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.9944E+06	1.67E+03
4	NI-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.6637E+03	1.73E+00
5	CO-60	0.00E+00	0.00E+00	0.00E+00	3.46E+02	3.00E+01	8.86E+01	1.48E+04	1.30E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.3512E+06	2.81E+03
6															
7	NI-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E+02	9.08E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.6180E+05	3.78E+01
8	SR-90	0.00E+00	0.00E+00	6.51E+01	4.82E+01	6.26E+01	7.90E+01	7.07E+05	2.19E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.3306E+05	3.52E+00
9	NB-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.7011E+01	5.44E-02
10	TC-99	0.00E+00	0.00E+00	0.00E+00	1.13E-04	4.90E-05	4.68E 05	5.08E 02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.4908E+01	7.47E-02
11	RU-106	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.0086E+03	1.99E+00
12															
13	SB-125	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.6852E+03	2.25E+01
14	I-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.23E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.9582E+01	1.99E-01
15	CS-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.69E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.6260E+05	1.99E+03
16	CS-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.08E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.4754E+01	7.47E-02
17	CS-137	0.00E+00	0.00E+00	0.00E+00	1.52E+02	6.59E+01	6.27E+01	4.77E+04	2.59E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.6627E+05	1.99E+03
18															
19	BA-137M	0.00E+00	0.00E+00	0.00E+00	1.52E+02	6.59E+01	6.27E+01	4.77E+04	2.59E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.6627E+05	1.99E+03
20	EU-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.7002E+02	2.25E+00
21	U-234	9.19E-01	3.15E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.2111E+01	9.10E-03
22	U-235	5.10E-02	1.76E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.8579E+00	1.46E-04
23	NP-237	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.18E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.5584E-04	6.54E-08
24															
25	U-238	3.16E+00	1.08E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.46E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.4158E+01	2.67E-03
26	PU 238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-02	5.17E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.1306E+03	6.37E 01
27	PU-239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.43E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.1220E+02	3.23E-01
28	PU 241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.23E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.7631E+04	1.57E+01
29	AM-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E+02	8.56E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.6848E+03	2.69E-01
30															
31	PU-242	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.11E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.5539E-01	7.04E-04
32	AM-243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.5346E+01	1.82E 02
33	CM-243	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.34E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.5611E+01	5.38E 04
34	CM-244	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.92E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.3369E+02	4.18E 01
35															
36	PO-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E+01	6.23E+02	6.8240E+02	0.00E+00
37	PB-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E+01	6.23E+02	6.8240E+02	0.00E+00
38	BI-214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E+01	6.23E+02	6.8240E+02	0.00E+00
39	PB-214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E+01	6.23E+02	6.8240E+02	0.00E+00
40	RA-226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0 00E+00	0.00E+00	0.00E+00	0.00E+00	1.19E+02	6.23E+02	7.4180E+02	0.00E+00
41	TH-232	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.0000E+00	0.00E+00
42															
ALL NUCLIDES		4.129E+00	1.417E+01	1.440E+02	2.365E+03	1.616E+03	1.332E+03	8.339E+05	5.711E+05	1.536E+06	1.739E+05	3.564E+02	3.115E+03	1.288E+07	1.056E+04

Table continued on next page

Table F-18 (continued)

LLW AND BRC WASTE NUCLIDE CONCENTRATION MATRIX

	LLW NAME:	P-COTRASH	P-CONDRSH	L-WASTOIL	C-SMOKDET	C-TIMEPCS	R-INSTDF1	R INSTDF2	R-GLASDS1	R GLASDF2
	EPA VOLUME:	265000	7390	21200	92000	10400	252	7.51	2850	1.6
	NUCLIDE CONCENT									
1	H-3	7.32E-04	1.60E-06			3.62E+01				
2	C-14	2.70E-05	5.84E-08							
3	FE-55	1.44E-02	1.92E-05							
4	NI 59	1.72E-05	1.68E-08							
5	CO-60	2.78E-02	2.76E-05	5.50E-05						
6										
7	NI-63	5.29E-03	5.17E-06							
8	SR-90	5.34E-05	1.56E-07							
9	NB-94	5.45E-07	4.25E-10							
10	TC-99	2.28E-07	5.16E-11							
11	RU-106	6.04E-06	8.16E-08							
12										
13	SB-125	2.22E-04	2.17E-07							
14	I-129	6.73E-07	1.52E-10							
15	CS-134	6.04E-03	2.88E-04							
16	CS-135	2.28E-07	1.06E-08							
17	CS-137	6.04E-03	2.76E-04	5.30E-06						
18										
19	BA-137M	6.04E-03	2.76E-04	5.30E-06						
20	EU-154	2.23E-05	2.92E-09							
21	U-234	5.12E-07	7.86E-09							
22	U-235	8.22E-09	3.79E-11							
23	NP-237	3.67E-12	7.28E-15							
24										
25	U-238	1.50E-07	2.99E-10				2.58E-04		8.53E-04	3.13E-02
26	PU-238	1.44E-05	2.09E-08							
27	PU-239	1.34E-05	7.32E-09							
28	PU-241	5.82E-04	6.38E-07							
29	AM-241	9.56E-06	1.50E-08		2.17E-03					
30										
31	PU-242	2.92E-08	3.20E-11							
32	AM-243	6.47E-09	1.01E-09							
33	CM-243	6.63E-09	7.98E-12							
34	CM-244	6.31E-06	1.11E-08							
35										
36	PO-210						3.97E-04			
37	PB 210									
38	BI-214									
39	PB-214									
40	RA-226						1.63E 02	1.86E 04		
41	TH 232						6.35E-06		3.51E-03	
42										
	TOTAL	6.732E-02	8.948E-04	6.560E-05	2.170E-03	3.620E+01	1.696E 02	1 860E-04	4.363E 03	3.130E-02

Table continued on next page

Table F-18 (continued)

	LLW NAME:	P-COTRASH	P-CONDRSH	L-WASTOIL	C-SMOKDET	C-TIMEPCS	R-INSTDF1	R-INSTDF2	R-GLASDS1	R-GLASDF2
	EPA VOLUME:	265000	7390	21200	92000	10400	252	7.51	2850	1.6
US	TOTAL NUCLID									
1	H-3	1.94E+02	1.18E-02	0.00E+00	0.00E+00	3.76E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	C-14	7.15E+00	4.32E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	FE-55	3.82E+03	1.42E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	NI-59	4.56E+00	1.24E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	CO-60	7.37E+03	2.04E-01	1.17E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6										
7	NI-63	1.40E+03	3.82E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	SR-90	1.42E+01	1.15E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	NB-94	1.44E-01	3.14E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	TC-99	6.04E-02	3.81E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	RU-106	1.60E+00	6.03E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12										
13	SB-125	5.88E+01	1.60E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	I-129	1.78E-01	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	CS-134	1.60E+03	2.13E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	CS-135	6.04E-02	7.83E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	CS-137	1.60E+03	2.04E+00	1.12E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18										
19	BA-137M	1.60E+03	2.04E+00	1.12E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	EU-154	5.91E+00	2.16E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	U-234	1.36E-01	5.81E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	U-235	2.10E-03	2.80E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	NP-237	9.73E-07	5.38E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24										
25	U-238	3.98E-02	2.21E-06	0.00E+00	0.00E+00	0.00E+00	6.50E-02	0.00E+00	2.43E+00	5.01E-02
26	PU-238	3.82E+00	1.54E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
27	PU-239	3.55E+00	5.41E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
28	PU-241	1.54E+02	4.71E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
29	AM-241	2.53E+00	1.11E-04	0.00E+00	2.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30										
31	PU-242	7.74E-03	2.36E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
32	AM-243	1.71E-03	7.46E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	CM-243	1.76E-03	5.90E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
34	CM-244	1.67E+00	8.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35										
36	PO-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-01	0.00E+00	0.00E+00	0.00E+00
37	PB-210	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
38	BI-214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
39	PB-214	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40	RA-226	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.11E+00	1.40E-03	0.00E+00	0.00E+00
41	TH-232	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-03	0.00E+00	1.00E+01	0.00E+00
42										
ALL	NUCLIDES	1.784E+04	4.613E+00	1.391E+00	1.996E+02	3.765E+05	4.273E+00	1.397E-03	2.431E+00	5.008E-02

This appendix presents the calculations of the absolute costs and health effects associated with the disposal of DOE LLW. In addition, a full set of economic impacts tables, which include DOE LLW as well as commercial LLW and NARM, are presented for both the BRC and LLW analyses. This appendix also discusses the methodology used in calculating costs and risks associated with the disposal of DOE waste and specifies the assumptions that were necessary to perform these calculations.

The actual costs and health risks associated with the disposal of DOE waste were not independently estimated due to the limited availability of public data. Rather, at EPA's request, the results for commercial LLW disposal were used as the basis for calculating costs and risks associated with DOE disposal. EPA's approach is based on information from DOE personnel in which DOE waste was stated to be similar in character to commercial LLW, although different in total volume [MEY86c, DOE82a].

While EPA is aware that the assumptions described further below are only first order approximations, the procedure seemed to be the best one available considering the lack of necessary information on DOE waste and site characteristics.

Generally, the calculation involved adjusting the results estimated for the disposal of commercial LLW by the relative regional volume of DOE to commercial LLW.* A region-specific DOE adjustment factor is necessary since unit health risks vary substantially across the three hydrogeologic regions, and since the regional distribution of waste volume differs substantially from DOE and commercial LLW. Multiplying the costs and population health risks by the DOE adjustment factors provides the associated costs and risks for DOE waste disposal.** In the LLW analysis of alternative standards, the nine commercial wastes expected to meet EPA's proposed 4 millirem BRC criterion were excluded. Consequently, an analogous proportion of BRC waste was calculated for DOE waste in each hydrogeologic region, which reflects the ratio of commercial BRC to total commercial waste volume, excluding NARM (since DOE does not generate NARM waste). Since it was necessary to estimate DOE impacts for four different implementation assumptions for both the BRC criterion and LLW standard, each at several alternative levels, the methodology is essentially equivalent to assuming that 25 "DOE Analog" wastes exist, each identical in character (and proportional in volume) to one of the 25 commercial LLW.

In the BRC analysis, which evaluates the cost-effectiveness of regulation for each waste, the regional DOE increase factors are multiplied by waste-specific volumes. Therefore, DOE and commercial wastes are explicitly assumed to have the same distribution of BRC candidate volumes

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* As discussed in Chapter 3, regional DOE volumes were estimated independently from DOE86, after assigning the DOE sites responsible for waste generation to one of the three hydrogeologic regions evaluated in this study.

** To calculate the costs and health effects for DOE waste disposal, commerical costs and health effects were multiplied by a factor of 0.0004 in the humid impermeable region, by a factor of 0.5378 in the humid permeable region, and by a factor of 2.1076 in the arid permeable region.

in each hydrogeologic region.* Similarly, the LLW DOE impacts calculation implicitly assumes that commercial and DOE waste volumes have the same distribution within each hydrogeologic region. Since the separate wastes are characterized by different unit risks and costs, DOE and commercial LLW must have the same volume distribution across wastes if the results for commercial waste are to be adjusted simply on the basis of relative volume. For the same reason, the methodology implicitly assumes that DOE waste has the same set of waste streams as commercial and is characterized by the same concentration and distribution of radionuclides.

The unit costs associated with these "DOE Analog" waste streams are assumed to be the same as commercial with the exception of the transportation cost component. Since DOE waste is expected to be disposed onsite, a 10-mile transportation distance is assumed rather than the 650-mile distance assumed for commercial. This translates into about a 96 percent savings in transportation costs for DOE waste disposal.

In summary, this methodology, which adjusts the results from the commercial LLW and BRC analyses on the basis of relative volume, is based on the following assumptions: (1) DOE has the same set of waste streams as commercial, (2) the concentration and distribution of radionuclides is the same for these corresponding commercial and DOE waste streams, (3) although aggregate volumes differ, the distribution of these volumes (i.e., the individual waste stream volume as a percent of total regional volume) is the same for DOE and commercial waste within each hydrogeologic region, (4) DOE will have the same percentage of BRC waste as commercial in each hydrogeologic region, and (5) the unit costs of disposal are assumed to be the same for DOE and commercial with the exception of transportation costs.

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* However, at the eighth annual DOE Low-Level Waste Management Forum held in Denver, Colorado, on September 23-25, 1986, A. Louise Dressen states: "DOE, on the other hand, has found in their analyses that at the 1 mrem/year [BRC] level, they see little or no significant reduction in the volume of waste to be disposed of as LLW, at least at Idaho and Savannah River; they also see minimal corresponding cost savings" [EGG87].

Under the above assumptions, the total costs and health risks associated with DOE waste disposal were calculated for the 17 regulated disposal practices considered in the LLW analysis and for the weighted average of the five unregulated disposal options considered in the BRC analysis. These calculations are presented in Table G-1. In addition, the economic impacts tables used in both the BRC and LLW analysis, under each of the four implementation assumptions, are presented in Tables G-2 to G-9.

Table G-1

TOTAL COSTS AND HEALTH EFFECTS FOR DOE WASTE DISPOSAL*

DISPOSAL OPTION			WASTE FORM			HUMID IMPERMEABLE		HUMID PERMEABLE		ARID PERMEABLE		TOTAL U.S.	
CLASS A	CLASS B	CLASS C	CLASS A	CLASS B	CLASS C	TOTAL COSTS ($MM)	TOTAL HEALTH EFFECTS	TOTAL COSTS ($MM)	TOTAL HEALTH EFFECTS	TOTAL COSTS ($MM)	TOTAL HEALTH EFFECTS	TOTAL COSTS ($MM)	TOTAL HEALTH EFFECTS
SLF	SLF	SLF	AG	AG	AG	0.08	4.15E-02	166	1.20E+01	192	1.18E+01	358	2.39E+01
SLD	SLD	SLD	AG	AG	AG	0.10	5.97E-03	207	8.21E+00	238	1.06E+01	445	1.88E+01
SLD	SLD	ISD	AG	AG	AG	0.10	5.85E-03	207	8.21E+00	241	1.06E+01	448	1.88E+01
SLD	ISD	ISD	AG	AG	AG	0.11	4.39E-03	220	8.14E+00	250	1.01E+01	470	1.83E+01
SLD	SLD	ISD	AG	HIC	S	0.13	8.51E-03	251	8.08E+00	284	1.06E+01	535	1.86E+01
SLD	SLD	SLD	AG	S	S	0.16	4.60E-03	288	7.17E+00	306	8.29E+00	594	1.55E+01
SLD**	SLD	ISD	AG	S	S	0.16	4.60E-03	289	7.17E+00	310	8.29E+00	600	1.55E+01
HF	HF	HF***	AG	AG	AG	0.18	3.57E-03	371	4.33E+00	400	6.64E+00	772	1.10E+01
IDD	IDD	IDD	AG	S	S	0.21	1.56E-03	385	6.37E+00	415	5.48E+00	800	1.19E+01
ISD	ISD	ISD	AG	S	S	0.23	2.00E-03	435	6.40E+00	472	6.55E+00	907	1.30E+01
DWI	DWI	DWI***	AG	AG	AG	0.24	4.53E-03	531	6.98E+00	538	8.30E+00	1,069	1.53E+01
SLD	SLD	SLD	I/AG	I/S	I/S	0.33	1.55E-03	609	2.96E+00	808	2.14E+00	1,417	5.10E+00
SLD	SLD	ISD	I/AG	I/S	I/S	0.33	1.55E-03	609	2.96E+00	808	2.14E+00	1,417	5.09E+00
SLD	SLD	ISD	HIC	HIC	HIC	0.40	9.50E-03	795	7.84E+00	1,053	1.04E+01	1,848	1.83E+01
CC	CC	CC	S	S	S	0.54	5.66E-04	1,072	3.00E+00	1,233	9.36E-01	2,306	3.93E+00
EM	CB	CB	S	S	S	0.66	1.06E-03	1,248	4.22E+00	1,376	2.88E+00	2.625	7.10E+00
DGD	DGD	DGD	S	S	S	0.88	5.07E-05	1,792	4.17E-02	1,962	6.98E-02	3,755	1.12E-01

* Costs and health effects exclude commercial wastes and wastes that meet the proposed 4 millirem BRC criterion.

** 10 CFR 61 disposal.

*** For waste streams not included in these disposal options, costs and health effects were assumed to be consistent with 10 CFR 61 for all classes of waste.

Table G-2

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS*

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	N.A.
15	12.00	780	510	P-COTRASH, B-COTRASH	44
4	2.58	620	96	I-COTRASH and Above	0.38
1	0.51	540	34	N-LOTRASH, I-ABSLIQD, and Above	1.4
0.1 ***	0.04	410	1.0	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	3.7
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

* DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. Consumer wastes and BIOMED waste are not included in the DOE calculation of costs and health effects. See text for further details.

Table continued on following page.

Table G-3

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS[+ *]

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	N.A.
15	0.22	490	1.1	P-COTRASH, B-COTRASH I-COTRASH, I-BIOWAST I-ABSLIQD, N-LOTRASH N-LOWASTE	1.1
4	0.22	490	1.1	Same as Above	N.M.
1	0.22	490	1.1	Same as Above	N.M.
0.1 ***	0.04	410	1.0	F-PROCESS, P-CONDRSN, U-PROCESS, and Above	12,000
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

\+ DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. Consumer wastes and BIOMED waste are not included in the DOE calculation of costs and health effects. See text for further detail.

Table continued on following page.

Table G-2 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN, which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.
N.M. = Not Meaningful.

Table G-3 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A NATIONAL BASIS

* Under Explicit implementation, BRC candidates are rejected if (1) the CPG *standard is exceeded*, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect. Different values would lead to different impacts.

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.
N.M. = Not Meaningful.

September 1987

Table G-4

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A REGIONAL BASIS *

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Additional Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated)	Marginal Cost-Effectiveness ($ Millions per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	N.A.
15	12.00	780	510	P-COTRASH, B-COTRASH	44
4	2.58	620	96	I-COTRASH and Above	0.38
1	0.51	540	34	N-LOTRASH, I-ABSLIQD, and Above	1.4
0.1 ***	0.04	410	1.0	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	3.7
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

NOTE: Costs represent values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

* DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. Consumer wastes and BIOMED waste are not included in the calculation of costs and health effects. See text for further detail.

Table continued on following page.

Table G-5

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS + *

BRC Criteria (Maximum CPG Dose in Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	BRC Savings vs. Current Practice ** ($ Millions)	Health Effects vs. Current Practice **	BRC Candidates Rejected (i.e., Regulated) Humid Permeable	Humid Permeable	Arid Permeable	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect) versus Next Highest Alternative
Deregulate All Candidates	500	1080	520	None	None	None	N.A.
15	12.00	560	4.2	P-COTRASH, B-COTRASH	P-COTRASH, B-COTRASH, I-COTRASH, N-LOTRASH, I-ABSLIQD, N-LOWASTE, I-BIOWAST	P-COTRASH, B-COTRASH, I-COTRASH, N-LOTRASH, I-ABSLIQD, I-BIOWAST	2.1
4	2.58	530	3.6	I-COTRASH and Above	Same as Above	Same as Above	71
1	0.51	510	3.5	I-ABSLIQD, N-LOTRASH, and Above	Same as Above	Same as Above	140
0.1 ***	0.04	410	1.0	N-LOWASTE, P-CONDRSN, I-BIOWAST, F-PROCESS, U-PROCESS, and Above	P-CONDRSN, F-PROCESS, U-PROCESS, and Above	N-LOWASTE, P-CONDRSN, F-PROCESS, U-PROCESS, and Above	40
0.0	0.00	(1,500)	(20)	All BRC Candidates, Consumer Waste, and BIOMED Waste	All BRC Candidates, Consumer Waste, and BIOMED Waste	All BRC Candidates, Consumer Waste, and BIOMED Waste	92

Table G-4 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING IMPLICIT IMPLEMENTATION ON A REGIONAL BASIS

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a] are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: F-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.
N.M. = Not Meaningful.

Table G-5 (Continued)

EVALUATION OF ALTERNATIVE BRC CRITERIA FOR COMMERCIAL
AND DOE LLW ASSUMING EXPLICIT IMPLEMENTATION ON A REGIONAL BASIS

NOTE: Costs represent present values for 20 years of disposal discounted at a 10 percent real rate expressed in 1985 dollars. Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. NARM waste is not included.

\+ DOE impacts calculated according to EPA assumptions, whereby the costs and risks for commercial LLW are scaled by regional commercial and DOE volumes, after adjusting regulated disposal costs to reflect a lower transport distance for DOE waste. Consumer wastes and BIOMED waste are not included in the DOE calculation of costs and health effects. See text for futher detail.

* Under Explicit implementation, BRC candidates are rejected if (1) the CPG standard is exceeded, as in Implicit implementation, or (2) if the cost-effectiveness ratio for regulated versus unregulated disposal is less than a value of $5 million per avoided health effect. Different values would lead to different impacts.

** Under current practice, commercial LLW BRC candidates disposed at a SLD in the As Generated form (except P-CONDRSN which is Solidified); consumer wastes and biomedical wastes deregulated by 10 CFR 20.306 (the Biomed Rule, [NRC81a]) are unregulated.

*** BRC candidates accepted (i.e., suitable for deregulation) at the standard include: P-COTRASH, I-LQSCNVL, N-SSTRASH, N-SSWASTE, F-NCTRASH, and L-WASTOIL. In addition, consumer and BIOMED wastes meet the standard and are assumed to remain unregulated.

N.A. = Not Applicable.
N.M. = Not Meaningful.

Table G-6

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS,
INCLUDING DOE WASTE

LLW Standard Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose (Mrem/Yr)	Predicted Maximum CPG Dose Doubled ** (Mrem/Yr)	Incremental Cost vs. Current Practice * ($ Millions)	Avoided Health Effects vs. Current Practice *	Marginal Cost-Effectiveness ($ Millions Per Avoided Health Effect)	Required Disposal Practice
125	62	124	(680)	(160)		Sanitary Landfill, As Is
					1.7	
75	35	70	(450)	(28)		Shallow Land Disposal, As Is
25*	9.2	18.4	155	3.4	19	10 CFR 61 Disposal
25	9.1	18.2	140	3.2		Shallow Land Disposal; Class A: As Is; Class B, C, & NARM Solidified
					41	
10	5	10	700	17		Intermediate Depth Disposal (A: As Is; B, C, & NARM: SOL)
					220	
4	1.3	2.6	5,000	36		Concrete Canister

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Table G-6 (Continued)

IMPACTS OF ALTERNATIVE LLW STANDARDS
ASSUMING IMPLICIT IMPLEMENTATION ON A NATIONAL BASIS,
INCLUDING DOE WASTE

NOTE: Costs represent present values at a 10 percent discount rate (1985 dollars). Health effects include fatal cancers and genetic effects over 10,000 years, and are not discounted. Costs and health effects are for commercial LLW and NARM waste only, excluding wastes expected to meet the BRC standard. Impacts for DOE waste are calculated using EPA assumptions, whereby commercial LLW costs and risks are scaled by the ratio of commercial and DOE LLW regional volumes, after adjusting costs to reflect a lower average DOE transport distance. See text for further detail.

* Current practice is assumed to be consistent with 10 CFR 61 disposal for all commercial LLW, improved shallow land disposal (solidified) for NARM waste, and shallow land disposal (as generated) for all DOE waste.

** An environmentally conservative assumption which reflects EPA concerns over whether or not an actual disposal site will meet an alternative standard given the uncertainty surrounding the generic modelling used in estimating the maximum CPG dose.