NUREG-0945
Vol. 3

Final Environmental Impact Statement on 10 CFR Part 61 "Licensing Requirements for Land Disposal of Radioactive Waste"

Appendices C-F

U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards

November 1982

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ABSTRACT

The three-volume final environmental impact statement (FEIS) is prepared to guide and support publication of a final regulation, 10 CFR Part 61, for the land disposal of low-level radioactive waste. The FEIS is prepared in response to public comments received on the draft environmental impact statement (DEIS) on the proposed Part 61 regulation. The DEIS was published in September 1981 as NUREG-0782. Public comments received on the proposed Part 61 regulation separate from the DEIS are also considered in the FEIS. The FEIS is not a rewritten version of the DEIS, which contains an exhaustive and detailed analysis of alternatives, but rather references the DEIS and presents the final decision bases and conclusions (costs and impacts) which are reflected in the Part 61 requirements. Four cases are specifically considered in the FEIS representing the following: past disposal practice, existing disposal practice, Part 61 requirements, and an upper bound example.

The Summary and Main Report are contained in Volume 1. Volume 2 consists of Appendices A - Staff Analysis of Public Comments on the DEIS for 10 CFR Part 61, and Appendices B - Staff Analysis of Public Comments on Proposed 10 CFR Part 61 Rulemaking. Volume 3 contains Appendices C-F, entitled as follows: Appendix C - Revisions to Impact Analysis Methodology, Appendix D - Computer Codes Used for FEIS Calculations, Appendix E - Errata for the DEIS for 10 CFR Part 61 and last, Appendix F - Final Rule and Supplementary Information.

FOREWARD

In September 1981, NRC published the Draft Environmental Impact Statement on 10 CFR Part 61: "Licensing Requirements for Land Disposal of Radioactive Waste" (NUREG-0782). This draft environmental impact statement (EIS) contains an exhaustive and detailed analysis of a wide range of alternatives. Based upon NRC analysis of public comments on both the draft EIS and upon the proposed Part 61 regulation itself (Federal Register Notice 46 FR 38081, July 24, 1981), no new alternatives or principles were identified which required analysis. No major changes were required for several requirements of the Part 61 regulation, including the overall performance objectives which should be achieved in the land disposal of low-level radioactive waste, administrative and procedural requirements for licensing a land disposal facility, and the requirements for financial assurance. Many clarifying and explanatory changes were, however, required with respect to specific rule provisions.

Given this conclusion and public comments suggesting that the number of alternatives considered in the EIS be reduced to a smaller, more understandable number, NRC has chosen not to republish the extensive analysis of alternatives as presented in the draft EIS. Rather, NRC has refined the EIS impact analysis methodology based upon public comments and has grouped the alternatives analyzed onto four major alternatives which present the basis for decisions made regarding the Part 61 requirements.

This final EIS is therefore not a revision of the draft EIS but a stand-alone statement which uses the draft EIS as a resource and reference document. Refinements made to the draft EIS assumptions and impact analysis methodology are noted and used in the final EIS. NRC hopes that in this way, the final EIS will be of a more managable size and the alternatives analyzed and conclusions reached presented in more of a concise, understandable manner.

List of Preparers

The overall responsibility for the preparation of this draft environmental impact statement was assigned to the Low-Level Waste Licensing Branch, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission. The statement was prepared with technical assistance from the firm of Dames and Moore, White Plains, New York.

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REVISIONS TO IMPACT ANALYSES METHODOLOGY

1. INTRODUCTION

In the draft environmental impact statement (EIS) on 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," a description of the alternatives, cost data, and methodology for calculating impacts was presented in a number of appendices to the statement. These appendices included:

- Appendix D: Low-Level Waste Sources and Processing Options
- Appendix E: Description of a Reference Disposal Facility
- Appendix F: Alternative Disposal Technologies
- Appendix G: Impact Analysis Methodology
- Appendix H: Alternative Analysis Codes
- Appendix J: Regional Case Studies
- Appendix Q: Calculation of Pre-operational, Operational, Closure and Institutional Control Costs

Since the publication of the draft EIS, the alternatives, cost data, and methodology for calculating impacts have been reviewed by the public and various comments have been received. Based upon these comments as well as upon review by NRC staff, some modifications to the alternatives, cost data, and impact calculational methodology have been made. These modifications are summarized in the remainder of this appendix.

The modifications are discussed as follows. First, modifications to the methodology used to determine unit disposal costs are discussed. Second, any modifications to any cost data which may be contained in the EIS are discussed. Third, modifications to the waste source data base are discussed. Finally, modifications to the calculational procedure used to determine radiological and other impacts are presented.

Listings of the computer codes used to calculate impact measures for this final EIS are presented in Appendix D.

Based upon the impact analyses methodology presented in the draft EIS, and upon the modifications to that impact analyses methodology as discussed in this appendix, the analysis for the final EIS was performed.

2. MODIFICATIONS TO METHODOLOGY USED TO CALCULATE DISPOSAL COSTS

In the draft EIS, the costs for siting, designing, constructing, operating, and closing a near-surface disposal facility, as well as institutional control costs, were summarized as three types of costs: total capital (pre-operational) costs, total operational costs, and closure and institutional control costs.

Total capital and operational costs were calculated by first calculating base capital and operational costs and then applying a series of multipliers to the base costs as follows:

Total capital and operational costs = $MULT_1$ x CAP + $MULT_2$ x OP, where

CAP = direct capital costs in 1980 dollars

OP = direct operational costs in 1980 dollars

$MULT_1$ = interest during construction x contingency x other costs x annual fixed capital charge x operating life of site x profit

$MULT_2$ = contingency x profit.

Comments on this approach were received from two commentors. One commentor (Ref. 1) suggested that a time-value-of-money approach would be more realistic than a cost-plus-fixed-fee approach, while another commentor (Ref. 2) questioned the use of constant dollars for operational costs and inflated dollars for closure and long-term care costs. These comments are reasonable, yet there are a couple of points worth remembering. One is that the actual costs of operating a disposal facility are very complicated and are furthermore site-specific, depending upon the manner in which the facility was originally financed as well as upon many other factors. Many of the costs would depend upon economic and business decisions which a disposal facility would make on a case basis given the overall economic conditions at the time the decisions are made. The best can be done here is an approximation which covers the high points. In addition, one of the reasons that operational costs were left in 1980 dollars was that although operational costs would tend to rise every year due to inflation, these inflated costs would rise irrespective of any additional NRC requirements.

In any case, a simplified present value approach is taken in the final EIS to estimate base disposal charges (prior to consideration of additional charges for closure, disposal facility observation, and institutional control). Basically, the approach incorporates the concept that the summation of the yearly discounted capital expenditures should be equal to the yearly discounted net cash inflows. For purpose of this EIS:

$PV_{out} = PV_{in}$, where

$$PV_{out} = \sum_{n=1}^{N} \frac{\text{yearly pre-operational expense}}{(1 + d)^n}, \text{ and}$$

$$PV_{in} = \sum_{n=1+N}^{ITo+N} \frac{\text{yearly net cash inflow}}{(1 + d)^n},$$

where both the yearly pre-operational expense and the yearly net cash inflow are functions of time (n), and

N = length of pre-operational period (years)

IT_o = operating life of the disposal facility (years)

d = discount rate.

The yearly pre-operational expense is the cost required to site, design, license, and construct the disposal facility. The net cash inflow for a given year is simply the total revenues received for the waste disposal service minus the operating and fixed costs. Operating costs include costs for disposal trench construction, personnel salaries, environmental monitoring, and so forth. For this EIS, fixed costs are assumed to include recovery of equity capital, amortization of debt capital, and taxes on income.

Calculating the present value of the pre-operational costs involves consideration of the timing of the expenditures. Initially, expenses would involve those associated with site selection, obtaining environmental samples, and preparation of environmental reports. Expenses would then shift to those associated with facility licensing, which could include costs associated with possible hearings and possible acquisition of additional information. Finally, expenses would shift to those associated with disposal facility construction, where most of the construction is assumed to take place after issuance of the disposal facility license. For the reference disposal facility, a total base capital cost of $7.87 million is calculated in 1980 dollars prior to consideration of contingency and other overhead expenses (see the discussion in the following Section 3 on "Total Direct Capital Costs"). Assuming that the preoperational period lasts 5 years, the following approximate yearly capital expenses are estimated in 1980 dollars:

Year	Expense (1980 $ x 10^6)
1	1.2
2	1.2
3	0.75
4	0.75
5	3.97

As for the draft EIS, these base capital costs would be multiplied by a factor which would consider contingency and other overhead expenses. As in the draft EIS, a 30% contingency charge is assumed, as well as a 10% charge to cover other miscellaneous overhead expenses. Combining these two charges results in a multiplier equal to 1.43.

Of these expenses, part would probably be covered by the firm's equity and part would be covered through debt financing. Financing for most utilities, for example, is generally about half equity and half debt financing. Financing for large private companies is often in the range of 75% equity and 25% debt financing.

For consistency, the effect of inflation should also be considered. For the purposes of this EIS, and given the need to correspond to the currently available data on waste projections, the fifth year of pre-operational activities is assumed to correspond to 1980 costs. Earlier pre-operational costs are then

deflated yearly. Operational costs are then inflated over the assumed 20 year life of the disposal facility so that the 20th year of facility operating life corresponds to the year 2000. This is equivalent to discounting all costs to the year 1975. Discounting to 1975 is expected to result in slightly lower costs than would be the case if a potential applicant instituted a siting procedure today in 1982 for a new disposal facility, since costs would be discounted to 1982 rather than 1975. Nonetheless, discounting to 1975 is believed to give acceptable results since the main purpose of the EIS is to compare one alternative against another rather than to precisely calculate the actual costs of disposal at a particular existing or new disposal facility.

In any case, PV_{out} may be approximated as follows:

$$PV_{out} = \sum_{n=1}^{5} CAP(n) * (1 + j)^{n-5} * (1 + d)^{-n}, \text{ where}$$

CAP(n) = annual capital charge, including contingency and overhead costs ($)

j = average inflation rate

d = discount rate.

In this simplified analysis, the yearly net cash inflow is given by the following:

yearly net cash inflow = revenues - operating expenses - fixed charges.

At an actual disposal facility, an expense would be probably included to cover costs of a capital nature incurred during operations, a principal component of which would be heavy equipment replacement. To reduce the complexity of the analysis in this EIS, however, all heavy equipment is assumed to be leased. This assumption is expected to somewhat overstate heavy equipment costs compared to such costs at an actual disposal facility.

For this EIS, an average disposal charge ($\$/m^3$) over the operating life of the site is determined, and so the yearly revenues are given by:

$D * VY(n)$, where

D = average disposal charge ($\$/m^3$)

VY(n) = yearly volume of waste received (m^3).

An alternative approach could have been to calculate a yearly disposal charge D(n), where D(n) would vary in a manner related to (but not necessarily proportional to) the inflation rate. The above should suffice for this EIS, however.

Operating expenses are simply given as the yearly charge in 1980 dollars as appropriately inflated for the year considered. Total operating expenses over the operating life of the site are then given by:

$$\sum_{n=6}^{ITo + 5} OPY(n) * (1 + j)^{n-5}, \text{ where}$$

OPY(n) = total (base plus contingency) operating costs for the year (n)

Fixed charges include recovery of equity and debt capital as well as taxes on income. Annual capital recovery costs are given by the product of the capital recovery factor (CRF) with the total investment (TCAP), or CRF * TCAP. The capital recovery factor is given by:

$$CRF = \frac{d\,(1 + d)^{ITo}}{(1 + d)^{ITo} - 1}$$

The total investment is given by:

TCAP = CAPE + CAPD * (1 + id), where

TCAP = total investment

CAPE = equity portion of capital

$$= \sum_{n=1}^{5} EDR * CAP(n) * (1 + j)^{n-5}$$

CAPD = debt portion of capital

$$= \sum_{n=1}^{5} (1 - EDR) * CAP(n) * (1 + j)^{n-5}$$

id = cost of debt (%)

EDR = fraction of financing provided by equity.

For this EIS, the yearly tax on income is assumed to be given by:

TAX(n) = TR * {GNI(n)) - IDP - DEPY(n)}, where

TR = TS + TF * (1 - TS)

TS = state and/or local tax rate

TF = federal income tax rate

GNI(n) = gross net income
$= D * VY(n) - OPY(n) * (1 + j)^{n-5}$

IDP = interest component of the yearly return on debt capital
= (CAPD/ITo) * id

DEPY(n) = yearly depreciation of depreciable capital items

Typically, the federal tax rate for a corporation would be in the neighborhood of 48%, while state/local income tax rates would be in the neighborhood of 6-7%. It is also possible that some manner of property tax would be assessed even though the disposal facility would be located on land owned by either the state or federal government, or some sort of other arrangement would be made so that the disposal facility operator contributes to the county or local tax base. This is already the case in at least one existing disposal facility.

Deductions from the gross net income include the yearly interest on recovery of the debt capital (IDP) and depreciation. For the reference disposal facility, the depreciable portion of the capital expense is considerably less than the total capital expense. Much of the capital expense consists of nondepreciable items such as environmental studies, legal expense, and so forth. For this EIS, depreciable items are assumed to include roads, fences, buildings, office equipment, etc., but does not include heavy equipment. No salvage value is assumed. Depreciation is calculated using a sum-of-the-digits approach. In this approach, yearly depreciation is calculated as follows:

$$DEPY(n) = 2 * DEP * (ITo + 6 - n)/((ITo) * (ITo - 1)), \text{ where}$$

DEP = total value of depreciable items in 1980 dollars.

In this equation, n varies from 6 to ITo + 5.

Combining terms and solving for D, one can obtain:

$$D = \frac{A}{(1 - TR) * \sum_{n=6}^{ITo+5} \{VY(n) * (1 + d)^{-n}\}}, \text{ where}$$

$$A = \sum_{n=1}^{5} CAP(n)\,(1 + j)^{n-5} * (1 + d)^{-n} +$$

$$\sum_{n=6}^{ITo+5} \{CRF * TCAP + (1 - TR) * OPY(n) * (1 + j)^{n-5} - TR * IDP - TR * DEPY(n)\} * (1 + d)^{-n}$$

As an example, the above equation is solved for the reference disposal facility assuming the above yearly capital expenses (in 1980 dollars) plus the following parameters:

ITo = 20 years

OPY = $5.46 million

DEP = $2.12 million

j = 9%

EDR = 75%

TS = 6.5%

TF = 48%

VY = 50,000 m^3/yr

In this example, the equation is solved for various values of the cost of debt, as well as various values of the discount rate (d). The results of this analysis are as follows:

Cost of debt (%)	Discount rate (%)	Disposal Cost $/m³	Disposal Cost $/ft³
10	10	307.70	8.71
10	15	325.20	9.21
10	20	355.50	10.07
12	10	312.40	8.85
12	15	300.00	9.35
12	20	360.40	10.21
14	10	315.80	8.94
14	15	333.50	9.45
14	20	364.00	10.31
16	10	318.40	9.02
16	15	336.20	9.52
16	20	366.80	10.39

As shown, economic factors at the time that the disposal facility is originally sited, as well as the discount rate chosen, can have a moderately significant effect on the disposal costs calculated. In economic calculations for an actual disposal facility, the disposal facility operator would choose a value for the discount rate which would result in the desired compensation for his efforts. Economic calculations by others for other types of (non-nuclear) businesses have often assumed a discount rate of 10%. The actual discount rates used by existing disposal facility operators are considered proprietary business information. However, as discussed in the draft EIS, NRC staff regard operating a disposal facility as a high risk business venture. One of the commenters on the draft EIS, who is an operator of an existing disposal facility, agreed with this statement and stated in his comments that the discount rate used should consider this high level of risk. A 10% discount rate is, therefore, considered by NRC staff to be unrealisticly low for a low level waste disposal facility. A discount rate of 15% is assumed for the EIS. A cost of debt of 10% is assumed.

3. MODIFICATIONS TO COST DATA

Based upon comments upon the draft EIS and upon additional input from these commenters in clarification of their comments, a number of modifications have been made to the cost data presented in Appendix Q. These modifications are presented as follows. First, specific changes to assumed values are discussed. Then the results of these changes on direct capital, direct operating, and closure and institutional costs are presented.

Land Acquisition.

One commenter suggested that NRC's assumed cost for land acquisition were too low (Ref. 1). In the draft EIS, NRC assumed that 200 acres would be purchased, of which about 140 acres would be actually used for the disposal facility, at a cost of $1200/acre. The commenter suggested that a disposal facility operator would actually probably purchase 400-500 acres of land (to allow for contingencies, possible future expansion, or unsuitable portions of land) and that land costs would be expected to be somewhat higher.

Land acquisition costs are therefore recalculated assuming acquisition of 400 acres at a cost of $1400/acre. This results in land acquisition capital costs of $560,000 for the reference disposal facility.

Base Personnel Occupations and Salaries.

In comments on the draft EIS, one commenter suggested that some of the base personnel salaries appeared low (Ref. 1). These comments were clarified in subsequent conversations with the commenter (Ref. 3). Based upon these conversations, the following modifications were made:

Job	Assumed annual salary ($ x 1000) Draft EIS	Final EIS
Site manager	40	45
Assistant site manager	35	40
Operations manager	26	38
QA and safety supervisor	26	30
Office manager	24	38
Waste shipment schedules	16	20
Security personnel	12	18
QA technician	14	25
Radiation safety technician	15	25

In addition, one commenter, who is an operator of a disposal facility, suggested that the assumed number of personnel at the reference disposal facility appeared low (Ref. 1). Based upon staff discussions with this commenter (Ref. 4), the number of personnel assumed for the reference facility was raised by 10 over the 70 assumed in the draft EIS. Assumed occupations for these additional personnel were also based upon these discussions. The additional personnel and annual salaries are as follows:

	Job	Annual salary ($ x 1000)
1	Personnel manager	32
1	Regulatory affairs manager	35
1	Site engineer	35
2	Junior engineers	24
3	Billing/accounting personnel	12
2	Secretarial personnel	9
10		

Building Costs.

As discussed above, the base number of personnel at the reference disposal facility has been raised by 10. Since all 10 would be expected to be administrative in nature, the size of the administration building at the reference disposal facility has been increased from 625 m^2 (6,725 ft^2) to 750 m^2 (8,075 ft^2). At an assumed average cost of $35/$ft^2$, the cost of the administrative building is raised from $235,400 to $282,600. Total building costs were therefore calculated for the final EIS as follows:

Building	1980 $
Administration	$ 282,600
Health physics/security	387,500
Warehouse	126,500
Garage	113,000
Waste activities	302,250
Storage shed	8,600
	$1,220,450

Environmental Monitoring Costs.

As suggested by a contractor, environmental monitoring costs for the reference disposal facility were calculated in the draft EIS based upon an assumed average cost of $50 per sample. This resulted in a yearly environmental monitoring cost for the reference disposal facility of $26,700 per year. Some commenters questioned this cost, however, saying that they would expect the costs to be considerably higher (Ref. 1, 5). Upon NRC staff request, the bases for these comments were provided by the commenters (Ref. 3, 6). Based upon this input and upon consideration of references 7 and 8, the following sample analysis costs are assumed:

Sample	Type of Analysis	Unit Costs ($)
TLD	Exposure	12
Atmospheric	Gamma isotopic I-131	165
Soil and vegetation	Gamma isotopic Gross alpha Tritium	235
Water	Gamma isotopic Gross alpha Tritium	200

*thermoluminescent dosimeter

This resulted (see below) in a total yearly environmental monitoring cost of $60,740.

Personnel Monitoring.

In the draft EIS, the costs for monitoring of site personnel were not included. These are so included in the final EIS based upon data received from a disposal facility operator (Refs. 1, 3). For this EIS, 50 of the 80 base personnel are assumed to have duties which would require reasonably routine access to the restricted area of the disposal facility. Personnel monitoring costs are based upon these 50. The remaining 30 personnel have duties which are administrative in nature (e.g., secretarial personnel, billing/accounting personnel) and would rarely need to enter the restricted area.

Yearly personnel monitoring costs per person are assumed to include costs for 12 TLD analyses, 1 whole body scan, and 2 bioassays per year. Costs per person are calculated (Ref. 3) to be the following:

Sample	Cost/sample ($)	Total costs ($)
TLD* analysis	12	144
Whole body scan	200	200
Bioassay	100	200
		$544/person

*thermoluminescent dosimeter

Total Direct Capital Costs.

Total direct capital costs for the final EIS are calculated to include the following items:

Capital outlay		1980 $ (X 1000)
1.	Site selection	$ 500
2.	Environmental impact studies	600
3.	NRC licensing fees	325
4.	Other licenses and permits	250
5.	Land acquisition (400 acres @ $1400/acre)	560
6.	Corporate administration	1,625.25
7.	Construction administration	496.65
8.	Legal fees	1,000
9.	Road construction	200
10.	Initial land preparation (40 acres @ $1145/acre)	45.8
11.	Office and other miscellaneous light equipment	400
12.	Building construction	1,220.45
13.	Utilities and supplies during construction	175
14.	Peripheral systems (fencing, lighting utilities installation, telephone, etc.)	300
15.	Engineering and design (10% of items 9, 12, and 14)	172.05
		$ 7,870.2

These costs are accumulated over five years and are further assumed to be multiplied by a factor equal to 1.3 x 1.1 = 1.43 to account for contingency and miscellaneous other overhead costs. Updated costs for land acquisition (item 5) and building construction (item 12) have been discussed previously. Engineering and design costs (item 15) have also been updated to reflect the increase in land acquisition costs. Construction administration costs have been modified to be consistent with the increase in personnel salaries for some site personnel as discussed above. Total construction administration costs are calculated to be $496,650 as calculated in the following Table C.1.

Total Direct Operating Costs.

Total direct operating costs over 20 years for the final EIS are calculated to include the following items:

Operating Costs Over 20 years (X 1000)

1.	Operations and maintenance (10% of buildings, grounds, facilities, and light equipment over 20 years)	5,360.9
2.	Disposal cell materials (58 trenches)	124.2
3.	Heavy equipment	12,228
4.	Payroll:	
	o Base	30,500
	o Fringe	3,050
	o Overhead	16,775
5.	Corporate administration (@ $300 k/yr)	6,000
6.	Legal fees (@ $150 k/yr)	3,000
7.	Environmental monitoring	1,214.8
8.	Personnel monitoring	544
9.	Regulatory costs	1,138
10.	Consumables (utilities, fuel, supplies, etc.) (@ $200 k/yr)	4,000
		$83,934.9

Changes from the draft EIS include revised costs for operations and maintenance (item 1), payroll (item 4), and environmental monitoring (item 7), plus an additional item 8 reflecting personnel monitoring costs. Revised operations and maintenance costs reflect additional capital costs for building construction and land acquisition. Payroll costs include a base salary, a 10% fringe, and a 50% overhead. The annual reference disposal facility base payroll is summarized on the following Table C.2.

Revised costs for the reference facility environmental monitoring program are summarized in Table C.3. Assumed unit costs per analysis have been discussed previously. Total costs for analysis of possible traces of accumulated water in filled disposal trench sumps are difficult to estimate and have therefore been estimated in a conservative manner. Costs for trench sump analyses can be (in effect) considered as a contingency cost. Assuming a total of 58 disposal trenches constructed over 20 years, this results in approximately 3 trenches

Table C.1 Revised DEIS Table Q.1 - Administrative Costs During Siting, Licensing, and Construction

			Costs ($ x 1000)
Corporate Personnel (annual for 5 years):			
1 Project Leader	@ 55 k		55.00
2 Senior Engineers	@ 35 k		70.00
3 Engineers	@ 24 k		48.00
2 Clerical	@ 12 k		24.00
			$ 197.00
		10 % Fringe	+ 19.70
			$ 216.70
		50 % Overhead	+ 108.35
			$ 325.05
Legal Fees (annual for 5 years):			
			$ 200.00
Site Administration (during one year construction period)			
1 Site Manager	@ 45 k		45.00
1 Assistant Site Manager	@ 40 k		40.00
1 Foreman	@ 28 k		28.00
1 Site Radiation Safety Officer	@ 35 k		35.00
1 Contracts Coordinator	@ 24 k		24.00
1 Radiation Safety Technician	@ 25 k		25.00
1 QA and Safety Supervisor	@ 30 k		30.00
1 Customer Service Coordinator	@ 24 k		24.00
1 Waste Shipment Scheduler	@ 20 k		20.00
1 Billing/Accounting Personnel	@ 12 k		12.00
2 Secretarial	@ 9 k		18.00
			$ 301.00
		10 % Fringe	+ 30.10
			$ 331.10
		50 % Overhead	+ 165.55
			$ 496.65

Table C.2 Revised DEIS Table Q.4 - Reference Disposal Facility Payroll

No.	Job	Annual Salary($)	Extended Total($)
	Senior Staff		
*1	Site Manager	45,000	45,000
1	Executive Secretary	12,000	12,000
*1	Site Radiation Safety Officer	35,000	35,000
*1	Assistant Site Manager	40,000	40,000
*1	Foreman	28,000	28,000
*1	Operations Manager	38,000	38,000
*1	QA & Safety Supervisor	30,000	30,000
1	Office Manager	38,000	38,000
*1	Security Chief	25,000	25,000
1	Librarian (Records)	12,000	12,000
1	Customer Service Coordinator	24,000	24,000
1	Contracts Coordinator	24,000	24,000
*1	Personnel Manager	32,000	32,000
*1	Regulatory Affairs Manager	35,000	35,000
*1	Site Engineer	35,000	35,000
	Support Staff		
4	Waste Shipment Schedulers	20,000	80,000
5	Billing/Accounting Personnel	12,000	60,000
*4	Security Personnel	18,000	72,000
6	Secretarial Personnel	9,000	54,000
*2	Junior Engineers	24,000	48,000
	Staff		
*3	QA Technicians	25,000	75,000
*8	Radiation Safety Technicians	25,000	200,000
*8	Heavy Equipment Operators	21,000	168,000
*13	Semi-Skilled Laborers (includes mechanics)	15,000	195,000
*12	Unskilled Laborers	10,000	120,000
80			$1,525,000

*Personnel contributing to annual personnel monitoring costs.

Table C.3 Revised DEIS Table Q.5 - Reference Facility Operational Monitoring Programs

Sample Description	No. of Locations	Type	Media	Frequency of Analysis	Type of Analysis	Unit Cost ($)	Annual Cost ($)
External Gamma	50	Continuous	TLD	Quarterly	Exposure	12	2,400
Atmosphere	3	Continuous	Particulate Filter	Daily	Gross Beta-Gamma		
			Particulate Filter	Weekly*	Gamma Isotopic	165	25,740
			Charcoal Cartridge	Weekly*	I-131		
Soil & Vegetation	10	Grab	Soil & Vegetation	Quarterly	Gross Beta-Gamma Gamma Isotopic Gross Alpha Tritium	235	9,400
Offsite Wells	5	Grab	H_2O	Semiannual	Gamma Isotopic Gross Alpha Tritium	200	2,000
Site Boundary Wells	10	Grab	H_2O	Semiannual	Gamma Isotopic Gross Alpha Tritium	200	4,000
Disposal Area Wells	15	Grab	H_2O	Quarterly	Gamma Isotopic Gross Alpha Tritium	200	12,000
Filled Disposal** Trench Sumps	As Constructed	Grab	H_2O	Monthly	Gamma Isotopic Gross Alpha Tritium	200	5,200

*Assume 52 operating weeks/yr.

**Trench sumps are surveyed on a monthly basis. Analysis would only take place if water was determined to be present in a sump. Conservatively assuming that analysis takes place 10% of the time that sumps are surveyed results in an "average" of about 26 analyses/year.

constructed per year. If disposal trench sumps are surveyed for water on a monthly basis, this results in 5133 such surveys over 20 years. Conservatively assuming for the purposes of the EIS that 10% of the sump surveys results in sample analyses, this results in an "average" of 26 such analyses per year.

Personnel monitoring costs are calculated based upon 50 personnel so monitored per year over a 20 year operating life at a cost of $544 per person.

Base Closure Costs.

In this EIS, two possible site closure scenarios are assumed: a low scenario and a high scenario. Revised costs for these two scenarios are presented in Tables C.4 and C.5. Revisions from the draft EIS include updated costs for building demolition, personnel salaries, personnel monitoring, consumables, and environmental monitoring.

In their comments on the draft EIS, two disposal facility operators (Ref. 1,9) commented that they believed that the assumed cost for facility building decontamination and demolition was excessive. Based upon these two comments, decontamination and demolition costs have been reduced from $300,000 to $200,000 for the final EIS. Other costs for personnel salaries, personnel monitoring, environmental monitoring, and consumables have been revised from the draft EIS to be consistent with the earlier revisions to site operational costs.

Base Institutional Control Costs.

In this EIS, annual institutional control base costs are calculated assuming that a contractor is hired by the site owner to maintain the site. These costs include the following:

- administrative costs to the site owner
- contractor personnel costs
- supplies
- equipment
- environmental monitoring
- contractor's fee.

Modifications to the above costs for the final EIS are made for personnel, supplies, and environmental costs, as well as the contractor's fee. Revised personnel salaries are summarized in Table C.6. These updated costs reflect revised salaries for individual occupations as well as yearly personnel monitoring costs. Yearly environmental monitoring costs are summarized in Table C.7, assuming similar sample analysis costs as previously. However, atmospheric sampling costs are reduced by $30/sample over that cost assumed previously to reflect a lesser need to perform I-131 analyses. For the high and moderate care scenarios, costs for disposal trench sump water analysis are based upon an assumed 10% of sump surveys being subjected to further analysis. For the low care scenario, costs are based upon an assumed 1% of sump surveys being subjected to additional analysis.

Supply costs and the contractor's fee are calculated in the same manner as the draft EIS. Supply costs are calculated as 10% of the base personnel costs. The contractor fee is calculated as 10% of the total costs for personnel, supplies, equipment and monitoring. Total estimated annual institutional control base costs are presented in Table C.8.

Table C.4 Revised DEIS Table Q.7 - Estimated Closure Costs--
Low Scenario

I.	Building Demolition	$200,000
II.	Waste Disposal Materials and Survey	
	40,000 ft^3 = 1133 m^3 of waste, need 22,700 m^3 of disposal space, assuming 50% efficiency. Assume one 7m X 47m X 8m trench	
	a) Standpipes 30 ft of 6" p.v.c. standpipe @ $2.45/ft 2 standpipes per trench = $300/trench well casings @ $150/pipe = $300/trench	$ 547
	b) French drain (.6m x .6m x 47m) = 17m^3 = 22 yd^3 22 yd^3 @ $5/$yd^3$	$ 2,582
	c) Seed and mulch 0.12 acres @ $295/acre	$ 35
	d) Cornermarkers & monuments 6.67 ft^2 x $18.30/$ft^2$	$ 480
	e) Surveyor Surveys @ $60/hr Assume 8 hrs/trench	$ 480
		$ 1,294
III.	Personnel	
	1st year: 1 Site Manager	45,000
	1 Foreman	28,000
	2 Security	36,000
	1 Radiation safety officer	35,000
	1 Radiation safety technician	25,000
	5 Semiskilled laborer	75,000
	2 Unskilled laborer	20,000
		$264,000
	Fringe	26,400
	Overhead	145,200
		$435,600
	2nd year: 1 Site manager	45,000
	1 Radiation safety technician	25,000
	1 Semiskilled laborer	15,000
		85,000
	Fringe	8,500
	Overhead	46,750
		$140,250
	Personnel monitoring 16 person-years @ $544/person-year	$ 8,704

Table C.4 (continued)

IV.	Consumables		
	(10% of base personnel costs) 2 years:		$ 34,900
V.	Equipment		
	1 4WD vehicle	24 months @ $ 800/mo	19,200
	1 Crawler tractor	6 months @ $4200/mo	25,200
	1 Farm tractor	24 months @ $ 800/mo	19,200
	1 Pan scraper	12 months @ $750/mo	48,000
	1 Pickup	12 months @ $750/mo	9,000
			$120,600
VI.	Environmental Monitoring		
	2 years @ $60,740/yr		$121,480
		Total	$1,062,828

Table C.5 Revised DEIS Table Q.8 - Estimated Closure Costs--High Scenario

I.	Building Demolition		$ 200,000
II.	Waste Disposal (Survey and Materials)		1,294
III.	Restabilization		
	Total disposal area: 86 acres = 348,000 m^2		
	a) Strip cap (1 m) 348,000 m^3 = 455,000 yd^3	@ $0.75/$yd^3$	341,250
	b) Vibratory compaction assume one week per trench	= 58 weeks = 13 months, 2 weeks	
	1 vibratory compactor 3 man crew	@ $1,950/mo, $675/wk @ $15/hr x 40 hr/wk	131,100
	c) Replace cap (1.15 m) 400,200/m^3 = 523,380 yd^3	@ $0.75/$yd^3$	392,438
	d) Compact Cap @$0.55/$m^3$		220,100
	e) Vegetate @$500/acre		43,000
			$1,127,888
IV.	Personnel		
	Year 1:		$ 435,600
	Years 2-3:		
	1 Site manager		45,000
	1 Foreman		28,000
	1 Radiation safety officer		35,000
	2 Radiation safety technician		50,000
	3 Semi-skilled laborer		45,000
	3 Unskilled laborer		30,000
			233,000
		Fringe:	23,300
		Overhead:	128,150
			384,450
		x 2 years	768,900
	Year 4:		140,250
			$1,344,750
	Personnel monitoring 38 person-years @ $544/person-yr		20,672

Table C.5 (continued)

IV.	Consumables	
	(@ 10% of base personnel costs)	$ 81,500
V.	Equipment	
	1 Crawler tractor 6 mo @ $4200/mo	25,200
	1 Farm tractor 48 mo @ $800/mo	38,400
	1 Pan scraper 6 mo @ $8000/mo	48,000
	1 4WD vehicle 48 mo @ $800/mo	38,400
	1 Pickup 36 mo @ $750/mo	27,000
		$ 177,000
VI	Environmental monitoring	
	4 years @ $60,740/yr	$ 242,960
	air sampler purchase and install	
	10 samplers @ $900/sampler	9,000
	air sampler analyses	
	10 samplers x 52 samples/yr x $135/sample	140,400
	2 years @ $70,200/yr	$ 392,360
	Total:	$3,345,464

Table C.6 Revised DEIS Table Q.9 - Personnel Requirements for Institutional Control

Level of Effort	Personnel		
High (6-man crew)	1 Site manager		$ 45,000
	1 Health physics technician		25,000
	3 Semi-skilled laborer		45,000
	1 Unskilled laborer		10,000
			$125,000
		Fringe :	12,500
		Overhead:	68,750
			$206,250
	personnel monitoring:		$ 3,264
Moderate (4-man crew)	1 Site manager		$ 45,000
	1 Health physics technician		25,000
	1 Semi-skilled laborer		15,000
	1 Unskilled laborer		10,000
			$ 95,000
		Fringe :	9,500
		Overhead:	52,250
			$156,750
	personnel monitoring:		$ 2,176
Low (2-man crew)	1 Foreman		$ 28,000
	1 Semi-skilled laborer		15,000
			$ 43,000
		Fringe :	4,300
		Overhead:	23,650
			$ 70,950
	personnel monitoring		$ 1,088
Very Low (1-man)	1 Caretaker		$ 20,000
		Fringe :	2,000
		Overhead:	11,000
			$ 33,000
	personnel monitoring:		$ 544

Table C.7 Revised DEIS Table Q.11 - Estimated Long-Term Environmental Monitoring Activities

		High			Moderate			Low		
Sample Description	Unit Cost	No. of Loc.	Frequency	Annual Costs	No. of Loc.	Frequency	Cost	No. of Loc.	Frequency	Annual Cost
TLD*	12	30	quarterly	1,440	10	quarterly	480	0	0	0
Atmospheric	135	3	daily gross beta-gamma weekly gamma isotopic	21,060	1	daily gross beta-gamma weekly gamma isotopic	7,020	0	0	0
Soil and Vegetation	235	10	quarterly	9,400	10	semi-annual	4,700	10	annual	2,350
Offsite Wells	200	5	semi-annual	2,000	2	semi-annual	800	2	annual	400
Boundary Wells	200	10	semi-annual	4,000	5	semi-annual	2,000	5	annual	1,000
Disposal Area Wells	200	15	quarterly	12,000	15	semi-annual	6,000	5	semi-annual	2,000
Disposal Trench Sumps	200	58	monthly	14,000 (10% of samples)	58	semi-annual	2,400 (10% of samples)	58	semi-annual	200 (1% of samples)
Estimated total annual costs				$63,900			$23,400			$5,950

*Thermoluminescent dosimeter.

Table C.8 Revised DEIS Table Q.12 - Estimated Annual Institutional Control Base Costs

Level of Effort	Adm	Contractor Costs ($ x 1000 per year) Personnel	Supplies	Equipment	Monitoring	Fee	Total
High							
0-10	150	209.51 (high)	12.5	53.4 (high)	63.9 (high)	33.93	523.24
11-25	100	158.93 (mod)	9.5	26.4 (mod)	63.9 (high)	25.87	384.60
26-100	50	72.04 (low)	4.3	6.9 (low)	23.4 (mod)	10.66	167.30
Moderate							
0-10	100	158.93 (mod)	9.5	26.4 (mod)	63.9 (high)	25.87	384.60
11-25	50	72.04 (low)	4.3	6.9 (low)	23.4 (mod)	10.66	167.30
26-100	50	33.54 (care)	2.0	- (nil)	5.95 (low)	-	91.49
Low							
0-10	50	72.04 (low)	4.3	6.9 (low)	23.4 (mod)	10.66	167.30
11-25	25	33.54 (care)	2.0	- (nil)	5.95 (low)	-	66.49
26-100	12.5	33.54 (care)	2.0	- (nil)	5.95 (low)	-	53.99

Institutional Control Contingency Costs.

In the draft DEIS, institutional control contingency costs were calculated for 3 contingencies:

- o small to moderate water accumulation problem
- o large scale water accumulation problem
- o site restabilization program.

For the final EIS, costs for these scenarios have been revised based upon updated cost estimates for personnel salaries, personnel monitoring, and environmental monitoring. These revised costs are presented in the following Tables C.9, C.10, and C.11.

Modifications to Cost Analysis for Alternatives to the Reference Disposal Facility.

Revisions have been made to the cost analysis performed in Appendix F of the draft EIS for alternative disposal technologies to the reference disposal facility. Revisions have been made to be consistent with assumptions and calculations for the reference disposal facility and are in two areas: (1) revisions to specific cost parameters, and (2) revisions to the methodology used to calculate total costs. The former includes revisions to costs for personnel salaries, consumables, and environmental monitoring. This is to be consistent with previous revised calculations for the reference disposal facility. Costs for personnel monitoring have been added. Costs for additional land acquisition, which were included in the draft EIS for some of the alternatives, have been eliminated. This is because the assumed increase in land acquisition for the reference case from 200 acres to 400 acres eliminates need to purchase additional land for the alternatives involving significantly reduced land use efficiency.

In Appendix F of the draft EIS, capital and operational costs associated with alternative disposal technologies to the reference facility were presented in Tables F.4 through F.24. Revised capital and operational costs for these tables are presented in 1980 dollars in the following Tables C.12 through C.32. Similarly to the draft EIS, many of these alternatives were then selected for inclusion into the computer codes, thus providing for further analysis in the EIS. The capital and operational costs for selected alternatives were converted into unit rates for use in the codes as summarized in Table C.33, which is a revision of Table G.16 of the draft EIS. Unit rates for closure and institutional control are also listed in Table C.33.

Based upon the data presented in Table C.33, unit disposal costs ($ per m^3 of waste) may be determined using the revised methodology presented in Section 2 of this appendix. The additional capital costs associated with the selected alternative disposal technologies are assumed to be incurred in the fifth year of construction. The depreciable portions of the alternative disposal capital costs are assumed to be equal to the capital costs minus engineering design fees. These depreciable costs for the selected disposal technologies are as follows:

Table C.9 Revised DEIS Table Q.13 - Small to Moderate Water Accumulation Costs

I.	Personnel	
	1 additional semi-skilled laborer @ $15,000/yr	$ 15,000
	Fringe & Overhead	$ 9,750
	Personnel Monitoring	$ 544
	Supplies @ 10%	$ 1,500
II.	Solidification Equipment	
	Cement solidify into 55 gallon drums @ 25,000 gallons per year, 1.4 VIF, $2.50/gal	$ 62,500
	637 drums @ $20/drum (Price includes equipment, cement, labor & fuel)	$ 12,740
III.	Disposal Trench Materials Costs	
	Continuously operated trench for 10 years (2650 m^3 disp. space). Trench dimensions = 8 m x 47 m x 8 m = 3008 m^3 = 3934 yd^3	
	a) Standpipes	
	30 ft. of 6" p.v.c standpipe @ $7/ft	
	2 standpipes per trench @ $210/pipe	$ 420
	standpipe casings @ $150/casing	$ 300
	b) French drain	
	(.6m x .6m x 47m) = 17m^3 = 22 yd^3	
	gravel fill @ $5/$yd^3$	$ 177
	c) Seed and mulch	
	550 m^2 = .14 acres @ $295/acre	$ 40
	d) Cornermarkers and monuments	
	Polished red granite: 6.7 ft^2 @ $18.30/$ft^2$	$ 122
	e) Surveyor	$ 480
	$60/hr @ 8 hr/trench	
	Total:	$ 1,539
	Cost per year:	$ 154
IV.	Disposal equipment	
	1 panscraper, 6 months @ $8000/mo	$ 48,000
	pumping equipment, 12 months @ $500/mo	6,000
		$ 54,000

Table C.9 (continued)

V.	Additional environmental monitoring		
	10 extra atm. samplers, 52 samples/yr, $135/sample		$ 70,200
	100 extra water samples/yr. @ $200/sample		20,000
			$ 90,200
		Subtotal:	$246,388
VI.	Contractor's Fee		
	10%		$ 24,639
		Total per yr:	$271,027
	Total operating costs over 10 years = $2,710,270		
	Purchase and install 10 atm. samplers @ $900 apiece = $9,000	Total cost =	$2,719,270

Table C.10 Revised DEIS Table Q.14 - Pumping, Processing, and Solidifying Costs for One Million Gallons of Contaminated Liquid Per Year

I.	Capital Costs	
	Purchase evaporator	$1,000,000
	Purchase ion-exchange pre-treatment system	$ 750,000
	Purchase and install 10 atm. samplers @ $900 apiece	9,000
		$1,759,000
II.	Yearly Costs	
	1) Equipment	
	Lease pump & hose @ $500/month	$ 6,000
	2) Labor Costs	
	2 semi-skilled laborers @ $15,000	
	2 unskilled laborers @ $10,000	
	30,000 + 20,000 =	$ 50,000
	Fringe	5,000
	Overhead	27,500
	Personnel Monitoring	2,176
	Supplies	5,000
	3) Treatment Costs	
	Volume reduction factor = 200	
	Ion exchange 1.E+6 gal/yr @ $0.10/gallon	$ 100,000
	Evaporate 1.E+6 gal/year @ $0.35/gallon	$ 350,000
	4) Solidification	
	Solidify 5,000 gallons of concentrated bottoms per year. Assume cement solidification, with 1.4 VIF, @ $2.50/gallon and $20 per 55-gallon drum	
	Solidification:	$ 12,500
	728 drums — Drum Charge:	$ 2,545
	5) Disposal Costs	
	7,000 gal solidified waste per year requires 53 m^3 of disposal space per year or 530 m^3 of disposal space over 10 years. Assume continuously operated 4 m x 19 m x 8 m trench.	
	a) Standpipes	
	30 ft. of 6" pvc pipe @ $7/ft	
	2 standpipes per trench @ $210/pipe	$ 420
	Standpipe casings @ $150/casing	$ 300

Table C.10 (continued)

b)	French drain (.6m x .6m x 19m) = $7m^3$ = 9 yd^3 gravel fill @ $\$5/yd^3$	$	72
c)	Seed and mulch 154 m^2 = 0.04 acre @ $295/acre		12
d)	Cornermarkers and monuments Polished red granite: 6.7 ft^2 @ $\$18.30/ft^2$	$	122
e)	Surveyor $60/hr @ 8hr/trench		480
	Total:	$	1406
	Cost per year:	$	141
6)	Disposal Equipment Lease 1 pan scraper: 12 months @ $800/mo	$	9,600
7)	Additional Environmental Monitoring 10 samplers x 52 samples/yr @ $135/sample	$	70,200
	300 extra water samples/yr @ $200/sample	$	60,000
		$	130,200
	Subtotal:	$	700,662
	Contractor's Fee @ 10%	$	70,066
	Total Yearly Costs	$	770,728
	Total Operating Costs Over 10 Years:	$	7,707,280
	Total Capital Costs:	$	1,759,000
	Total Costs Over 10 Years	$	9,466,280

Table C.11 Revised DEIS Table Q.15 - Site Restabilization Program

I.	Restabilization		
	(from Table Q.8)		$1,127,888
II.	Additional Personnel		
	1 Foreman		$ 28,000
	1 Radiation safety officer		35,000
	1 Radiation safety technician		25,000
	2 Unskilled laborer		20,000
			$ 108,000
			10,800
			59,400
			$ 178,200
		x2 years	$ 356,400
	Personnel Monitoring @ $544/person-yr		$ 5,440
III.	Additional Equipment		
			0
IV.	Additional Supplies		$ 21,600
V.	Additional Environmental Monitoring 10 samplers @ 52 samples/yr $135/sample x 2 years		140,400
			$1,651,728
	Contractors Fee:		$ 165,173
			$1,816,901
		Purchase and install 10 atm samplers @ $900/sampler	9,000
			$1,825,901*

*If the restabilization program is combined with a moderate to large water accumulation program, then additional atmospheric samplers are already included. In this case, total costs = $1,671,461.

Table C.12 Revised DEIS Table F.4 - Differential Costs for Deep Trench Disposal

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Assumptions:

- o Total volume input of 1 million m^3/20 years, or 50,000 m^3/year
- o 30 deep trenches (approximate dimensions: 180 m x 30 m x 16m) replace 58 reference trenches
- o Random disposal of waste
- o Waste volume capacity of deeper trench = 33,600 m^3
- o Costs are calculated with and without shoring

ADDITIONAL CAPITAL COSTS	
A. Without Shoring	$ 0
B. With Shoring	
(1) Increase health physics/security building by 4,000 ft^2 @ $45/$ft^2$	$180,000
(2) Increase warehouse by 10,000 ft^2 @ $42/$ft^2$	250,000
	$430,000
Engineering and Design:	43,000
	$473,000
ADDITIONAL OPERATIONAL COSTS	
A. Additional Trench Construction Materials	
(1) Standpipes and Casings	
58 reference trenches @ $670.50/trench	$ 38,889
30 deep trenches	
56 ft of 6" pvc standpipe @ $2.45/ft	
3 standpipes/trench = $411.60/trench	
3 standpipe casings @ $150/standpipe = $450/trench	
30 trenches @ $861.60/trench	$ 25,848
	-$ 13,041
(2) French Drain	
58 reference trenches @ $425/trench	$ 24,650
30 deep trenches @ $425/trench	$ 12,750
	-$ 11,900

Table C.12 (continued)

(3) Seed and Mulch		
1.5 acres/trench @ \$295/acre		
58 reference trenches		\$ 25,665
30 deep trenches		\$ 13,275
		–\$ 12,390
(4) Corner Markers and Monuments		
6.7 ft² of granite corner markers and monuments per trench @ \$18.30/ft² = \$122/trench		
58 reference trenches		\$ 7,076
30 deep trenches		\$ 3,662
		–\$ 3,414
(5) Surveyor		
\$60/hr and 8 hrs/trench		
58 reference trenches		\$ 27,840
30 deep trenches		\$ 14,400
		–\$ 13,440
(6) Shoring (optional)		
58 reference trenches		\$ 0
30 deep trenches		
wall area/trench = 6720 m² = 72,334 ft²		
material charge = \$2.40/ft²		\$5,208,050
30 trenches x 72,334 ft² x \$2.40		+ \$5,208,050
B. Additional Personnel		
(1) With No Shoring		
1 heavy equipment operator @ \$21,000		\$ 21,000
	Fringe:	2,100
	Overhead:	\$ 11,550
		\$ 34,650
	x 20 yrs	\$ 693,000
personnel monitoring:		\$ 10,880
(2) With Shoring		
1 heavy equipment operator @ 21,000		21,000
5 semiskilled laborers @ \$15,000		75,000
10 unskilled laborers @ \$10,000		100,000
		\$ 196,000
	Fringe:	19,600
	Overhead:	107,800
		\$ 323,400
	x 20 yrs	\$6,468,000
personnel monitoring:		\$ 174,080

Table C.12 (continued)

C.	Additional Consumables	
	With no shoring	$ 42,000
	With shoring	$ 392,000
D.	Additional Equipment	
	1 - drag-line excavator for 240 months @ $8,000/mo	$ 1,920,000
E.	Additional Monitoring	0
	Total additional operational charges	
	With shoring:	$14,107,945
	Without shoring:	$ 2,566,687

Table C.13 Revised DEIS Table F.5 - Differential Costs for Thicker Trench Covers

Assumptions:

- Costs are estimated based upon the equivalent construction costs of \$0.75/yd^3 to excavate, haul, and spread earth using scrapers at an average haul distance of 1,500 ft and an average rate of 5,500 yd^3/day
- Fill required = disposal area x cover thickness, where the disposal area = vol/(EMP x EFF x SEFF); Vol = waste volume (m^3); EMP = emplacement efficiency; EFF = volumetric disposal efficiency (m^3/m^2); SEFF = surface use efficiency
- Example calculations are developed for Vol = 1,000,000 m^3; EMP = 0.5 (random disposal); EFF= 6.4 m^3/m^2 (reference trench); SEFF = 0.9 (reference trench); and a cover thickness = 3m.

ADDITIONAL CAPITAL COSTS	\$ 0
ADDITIONAL OPERATIONAL COSTS	
Excavation, haul, and spread of fill volume required = 1,000,000/(.5 x 6.4 x .9) = 347,222 m^3/m^2 of cover 3 meters cover: 1,041,667 m^3 = 1,362,500 yd^3	
Costs = 1,362,500 yd^3 @ \$0.75/yd^3	\$1,021,875
Total additional operational costs	\$1,021,875

Table C.14 Revised DEIS Table F.6 - Differential Costs for Increasing the Distance Between the Waste and the Top of the Disposal Cell

Assumptions:

- o Costs are calculated on the basis of 1,000,000 m^3 of waste randomly disposed into reference disposal trenches.
- o The bottom 4 m (rather than the bottom 7 meters) is used for waste disposal, resulting in a reduction in trench waste capacity (50% disposal efficiency) from about 17,230 m^3 to about 9,524 m^3. The number of trenches required is increased from 58 to 105, and the number of disposal trenches that need to be constructed per year is raised from about 3 to 5-6.
- o The land area commited for disposal is raised from about 87 acres to about 157 acres, or an additional 70 acres.
- o Additional costs involve additional material costs such as standpipes and markers, as well as additional land. Also, since the number of trenches that must be excavated is increased, additional machinery and personnel are assumed to be required.

ADDITIONAL CAPITAL COSTS

	$ 0

ADDITIONAL OPERATIONAL COSTS

A. Additional Trench Construction Materials

1. Standpipes and Casing

58 reference trenches @ $670.50/trench	$	38,889
105 reference trenches @ 670.50/trench		70,403
	+ $	31,514

2. Gravel Drain

58 reference trenches @ $425/trench	$	24,650
105 reference trenches @ $425/trench		44,625
	+ $	19,975

3. Seed and Mulch

87 acres @ $295/acre	$	25,665
157 acres @ $295/acre		46,315
	+ $	20,650

Table C.14 (Continued)

4.	Corner markers and monuments		
	58 reference trenches @ $122/trench		$ 7,076
	105 reference trenches @ $122/trench		12,810
			+ $ 5,734
5.	Surveyor		
	58 reference trenches @ $480/trench		$ 27,840
	105 reference trenches @ $480/trench		50,400
			+ $ 22,560
B.	Additional Personnel		
	1-heavy equipment operator @ $21,000		$ 21,000
		Fringe:	2,100
		Overhead:	11,550
		x 20 yr	$ 693,000
	personnel monitoring		$ 10,880
C.	Additional Consumables		$ 42,000
D.	Additional Equipment		
	1 - panscraper for 24 mo. @ $8,000/mo		$ 1,920,000
E.	Additional Monitoring		0
	Total additional operational costs		$ 2,724,313

Table C.15 Revised DEIS Table F.7 - Differential Costs for Layering Operations

Assumptions:

- 10% of the one million m^3 (100,000 m^3) requires layering
- Layering requires a waste storage building and additional labor

ADDITIONAL CAPITAL COSTS

Building Construction-add 6,000 ft^2 storage building @ $20/$ft^2$		$ 120,000
	Engineering and Design	$ 12,000
		$ 132,000

ADDITIONAL OPERATIONAL COSTS

A.	Additional Trench Construction Materials		$ 0
B.	Additional Personnel		
	1 Radiation safety technician @ $25,000		$ 25,000
	1 Semiskilled laborer @ $15,000		$ 15,000
	1 Quality assurance technician @ $25,000		$ 25,000
			$ 65,000
		Fringe:	$ 6,500
		Overhead:	$ 35,750
			107,250
		x 20 yrs	$2,145,000
	personnel monitoring		$ 32,640
C.	Additional Consumables		$ 130,000
D.	Additional Equipment		0
E.	Additional Monitoring		0
	Total additional operational costs:		$2,307,640

Table C.16 Revised DEIS Table F.8 - Differential Costs for Silt Trench Operations (Ten Percent of Waste Volume)

Assumptions:

- o About ten percent of 1,000,000 m^3 of waste is disposed in slit trenches, which replace an equivalent volume of randomly disposed waste in reference trenches.
- o Slit trench dimensions: 20m x 3m x 8m, of which the bottom 7m is used for waste disposal. Spacing between trenches = 2m. Disposal efficiency = 50%.
- o Slit trench waste capacity = 210 m^3, reference trench waste capacity = 17,230 m^3. Therefore, 492 slit trenches (disposal volume = 100,320 m^3) replace 6 reference trenches.
- o Unit area of slit trench = (22m x 5m) = 110m^2 = 1184 ft^2. Surface area of 492 slit trenches = 582,528 ft^2. Surface area of 6 reference trenches = 6 x (183m x 33m) = 36,234 m^2 = 390,057 ft^2 = 8.95 acres.
- o Use of slit trenches for 10% of waste requires additional 517,518 ft^2 = 11.88 acres.
- o Construct approximately 25 trenches/yr, or one every 2 weeks
- o Assume deletion of standpipe and gravel drain. Emplacement would otherwise require trench shoring at considerable additional expense.

ADDITIONAL CAPITAL COSTS

Add atmospheric sampler @ $900	$	900
Engineering and Design		90
	$	990

ADDITIONAL OPERATIONAL COSTS

A. Additional Materials

(1) Standpipes

6 reference trenches @ $670.50/trench	$	4,023
492 slit trenches assume no stand pipes		0
	-$	4,023

(2) French Drain

6 reference trenches @ $425/trench	$	2,550
492 slit trenches assume no installed drain		0
	-$	2,550

(3) Seed and mulch

6 reference trenches x 1.5 acres/trench x $295/acre	$	2,655
492 slit trenches require 12 acres		
12 acres x $295/acre		3,540
	+$	885

Table C.16 (continued)

(4) Corner Markers and Monuments		
6.7 ft² of granite corner markers and monuments per trench @ $18.30/ft²		
6 reference trenches		$ 732
492 slit trenches		60,054
		+$ 59,322
(5) Surveyor		
$60/hr and 8 hrs/trench		
6 reference trenches		$ 2,880
492 slit trenches		236,160
		+$ 233,280
B. Additional Personnel		
1-heavy equipment operator @ $21,000		$ 21,000
2-semiskilled laborers @ $15,000		30,000
2-unskilled laborers @ $10,000		20,000
1-radiation safety technician @ $25,000		25,000
1-quality assurance technician @ $25,000		25,000
		$ 121,000
	Fringe:	12,100
	Overhead:	66,550
		$ 199,650
	x 20 yrs	$3,993,000
personnel monitoring		$ 76,160
C. Additional Consumables		$ 242,000
D. Additional Equipment		
1-backhoe for 240 mo @ $4,000/mo		960,000
1-40 ton crane for 240 mo @ $4,500/mo		1,080,000
		$2,040,000
E. Additional Monitoring		
52 sample analyses/yr @ average $165/sample x 20 years		$ 171,600
Total additional operational costs		$6,809,674

Table C.17 Revised DEIS Table F.9 - Dfferential Costs for Caisson Disposal (Ten Percent of Waste Volume)

Assumptions:

- About ten percent of 1,000,000 m^3 of waste is disposed in caissons, which replace an equivalent volume of randomly disposed waste in reference trenches.
- Assume caissons consist of 30" concrete culvert pipes 24 ft in length, placed in slit trenches constructed 15m x 1.5m x 8m, 16 caissons per trench. Average spacing between trench = 1m.
- Assume deletion of standpipes and gravel drain. Emplacement would otherwise require trench shoring at considerable additional expense.
- Disposal capacity is $40m^3$/trench, assuming stacked disposal at 75% efficiency. Reference trench waste capacity = $17,230m^3$. Therefore, 2,585 caisson trenches (disposal volume = 103,400) replace 6 reference trenches.
- Unit area of caisson trench = (16m x 2.5m) = 40 m^2 = 430.6 ft^2. Surface area of 2,585 caisson trenches = 1,113,100 ft^2. Surface area of 6 reference trenches = 390,060 ft^2.
- Use of slit trenches for 10% of waste requires additional 723,040 ft^2 = 16.6 acres.
- Construct approximately 129 caisson trenches, or 2.5/week.
- After waste placement, backfill with concrete (0.6 m thick concrete cap) plus overburden.

ADDITIONAL CAPITAL COSTS

(1)	3-atmospheric samplers @ $900 each	$ 2,700
(2)	increase health physics/security building by 4,000 ft^2 @ $45/$ft^2$	180,000
(3)	increase garage by 1000 ft^2 @ $25/$ft^2$	25,000
(4)	increase warehouse by 1000 ft^2 @$25/$ft^2$	25,000
		$ 232,700
	Engineering and Design:	23,270
		$ 255,970

ADDITIONAL OPERATIONAL COSTS

A. Additional Construction Materials

(1) Standpipes

6 reference trenches @ $670.50/trench	$ 4,023
2585 caisson trenches assume no standpipes	0
	-$ 4,023

Table C.17 (continued)

(2)	French Drain	
	6 reference trenches @ $425/trench	$ 2,550
	2,585 caisson trenches assume no gravel required	0
		-$ 2,550
(3)	Seed and Mulch	
	6 reference trenches x 1.5 acres/trench x $295/acre	$ 2,655
	2,585 caisson trenches require 24 acres	
	24 acres x $295/acre	7,080
		+$ 4,425
(4)	Corner Markers and Monuments	
	6 reference trenches @ $122/trench	$ 732
	2,585 caisson trenches @ $122/trench	315,528
		+$ 314,796
(5)	Surveyor	
	6 reference trenches @ $480/trench	$ 2,880
	Surveyor consulting fees @ $120,000/yr	240,000
		+$ 237,120
(6)	Concrete Backfill (cap)	
	fill/trench = (15m x 1.5m x 0.6m) = 13.50 m^3 = 17.7 yd^3	
	17.7 yd^3 @ $45/$yd^3$ x 2,585 trenches	+$2,054,067
B.	Additional Personnel	
	2-heavy equipment operators @ $21,000	$ 42,000
	4-semiskilled laborers @ $15,000	60,000
	2-unskilled laborers @ $10,000	20,000
	2-radiation safety technicians @ $25,000	50,000
	1-quality assurance technician @ $25,000	25,000
		$ 197,000
	Fringe:	19,700
	Overhead:	108,350
		$ 325,050
	x 20 yrs	$6,501,000
	personnel monitoring	$ 119,680
C.	Additional Consumables	$ 394,000

Table C.17 (continued)

D.	Additional Equipment	
	2-backhoes for 240 mo @ $4,000/mo	$ 1,920,000
	2-40 ton cranes for 240 mo @ $4500/mo	2,160,000
		+$ 4,080,000
E.	Additional Monitoring	
	156 sample analyses/yr @ average $165/sample x 20 years	$ 514,800
	Total additional operational costs	$14,213,315

Table C.18 Revised DEIS Table F.10 - Differential Costs for Concrete Walled Trench (Ten Percent of Waste Volume)

Assumptions:

- o About ten percent of 1,000,000 m^3 of waste is disposed in walled trenches, which replace an equivalent volume of waste randomly disposed in reference trenches
- o Walled trench inside dimensions: 12 m x 3 m x 8.3 m, of which the bottom 7.3 m is used for waste disposal. The thickness of walls and slab = 0.3 m. A 0.3 m-thick gravel base is placed on the bottom of the trench. Spacing between trenches = 3 m. Disposal efficiency = 75% (stacked disposal).
- o Concrete walled trench waste capacity = 189 m^3; reference trench waste capacity = 17,230 m^3. Therefore, 547 walled trenches replace 6 reference trenches (disposal volume = 103,400 m^3).
- o Unit area of walled trench = (15.3 m x 6.3 m) = 96.4 m^2 = 1,038 ft^2. Surface area of 6 reference trenches = 390,060 ft^2 = 9 acres. Surface area of 547 walled trenches = 567,645 ft^2 = 13 acres.
- o Use of concrete walled trenches for 10% of waste requires an additional 177,585 ft^2 = 4 acres
- o Construct approximately 27 walled trenches/yr or about one every two weeks.

ADDITIONAL CAPITAL COSTS

(1) add 1 atmospheric sampler @ $900	$ 900
(2) increase health physic/security building by 4,000 ft^2 @ $45/$ft^2$	180,000
(3) increase garage by 1,000 ft^2 @ $25/$ft^2$	25,000
(4) increase warehouse by 1,000 ft^2 @$25/$ft^2$	25,000
	$ 230,900
Design and Engineering:	23,090
	$ 253,990

ADDITIONAL OPERATIONAL COSTS

A. Additional Construction Materials

(1) Standpipes and Casings

6 reference trenches @ $670.50/trench	$ 4,023
547 walled trenches with one standpipe/trench 547 trenches @ $223.50/trench	$ 122,255
	+$ 118,232

Table C.18 (continued)

(2)	Gravel Drain	
	reference trenches @ $425/trench	$ 2,550
	547 walled trenches. Gravel volume/trench = (12m x 3m x 1.3m) = 10.8 m^3 = 14.13 yd^3	
	547 trenches x 14.13 yd^3/trench x $5/$yd^3$	$ 38,636
		+ $ 36,086
(3)	Seed and Mulch	
	6 reference trenches x 1.5 acres/trench x $295/acre	$ 2,655
	547 walled trenches require 13 acres	
	13 acres @ $295/acre	$ 2,835
		+$ 1,180
(4)	Corner Marker and Monuments	
	6 reference trenches @ $122/trench	$ 732
	547 walled trenches @ $122/trench	$ 66,734
		+$ 66,002
(5)	Surveyor	
	6 reference trenches $$480/trench	$ 2,880
	Surveyor consulting fees	$ 240,000
		+$ 237,120
(6)	Additional Material	
	Form work	
	30 m x 8.6m = 258m^2 = 2777 ft^2/trench. Form work = $0.68/$ft^2$ for 3 uses prior to replacement	
	2777 ft^2/trench x 547 trenches x $0.68/$ft^2$	$1,032,933
	Concrete	
	124.2 m^3/trench = 162.45 yd^3 x 547 trenches @ $45/$yd^3$	$3,998,795
	Reinforcing Steel	
	0.74 tons/trench x 547 trenches @ $430/ton	$ 174,055
B.	Additional Personnel	
	4-semiskilled laborers @ 15,000	$ 60,000
	4-unskilled laborers @ $10,000	40,000
	1-heavy equipment operator @ $21,000	21,000
	1-radiation safety technician @ $25,000	25,000
	1-quality assurance technician @ $25,000	25,000
		$ 171,000
	Fringe:	$ 17,100
	Overhead:	94,050
		282,150
	x 20 yrs	$5,643,000
	personnel monitoring	$ 119,680

Table C.18 (continued)

C.	Additional Consumables	$ 342,000
D.	Additional Equipment	
	2-40 ton cranes for 240 mo @ $4,500/mo	$ 2,160,000
	1-concrete pump for 240 mo @ $5,000/mo	1,200,000
	1-backhoe for 240 mo @ $4,000/mo	960,000
		$ 4,320,000
E.	Additional Monitoring	
	52 offsite sample analyses/yr @ average $165/sample x 20 yrs	$ 171,600
	Total additional operational costs	$16,260,683

Table C.19 Revised DEIS Table F.11 - Differential Costs for Concrete Walled Trench (Entire Waste Volume)

Assumptions:

- o Disposal of 1,000,000 m^3 of waste entirely in walled trenches.
- o Walled trench capacity = 189 m^3, requires 5,291 trenches.
- o Surface area of 5,291 trenches = 5,492,000 ft^2 = 126.08 acres. Surface area of 58 reference trenches = 3,770,000 ft^2 = 87 acres. Use of walled trenches requires additional 39.5 acres.
- o Construct 265 trenches/yr or about 5 trenches/week.

ADDITIONAL CAPITAL COSTS

(1) Add five atmospheric samplers @ $900	$ 4,500
(2) Increase health physics/security building by 8,000 ft^2 @ $45/$ft^2$	360,000
(3) Increase garage by 2,000 ft^2 @ 25/ft^2	50,000
(4) Increase warehouse by 5,000 ft^2 @ $25/$ft^2$	$ 125,000
	539,500
Engineering and Design:	53,950
	$ 593,450

ADDITIONAL OPERATIONAL COSTS

A. Additional Trench Constructional Materials

(1) Standpipes and Casings	
58 reference trenches @ $670.50/trench	$ 38,889
5,291 walled trenches with one standpipe/trench 5,291 trenches @ $223.50/trench	$1,182,539
	+$1,143,650
(2) Gravel Drain	
58 reference trenches @ $425/trench	$ 24,650
5,291 walled trenches. 5,291 trenches x 14.13 yd^3/trench x $5/$yd^3$	$ 373,809
	+$ 349,159
(3) Seed and Mulch	
58 reference trenches x 1.5 acres/trench @ $295/acre	$ 25,665
5,291 walled trenches 126 acres @ $295/acre	$ 37,170
	+$ 11,505

Table C.19 (continued)

(4)	Corner Markers and Monuments	
	58 reference trenches @ $122/trench	$ 7,076
	5,291 walled trenches @ $122/trench	$ 645,502
		+$ 638,426
(5)	Surveyor	
	58 reference trenches @ $480/trench	$ 27,840
	Surveying consultant costs @ $120,000/yr	$ 2,400,000
		+$ 2,372,160
(6)	Additional Material	
	Formwork - 2777 ft^2/trench x 5291 trenches @ $0.68/$ft^2$	$ 9,991,313
	Concrete - 162.45 yd^3/trench x 5291 trenches @ $45/$yd^3$	$38,678,533
	Reinforcing Steel - 0.74 tons/trench x 5291 trenches @ $430/ton	$ 1,683,596
B.	Additional Personnel	
	3-radiation safety technicians @ $25,000	$ 75,000
	30-semiskilled laborers @ $15,000	450,000
	30-unskilled laborers @ $10,000	300,000
	3-heavy equipment operators @ $21,000	63,000
	3-quality assurance technicans @ $25,000	75,000
	1-foreman @ $28,000	28,000
		$ 991,000
	Fringe:	99,100
	Overhead:	$ 545,050
		$ 1,635,150
	x 20 yrs	$32,703,000
	personnel monitoring	$ 761,600
C.	Additional Consumables	$ 1,982,000
D.	Additional Equipment	
	4-concrete pumps 240 mo @ $5,000/mo	$ 4,800,000
	3-backhoes for 240 mo @ $4,000/mo	2,880,000
	3-40 ton cranes for 200 mo @ $4,500/mo	3,240,000
	3-pickup trucks for 240 mo @ $750/mo	540,000
	1-farm tractor for 240 mo @ $800/mo	192,000
		$11,652,000

Table C.19 (continued)

E.	Additional Monitoring	
	260 offsite sample analyses/yr @ average $165/sample x 20 yrs.	$ 858,000
	Total additional operational costs:	$102,824,942

Table C.20 Revised DEIS Table F.12 - Differential Costs for Grouting

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Assumption:

- Costs based upon 1,000,000 m^3 of waste disposed by stacking into reference trenches. (75% efficiency). Available disposal volume per trench = 2 x 17,230 m^3 = 34,460 m^3. At 75% efficiency, have 25,845 m^3 of waste and 8,615 m^3 of void space per trench (not counting 1 m backfill between top of waste and trench). Disposal of 1,000,000 m^3 of waste by stacking therefore requires 1E+6/25,845 = 39 trenches having 333,000 m^3 of void space. Grout volume therefore equals waste volume x $\frac{(1-EFF)}{EFF}$

- Differential costs for stacking included elsewhere (see Table F.21). Costs are for grouting alone.

- Case A: cement
  Case B: low strength (200 psi) cement)

ADDITIONAL CAPITAL COSTS

(1)	Increase garage by 1,000 ft^2 @ $25/$ft^2$	$ 25,000
(2)	Increase warehouse by 1,000 ft^2 @ $25/$ft^2$	25,000
		$ 50,000
	Engineering and Design:	5,000
		$ 55,000

ADDITIONAL OPERATIONAL COSTS

A. Additional Materials

Grout

Case A.	333,000 m^3 = 436,000 yd^3 @ $45/$yd^3$	$19,619,980
Case B.	436,000 yd^3 @ $25/$yd^3$	$10,900,000

B. Additional Personnel

1-semiskilled laborer @ $15,000		$ 15,000
2-unskilled laborers @ $10,000		20,000
1-quality assurance technician @ $25,000		25,000
		$ 60,000
	Fringe:	6,000
	Overhead:	33,000
		$ 99,000
	x 20 yrs	$ 1,980,000
personnel monitoring		$ 43,520

C. Additional Consumables $ 120,000

Table C.20 (continued)

D.	Additional Equipment	
	2-cement pumps for 240 mo @ $5,000/mo	$ 2,400,000
	2-tremie pipe and hose systems	400,000
		$ 2,800,000
E.	Additional Monitoring	$ 0
	Total additional operational costs	
	Case A	$24,563,500
	Case B	$15,843,520

Table C.21 Revised DEIS Table F.13 - Differential Costs for Installation of an Engineered Human Intruder Barrier

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Assumptions:

- Costs based upon 1,000,000 m^3 of waste randomly disposed into reference trenches. This results in a total disposal area = vol/(EMP X EFF X SEFF) = 347,000 m^2, where EMP = 0.5, EFF = 6.4, and SEFF = 0.9.
- The engineered intruder barrier is 5.5 m thick and consists of layers of sand, clay, gravel, cobbles, boulders, asphaltic concrete, and topsoil, and is installed on top of existing 1 m thick backfill and 1 m thick cap.
- The engineered intruder barrier consists of 43,511 yd^3 of material per trench at an average cost of \$6.00/yd^3

CAPITAL COSTS:

Increase health physics/security building by 4,000 ft^2 @ \$45/ft^2	\$ 180,000
Increase garage by 2,000 ft^2 @ \$25/ft^2	50,000
Increase warehouse by 1000 ft^2 @ \$25/ft^2	25,000
	\$ 255,000
Engineering and Design:	25,500
	\$ 280,500

OPERATIONAL COSTS

A. Additional Materials

(1) Standpipes add 20 ft to each standpipe. 58 trenches x 3 standpipes/trench x 20 ft @ \$2.45/ft	\$ 8,526
(2) Barrier material 43,511 yd^3/trench x 58 trenches @ \$6/yd^3	\$15,141,828

B. Additional Personnel

4-heavy equipment operators @ 21,000/yr	\$ 84,000
4-semiskilled laborers @ \$15,000/yr	60,000
2-unskilled laborers @ \$10,000/yr	20,000
2-quality assurance technicians @ \$25,000	50,000
	\$ 214,000
Fringe:	21,400
Overhead:	117,700
	\$353,100
x 20 yrs	\$ 7,062,000
personnel monitoring	\$ 130,560

Table C.21 (Continued)

C.	Consumables	$ 428,000
D.	Additional Equipment	
	2-pan scrapers for 240 months @ $8,000/mo	$ 3,840,000
	1-asphalt paver for 240 months @ $3,775/mo	906,000
	1-crawler tractor for 240 months @ $4,200/mo	1,008,000
	1-vibratory compactor for 240 months @ $6,000/mo	468,000
	5-dump trucks for 240 months @ $6,000/mo	7,200,000
	1-motor grader for 240 months @ $3,200/mo	768,000
		$14,190,000
E.	Additional Monitoring	0
	Total additional operational costs	$36,960,914

Table C.22 Revised DEIS Table F.14 - Differential Costs for Improved Monitoring

Assumptions:

- Improved monitoring consists of 25 additional wells at an average depth of 60 ft, 10 particulate air samplers, and (optional) one automatic runoff sampler.
- Well construction: 1,500 total feet at $15/ft = $22,500.
- Cost of consulting services for well location selection = $20,000.
- Purchase and installation of 10 particulate air samplers @ $900/sampler = $9,000.
- Purchase and installation of automatic runoff sampler = $7,000.
- Construction of WEIR for sampler = $10,000.

CAPITAL COSTS			
Monitoring systems purchase and installation		$	48,500
Engineering and design fees			4,850
Consulting fees			20,000
		$	73,350
Without runoff sampler		$	54,650
OPERATIONAL COSTS			
A. Additional Trench Construction Materials			0
B. Additional Personnel			
1-radiation safety technician @ $25,000		$	25,000
	Fringe:		2,500
	Overhead:		13,750
			41,250
	x 20 yrs	$	825,000
personnel monitoring		$	10,880
C. Additional Consumables			50,000
D. Additional Equipment			0
E. Additional Monitoring			
25 wells, quarterly samples, @ $200/sample			20,000
10 air samples, 52 each/yr, @ $165/sample			85,800
runoff samples, 52/yr, @ $200/sample			10,400
		$	116,200
	x 20 yrs	$	2,324,000
Total additional operational costs:		$	3,209,880
Without runoff samples		$	3,001,880

Table C.23 Revised DEIS Table F.15 - Differential Costs for Improved Compaction

Assumptions:

o The costs are a function of the area compacted, which is Vol/(EMP x EFF x SEFF). Costs are estimated based upon 1,000,000 m^3 of randomly disposed waste, where EMP = 0.5, EFF = 6.4 m, and SEFF = 0.9.

ADDITIONAL CAPITAL COSTS			$ 0
ADDITIONAL OPERATIONAL COSTS			
A. Additional Materials			$ 0
B. Additional personnel			
1-heavy equipment operator @ $21,000			$ 21,000
		Fringe:	$ 2,100
		Overhead:	$ 11,550
			$ 34,650
		x 20 yrs	$ 693,000
	personnel monitoring		$ 10,880
C. Additional Consumables			$ 42,000
D. Additional Equipment			
1-vibratory compactor for 240 mo @ $1,950/mo			$ 468,000
E. Additional Monitoring			0
	Total additional operational costs		$1,213,880

Table C.24 Revised DEIS Table F.16 - Differential Costs for Improved Thicker Cap

Assumptions:

- o Thicker Cap Case A. Two meters of imported clay compacted to 95% of maximum density.
- o Thicker Cap Case B. Three meters of imported clay compacted to 95% of maximum density.
- o Fill required = disposal area x cover thickness, where the disposal area = Vol/(EMP x EFF x SEFF), and
  - Vol = waste volume (m^3)
  - EMP = emplacement efficiency
  - EFF = volumetric disposal efficiency (m^3/m^2)
  - SEFF = surface use efficiency
- o Example calculation for vol = 1 million m^3, EMP = 0.5 (random disposal), EFF = 6.4 m^3/m^2 (reference trench), and SEFF = 0.9 (reference trench)

ADDITIONAL CAPITAL COSTS		$ 0
ADDITIONAL OPERATIONAL COSTS		
A. Additional Trench Construction Materials		
Case A: 2 meter cap disposal area = 1,000,000/(.5 x 6.4 x .9) = 347,222 m^2. Fill required = 694,444 m^3 = 908,333 yd^3 Purchase and haul fill @ $3.50/$yd^3$		$ 3,179,165
Case B: 3 meter cap fill required = 1,041,666m^3 = 1,362,499 yd^3 Purchase and haul fill @ $3.50/$yd^3$		$ 4,768,747
B. Additional Personnel		
1-heavy equipment operator @ $21,000		$ 21,000
	Fringe:	$ 2,100
	Overhead:	11,550
		$ 34,650
	x 20	$ 693,000
personnel monitoring		$ 10,880
C. Additional Consumables		$ 42,000
D. Additional Equipment		
1-crawler tractor for 240 mo @ $4200/mo		$ 1,008,000
1-vibratory compactor for 240 mo @ $1950/mo		$ 468,000
		$ 1,476,000

Table C.24 (continued)

E.	Additional Monitoring	$ 0
	Total additional operational costs:	
	Case A:	$ 5,401,045
	Case B:	$ 6,990,627

Table C.25 Revised DEIS Table F.17 - Differential Costs for Moisture Barriers

Assumptions:

- o Costs based upon random disposal of 1,000,000 m^3 of waste into 58 reference disposal trenches.
- o Barrier options: A = one bentonite layer
  B = one polymer membrane layer
  C = one polymer membrane layer plus one bentonite layer
  D = two polymer membrane layers
- o Bentonite is used as a rate of 4 lbs/ft^2
- o Costs in addition to those for 2 m-thick compacted clay caps (Table F.16).

ADDITIONAL CAPITAL COSTS			$ 0
ADDITIONAL OPERATIONAL COSTS			
A. Additional Trench Construction Materials			
Two meter thick clay cap (from Table F.16)			$ 3,179,165
Case A	86 acres (3,746,160 ft^2) of bentonite 7,492 tons @ $260/ton		$ 1,948,003
Case B	3,746,160 ft^2 of 36 mil reinforced hypalon @ $0.60/$ft^2$		$ 2,247,696
Case C	Material Cost of Case A plus Case B.		$ 4,195,699
Case D	Twice additional material cost of Case B.		$ 4,495,392
B. Additional Personnel			
1-heavy equipment operator @ $21,000			$ 21,000
		Fringe:	2,100
		Overhead:	11,550
			$ 34,650
		x 20	$ 693,000
	personnel monitoring		$ 10,880
C. Additional Consumables			$ 42,000
D. Additional Equipment			
1-crawler tractor for $240 mo @ $4200/mo			$ 1,008,000
1-vibratory compactor for $240 mo @ $1950/mo			$ 468,000
			$ 1,476,000

Table C.25 (Continued)

E.	Additional Monitoring		$ 0
	Total additional operational costs:		
		Case A:	$ 7,349,048
		Case B:	$ 7,648,741
		Case C:	$ 9,596,744
		Case D:	$ 9,896,437

Table C.26 Revised DEIS Table F.18 - Differential Costs for Use of a Sand Backfill

Assumptions:

- Costs estimated based upon disposal of 1,000,000 m^3 of waste into reference disposal trenches.
- Sand backfill is assumed to be procured, trucked to the disposal facility, and stockpiled for use at an average cost of $2.50/$yd^3$.
- Costs are calculated for both random and stacked disposal, and include an equivalent of a 1 m thick backfill between the waste and the top of the trench. For random disposal, required sand volume = 1,000,000 m^3 + 58 x (180 m x 30 m x 1 m) = 1,313,200 m^3. For stacked disposal, required sand volume = 333,333 m^3 + 39 x (180 m x 30 m x 1m) = 543,933 m^3.

ADDITIONAL CAPITAL COSTS	$ 0
ADDITIONAL OPERATIONAL COSTS	
A. Additional Materials	
Random disposal 1,313,200 m^3 = 1,717,666 yd^3 @ $2.50/$yd^3$	$ 4,294,164
Stacked disposal 543,933 m^3 = 711,464 yd^3 @ $2.50/$yd^3$	$ 1,778,661
B. Additional Personnel	$ 0
C. Additional Consumables	$ 0
D. Additional Equipment	$ 0
E. Additional Monitoring	$ 0
Total additional operational costs:	
random disposal	$ 4,294,164
stacked disposal	$ 1,778,661

Table C.27 Revised DEIS Table F.19 - Differential Costs for a Surface Water Drainage System

Assumptions:

- Primary system, discharge channel, and run-off monitor installed during facility construction, secondary system installed in stages during facility operations.

- Primary system runs entirely around 60 ha state-owned land plus along 2 north-south site access roads. (See Figure E.11) (system 5200 m in total length)

- Secondary system runs between trenches (along lengths and ends) and carries discharge to primary system (system 10,900 m in total length).

- Drainage channel carries discharge from primary system to an offsite publicly owned drainage channel which empties into a nearby stream.

- Primary system consists of 1/3 section of 24" radius galvanized pipe; secondary system consists of 1/3 section of 15" radius galvanized pipe; discharge channel consists of trapezoidal sectioned gravel channel 500 m long. Gravel layer 3.5 m wide and 0.6 in thick.

CAPITAL COSTS

(1)	Primary system: 5200 m = 17,061 ft @ $19.43 ft	$ 331,499
(2)	Discharge channel: gravel (3.5 m x 500m) = 1050m^3 = 1,373 yd^3 @ $10/yd^3	$ 13,730
(3)	Purchase and install automatic runoff sampler	$ 7,000
(4)	Construction of WEIR for sampler	$ 25,000
(5)	Increase warehouse by 1,000 ft^2 @ $25/ft^2	$ 25,000
		$ 387,229
	Engineering and Design	$ 38,723
	Total additional capital costs	$ 425,952

Table C.27 (continued)

OPERATIONAL COSTS			
A. Additional Materials			
(1) Secondary System			
10,900 m = 35,763 ft @ $10.25/ft			$ 366,570
(2) System Maintenance Contingency			
5 maintenance operations @ $1.19/ft for 52,824 ft of system			$ 314,303
(3) Additional Personnel			
1-semiskilled laborer @ $15,000			$ 15,000
2-unskilled laborers @ $10,000			20,000
			$ 35,000
		Fringe:	$ 3,500
		Overhead	$ 19,250
			$ 57,750
		x 20 years	$1,155,000
	personnel monitoring		$ 32,640
C. Additional Consumables			$ 70,000
D. Additional Equipment			0
E. Additional Monitoring			
Offsite sample analysis @ average $200/sample, 52 samples/yr			$ 208,000
	Total additional operational costs:		$ 2,146,513

Table C.28 Revised DEIS Table F.20 - Differential Costs for Weather Shielding

Assumptions:

- Tension structures employed.
- Purchase 3 tension structures having dimensions 36.6m x 190m @ $\$100/m^2$ = $695,400 apiece
- Weather shield moves during operations cost 1.5% of total capital cost and include costs for temporary help, repairs, etc.
- Costs calculated on basis of 1,000,000 m^3 of waste.

CAPITAL COSTS

3 tension structures @ $695,400 apiece	$2,086,200
Engineering and Design	208,620
	$2,294,820

OPERATIONAL COSTS

Weather shield moves	
55 moves at 1.5% of $2,294,800	$1,893,210

Table C.29 Revised DEIS Table F.21 - Differential Costs for Stacked Waste Emplacement

Assumptions:

- o Costs based upon 1,000,000 m^3 of waste disposed by stacking into reference trenches at 75% efficiency. The available disposal volume per trench is 34,460 m^3. At 75% efficiency, can dispose of 25,845 m^3 per trench. The number of disposal trenches is reduced from 58 to 39.

ADDITIONAL CAPITAL COSTS

Increase health physics/security building by 4,000 ft^2 @ \$45/ft^2	\$ 180,000
Increase garage by 1,000 ft^2@ \$25/ft^2	\$ 25,000
	\$ 205,000
Engineering and Design:	20,500
	\$ 225,500

ADDITIONAL OPERATIONAL COSTS

A. Additional Materials

1. Standpipes	
58 trenches @\$670.50/trench	\$ 38,889
39 trenches @\$670.50/trench	\$ 26,150
	-\$ 12,739
2. French Drain	
58 trenches with 85 yd^3/trench @ \$5/yd	\$ 24,650
39 trenches with 85 yd^3/trench @ \$5/yd	\$ 16,575
	-\$ 8,075
3. Seed and Mulch	
58 trenches = 87 acres @ \$295/acre	\$ 25,665
39 trenches = 58.5 acres @ \$295/acre	\$ 17,258
	-\$ 8,407
4. Monuments and Markers	
58 trenches @ \$122/trench	\$ 7,076
39 trenches @ \$122/trench	\$ 4,758
	-\$ 2,318
5. Surveyor	
\$60/hr @ 8 hrs/trench	
58 trenches @ \$480/trench	\$ 27,840
39 trenches @ \$480/trench	\$ 18,720
	-\$ 9,120

Table C.29 (continued)

B.	Additional Personnel		
	4-Radiation safety technicians @ $25,000		$ 100,000
	4-Heavy equipment operators @ $21,000		84,000
	5-Semiskilled laborers @ $15,000		75,000
	6-Unskilled laborers @ $10,000		10,000
	1-Quality assurance technician @ $25,000		25,000
			$ 294,000
		Fringe:	$ 29,400
		Overhead:	$ 161,700
			$ 485,100
		x 20 yrs	$9,702,000
	personnel monitoring		$ 217,600
C.	Consumables		$ 588,000
D.	Additional Equipment		
	4-forklifts for 240 months @ $1,000/mo		$ 960,000
	1-40 ton crane for 240 months @ 4,500/mo		$ 1,080,000
	1-onsite transport vehicle 240 months @ $2,100/mo		$ 504,000
			$ 2,544,000
E.	Additional Monitoring		0
	Total additional operational costs:		$13,010,941

Table C.30 Revised DEIS Table F.22 - Differential Costs for Waste Segregation

Assumptions:

o Waste segregation requires additional labor and additional equipment

o Costs calculated based on 1,000,000 m^3 of randomly disposal waste

ADDITIONAL CAPITAL COSTS		
Add atmospheric sampler @ $900		$ 900
	Engineering and Design	90
		$ 990
ADDITIONAL OPERATIONAL COSTS		
A. Additional Trench Construction Materials		$ 0
B. Additional Personnel		
1-radiation safety technician @ $25,000		$ 25,000
1-semiskilled laborer @ $15,000		$ 15,000
3-unskilled laborers @ $10,000		$ 30,000
1-quality assurance technician @ $25,000		$ 25,000
		$ 95,000
	Fringe:	9,500
	Overhead:	52,250
		$ 156,750
	x 20 yrs	$ 3,135,000
personnel monitoring		$ 65,280
C. Additional Consumables		$ 190,000
D. Additional Equipment		
1-40-ton boom crane for 240 mo. @ $4,500/mo.		$ 1,008,000
1-forklift for 240 mo. @ $1,000/mo		240,000
		$ 1,248,000
E. Additional Monitoring		
52 offsite analyses/yr @ $165/sample x20 yrs		$ 171,600
Total additional operational costs:		$ 4,809,880

Table C.31 Revised DEIS Table F.23 - Differential Costs for Decontainerized Disposal

Assumptions:

- Costs based upon decontainerized disposal of lower activity compressible unstable waste, assumed to be about 56% of 1,000,000 m^3, or 560,000 m^3 for waste spectrum 1 (50% disposal efficiency).
- Operations require additional personnel, increased storage space, increased facility building sizes and increased airborne sampling.
- Operations require segregated waste disposal and use of weather shielding; however, costs calculated here do not include costs for segregation.

CAPITAL COSTS:

1.	Add 10 atmospheric samplers @ $900	$ 9,000
2.	Increase health physics/security building by 8,000 ft² @ $45/ft²	$ 360,000
3.	Increase garage by 1,000 ft² @ $25/ft²	$ 25,000
4.	Increase warehouse by 1,000 ft² @ $25/ft²	$ 25,000
5.	Construct additional storage area covering 6,000 ft² @ $20/ft²	$ 120,000
6.	Increase waste activities building by 6,025 ft² @ $50/ft²	$ 301,250
		$ 840,250
	Engineering and Design	$ 84,025
		$ 924,275

ADDITIONAL OPERATIONAL COSTS

A.	Additional Construction Materials	$ 0
B.	Additional Personnel	
	6-Radiation safety technicians @ $25,000	$ 150,000
	6-Heavy equipment operators @ $21,000	$ 126,000
	12-Semiskilled laborers @ $15,000	$ 180,000
	25-Unskilled laborers @ $10,000	$ 250,000
	2-Quality assurance technicians @ $25,000	$ 50,000
		$ 756,000
	Fringe:	$ 75,600
	Overhead:	$ 415,800
		$ 1,247,400
	x 20 yrs	$24,948,000
	personnel monitoring:	$ 554,880

Table C.31 (continued)

C.	Additional Consumables	$ 1,512,000
D.	Additional Equipment	
	1-four wheel drive vehicle for 240 months @ $800/mo	$ 192,000
	1-pickup for 240 months @ $750/mo	180,000
	2-forklifts for 240 months @ $1,000/mo	480,000
	1-crawler tractor for 240 months @ $4,200/mo	1,008,000
	1-vibratory compactor for 240 months @ $1,950/mo	468,000
	1-farm tractor for 240 months @ $2,100/mo	504,000
	1-onsite transport vehicle 240 months @$2,100/mo	504,000
		$ 3,336,000
E.	Additional Monitoring	
	520 offsite sample analyses per year @ $165/analysis x 20 years	$ 1,716,000
	Total additional operational costs:	$32,066,880

Table C.32 Revised DEIS Table F.24 - Differential Costs for In-Situ Dynamic Compaction of Compressible Waste

Assumptions:

- Costs based upon dynamic consolidation of trenches containing unstable wastes, or 1,000,000 m^3, if no waste segregation is performed.
- Dynamic consolidation costs calculated as if performed by outside firm under contract.
- Compacted area = Vol/(EMP x EFF) = 312,500 m^2, where EMP = 0.5 and EFF = 6.4.
- Disposal area (347,222 m^2) requires additional clayey cover averaging 3 meters thick.

CAPITAL COSTS

Add 10 atmospheric samplers @ $900	$ 9,000
Engineering and Design:	$ 900
	$ 9,900

ADDITIONAL OPERATIONAL COSTS

A. Additional Materials

1. Additional Clay Soil
   3m x 347,222 m^2 = 1,041,666 m^3 = 1,362,499 yd^3
   1,362,499 yd^3 @ $3.50/$yd^3$ — $ 4,768,747

2. Standpipes
   Repair one standpipe/trench
   58 trenches @ $223.5/trench — $ 12,963

B. Dynamic Compaction Costs

1. Dynamic consolidation @ $6.50/$m^2$
   312,500 m^2 x $6.50/$m^2$ — $ 2,031,250

2. Install new fill and compact, move, spread, and backfill earth into trenches, plus compaction of 1,362,499 yd^3 at approximately $2.00/$yd^3$ — $ 2,724,998

Table C.32 (continued)

C.	Additional Personnel		
	2-radiation safety technicians @ $25,000		$ 50,000
	1-quality assurance technician @ $25,000		25,000
			$ 75,000
		Fringe:	7,500
		Overhead:	41,250
			$ 123,750
		x 20 yrs	$ 2,475,000
	personnel monitoring		$ 32,640
D.	Additional Consumables		$ 150,000
E.	Additional Equipment		0
F.	Additional Monitoring		
	520 offsite sample analyses @ $135/analysis x 20 yrs		$ 1,404,000
	Total additional operational costs:		$13,599,598

Table C.33 Revised DEIS Table G.16 - Unit Rates for Impact Measures

Activity	Cost (thousand 1980 $)	Occupational[a] Exposure (person-rem)	Energy Use (thousand gallons)	Units[b]
<u>Capital</u>				
Reference Base Case (total)	7,870	--	212	Lump Sum
Additive Alternatives[c]				
Walled Trench	594	--	--	" "
Stacking	226	--	--	" "
Segregation of Unstable Waste	1	--	--	" "
Segregation of Chemical Waste	1	--	--	" "
Layering	132	--	--	" "
Decontainerized Disposal	924	--	--	" "
Hot Waste Facility	260	--	--	" "
Grouting	55	--	--	" "
Intruder Barrier	281	--	--	" "
Extreme Stabilization	10	--	--	" "
<u>Operational</u>				
Reference Base Case				
Trench (-Cover)	2,341	300	200	Disposal Vol.
Regular Cover	1,420	2400	100	Disposal Area
Other Costs	78,760	1000	200	Lump Sum
Additive Alternatives[c]				
Walled Trench	77,119	700	300	Disposal Vol.
Stacking	13,011	100	100	Waste Volume
Segregation of Unstable Waste	4,810	100	30	" "
Segregation of Chemical Waste	4,810	100	30	Chemical Wast Vol.
Layering	23,076	-100	30	Layered Vol.
Decontainerized Disposal	57,262	400	100	Decont. Vol.
Hot Waste Facility	181,823	-200	450	Hot Waste Vol
Grouting	73,691	2550	800	Grout Volume
Sand Backfill	3,270	--	185	Sand Volume
Cover Options				
Thick	15,555	2400	150	Disposal Area
Intruder Barrier	106,447	2400	300	" "
Moderate Stabilization	3,496	4800	300	" "
Extreme Stabilization	39,167	4800	600	" "

Table C.33 (Continued)

Activity	Cost (thousand 1980 $)	Occupational[a] Exposure (person-rem)	Energy Use (thousand gallons)	Units[b]
Post-Operational				
Closure Period				
Regular Closure	1,063	500[d]	15	Lump Sum
Extensive Closure	3,345	1000	60	" "
Institutional Period[e]				
Low Care Level				
Years 1-10	167	--	2	Per Year
Years 11-25	66	--	2	" "
Years 26-100	54	--	2	" "
Medium Care Level				
Years 1-10	385	--	6	" "
Years 11-25	167	--	6	" "
Years 26-100	91	--	6	" "
High Care Level				
Years 1-10	523[f]	--	10	" "
Years 11-25	385	--	10	" "
Years 26-100	167	--	10	" "

(a) Occupational exposures associated with operations other than waste unloading and disposal.

(b) Lump sum items are assumed to be independent of the waste volume; disposal volume dependency is for 1 million m^3 of disposal (not waste) volume; layered volume dependency is for 1 million m^3 of layered waste disposed; analogously, chemical, decontainerized, hot waste, grout, and sand volume dependencies are for 1 million m^3 of waste/material of concern; disposal area dependency is for 1 million m^2 of trench cover area.

(c) All these rates for alternatives are incremental rates in addition to the rates given for the reference system.

(d) Regular closure is assumed to last 2 years; extensive closure is assumed to last four years. Both cases assume 5000 person-hours of field work per year in an average radiation field of 0.05 mR/hr.

(e) These costs are basic costs not considering inflation or interest. Details for complete calculation of the institutional period costs, including consideration of inflation and interest, can be found in Appendix Q of the draft EIS as revised by this Appendix.

(f) To this cost, a ten-year annual contingency cost is added which depends on the soil conditions: $439,000 for medium-permeability soils, $183,000 for high-permeability soils, and $1,114,000 for low-permeability soils.

Technology	Cost (thousand 1980 $)
Reference Base Case	3,120
Additive Alternatives	
Walled Trench	540
Stacking	205
Segregation of Unstable Waste	0.9
Segregation of Chemical Waste	0.9
Layering	120
Decontainerized Disposal	840
Hot Waste Facility	236
Grouting	50
Intruder Barrier	255
Extreme Stabilization	9

4. MODIFICATIONS TO THE WASTE SOURCE DATA BASE

Relative to the draft EIS, modifications to the waste source data base (presented in Appendix D of the draft EIS) include the following:

- o Use of a distributed source term for certain LWR process wastes.
- o Modified waste spectral files.
- o Addition of a waste stream representing wastes from clean-up and decommissioning of small scale mixed oxide fuel research facilities.
- o Estimated radioisotope concentrations in waste streams generated from possible future fuel storage and recycle activities.
- o Other minor modifications.

These are discussed below:

Distributed Source Term.

In the draft EIS, LWR process waste streams included the following streams:

- o PWR ion exchange resins (P-IXRESIN)
- o PWR concentrated liquids (P-CONCLIQ
- o PWR filter sludge (P-FSLUDGE)
- o PWR cartridge filters (P-FCARTRG)
- o BWR ion exchange resins (B-IXRESIN)
- o BWR concentrated liquids (B-CONCLIQ)
- o BWR filter sludge (B-FSLUDGE)

The average concentration of 23 different radionuclides were determined based upon extrapolations of experimental data as discussed in the draft EIS and reference 10. These average concentrations, as well as the total concentrations obtained from summing the concentrations over all 23 radionuclides, are

presented in Tables D.11 and D.27 of Appendix D to the draft EIS. For illustration, Table D.11 is reprinted here as Table C.34. In the final EIS, however, a distributed source term is used for all LWR process streams except filter cartridges based upon new data obtained from a survey of records of waste shipments to disposal sites (Ref. 11).

Distribution data obtained from the records (in units of Ci/ft^3 as directly obtained from the data) are presented in Table C.35 and show the volume-percent distribution of gross concentration in LWR wet wastes. The records reviewed to obtain the data cover waste shipments for the years 1978 and 1979 and include 79% and 77%, respectively, of the total volume of waste disposed in the country for the two years considered. Six different LWR waste streams are shown: PWR resins, PWR sludges, PWR concentrated liquids, BWR resins, BWR sludges, and BWR concentrated liquids. The concentrations are separated into 14 ranges from .000005 Ci/ft^3 to 10+ Ci/ft^3. Within each range, the percentage of the total volume of the particular stream found to be within the range is indicated, as well as the average concentration (in Ci/ft^3) of the wastes within the concentration range. Also shown are the total number of data points (shipments) found for each waste stream as well as the total waste volumes. In the table, resins and sludges are shown as dewatered, while concentrated liquids are shown prior to solidification.

The data obtained require some interpretation. For example, the distinction in the shipment records between resins and sludges was often unclear. Some of the data points were listed as "resins + diatomaceous earth" (counted as sludge) while others were listed as "powdex resin" (counted as resin). Many other potential data points, which were disregarded for purposes of constructing the table, were described in vague terms such as "solidified product" or "radwaste solidified in concrete." Several other potential data points (also disregarded) were listed in the shipment records as "evaporator bottoms plus dry waste." Another factor was that the distribution of data points was uneven. While over a thousand data points were available for BWR resin waste, only 10 data points, for example, were found for PWR sludge. Given the above, the results for LWR resins and sludges are also presented in the table as combined (resin + sludge) streams. Support for this action is indicated by the similar concentration distribution shown for BWR resins and BWR sludges.

Based upon this data, and converting from Ci/ft^3 to Ci/m^3, the distribution of gross radioactivity in LWR resins, filter sludge, and concentrated liquids was taken to be as shown in Table C.36. Concentrations of individual radionuclides in each range are obtained by first determining the ratio of the average activity in a range to the activity obtained from the sum of the 23 individual radionuclides (e.g., in Table C.34, the summed activity for PWR ion exchange resins is 3.36E-2 Ci/m^3). This ratio is then multiplied by the individual radionuclide concentration listed. For example, 22.1% of PWR resins have a gross activity in the range of 0.01 to 0.05 Ci/ft^3. The concentration of Co-60 in this range is taken to be (.85/3.36E-2) x 4.53 E-3 = 0.11 Ci/m^3. This procedure, which assumes a fixed fractional distribution of individual radionuclides within each range, is conservative (by an approximate factor of between 1 and 2) since it disregards the contribution of many short-lived radionuclides.

The use of this data on waste activity distributions in the impact analyses methodology and computer codes is presented in Section 2, Appendix D, of this final EIS.

Table C.34 Reprinted DEIS Table D.11 - Group 1: Untreated Isotopic Concentrations (Ci/m³)

	P-IXRESIN	P-CONCLIQ	P-FSLUDGE	P-FCARTRG	B-IXRESIN	B-CONCLIQ	B-FSLUDGE
TOTAL	3.36E-02	1.09E-01	1.06E+00	1.86+00	4.63E+00	2.77E-01	5.24E+00
H-3	2.66E-03	3.45E-03	2.59E-03	1.15E-03	1.92E-02	6.24E-04	1.26E-02
C-14	9.74E-05	1.27E-04	9.55E-05	4.25E-05	1.19E-03	3.89E-05	7.78E-04
FE-55	2.34E-03	2.27E-02	3.10E-01	5.55E-01	9.48E-01	7.60E-02	1.44E+00
NI-59	2.79E-06	2.71E-05	3.71E-04	6.60E-04	9.80E-04	7.85E-05	1.49E-03
CO-60	4.53E-03	4.40E-02	6.00E-01	1.07E+00	1.59E+00	1.27E-01	2.41E+00
NI-63	8.61E-04	8.36E-03	1.14E-01	2.04E-01	2.15E-02	1.72E-03	3.25E-02
NB-94	8.84E-08	8.58E-07	1.17E-05	2.09E-05	3.09E-05	2.48E-06	4.70E-05
SR-90	1.94E-04	2.52E-04	1.89E-04	8.40E-05	3.64E-03	1.18E-03	2.37E-03
TC-99	8.23E-07	1.07E-06	8.03E-07	3.58E-07	7.65E-05	2.50E-06	5.00E-05
I-129	2.44E-06	3.16E-06	2.37E-06	1.06E-06	2.04E-04	6.65E-06	1.33E-04
CS-135	8.23E-07	1.07E-06	8.03E-07	3.58E-07	7.65E-05	2.50E-06	5.00E-05
CS-137	2.19E-02	2.85E-02	2.14E-02	9.54E-03	2.04E+00	6.65E-02	1.33E+00
U-235	4.71E-08	6.15E-08	1.46E-07	3.64E-07	5.33E-08	3.44E-08	3.32E-07
U-238	3.71E-07	4.84E-07	1.15E-06	2.87E-06	4.20E-07	2.71E-07	2.61E-06
NP-237	9.06E-12	1.18E-11	2.81E-11	7.02E-11	1.02E-11	6.61E-12	6.38E-11
PU-238	2.60E-05	5.12E-05	4.76E-05	2.51E-04	8.34E-05	1.99E-04	4.66E-04
PU-239/240	1.82E-05	3.31E-05	1.55E-04	3.80E-04	5.34E-05	9.43E-05	2.36E-04
PU-241	7.94E-04	1.44E-03	6.75E-03	1.66E-02	2.60E-03	4.60E-03	1.15E-02
PU-242	3.99E-08	7.25E-08	3.39E-07	8.34E-07	1.17E-07	2.06E-07	5.18E-07
AM-241	1.87E-05	2.99E-05	2.64E-04	1.64E-04	2.32E-05	1.20E-04	1.56E-04
AM-243	1.26E-06	2.02E-06	1.78E-05	1.10E-05	1.57E-06	8.10E-06	1.05E-05
CM-243	9.92E-09	1.17E-08	3.10E-07	1.93E-07	2.70E-08	2.59E-07	2.97E-07
CM-244	1.38E-05	1.92E-05	1.77E-04	1.10E-04	1.82E-05	2.05E-04	2.24E-04

Table C.35 Volume Percent and Average Concentration (Ci/ft^3) in Range

	PWR RESIN		PWR SLUDGE		PWR CONC LIQ		BWR RESIN		BWR SLUDGE		BWR CONC LIQ		PWR RESIN + SLUDGE		BWR RESIN + SLUDGE	
Range (Ci/ft^3)	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc
.000005 - .00001							0.2	.0000071							0.1	.0000071
.00001 - .00005	0.8	.000032			0.4	.000048	0	-					0.7	.000032	0	-
.00005 - .0001	5.2	.000064			0.6	.000068	0.2	.000059	1.2	.000060			4.8	.000064	0.4	.000060
.0001 - .0005	8.4	.00025			4.3	.00033	3.7	.00028	3.5	.00025	7.5	.00027	7.8	.00025	3.7	.00027
.0005 - .001	5.9	.00071	8.1	.00071	9.1	.00067	3.2	.00061	1.1	.00092	0	-	6.1	.00071	2.9	.00070
.001 - .005	15.5	.0026	67.8	.0019	28.6	.0028	9.7	.0030	19.4	.0028	45.7	.0030	19.3	.0025	11.4	.0029
.005 - .01	8.2	.0074	9.3	.0076	20.4	.0077	7.2	.0076	7.3	.0072	22.3	.0072	8.3	.0074	7.2	.0075
.01 - .05	23.0	.024	10.9	.018	30.4	.024	31.0	.024	29.0	.025	8.8	.027	22.1	.024	30.6	.024
.05 - .1	8.9	.074	3.9	.084	3.2	.067	11.6	.076	12.3	.070	6.1	.075	8.5	.074	11.8	.075
.1 - .5	15.4	.22			2.6	.16	26.9	.21	20.0	.21	9.7	.15	14.3	.21	25.7	.21
.5 - 1.0	4.2	.71			0.1	.51	3.6	.72	3.8	.75			3.9	.71	3.6	.73
1.0 - 5.0	3.5	2.08			0.3	2.45	2.4	1.69	2.3	1.81			3.2	2.08	2.4	1.72
5.0 - 10	0.9	7.37					0.1	7.17					0.8	7.37	0.1	7.17
10+	0.2	11.19					0.1	13.08					0.2	11.19	0.1	13.08
Data Points (1818)	254		10		286		1024		181		63		264		1205	
Total Volume (ft^3)	39,924		3121		55,081		142,097		30,044		71,790		43,045		172,141	

Table C.36 Distribution of Gross Activity in LWR Process Waste Streams

Range		P-IXRESIN		P-CONCLIQ		P-FSLUDGE		B-IXRESIN		B-CONCLIQ		B-FSLUDGE	
Ci/ft^3	Ci/m^3	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc	Vol%	Conc
.000005 - .00001	.00018 - .00035							0.1	.00025			0.1	.00025
.00001 - .00005	.00035 - .0018	0.7	.0011	0.4	.0017	0.7	.0011	0	-			0	-
.00005 - .0001	.0018 - .0035	4.8	.0023	0.6	.0024	4.8	.0023	0.4	.0021			0.4	.0021
.0001 - .0005	.0035 - .018	7.8	.0088	4.3	.0012	7.8	.0088	3.7	.0096	7.5	.0095	3.7	.0096
.0005 - .001	.018 - .035	6.1	.025	9.1	.024	6.1	.025	2.9	.025	0	-	2.9	.025
.001 - .005	.035 - .18	19.3	.088	28.6	.099	19.3	.088	11.4	.10	45.7	.10	11.4	.10
.005 - .01	.18 - .35	8.3	.26	20.4	.27	8.3	.26	7.2	.26	22.3	.26	7.2	.26
.01 - .05	.35 - 1.8	22.1	.85	30.4	.84	22.1	.85	30.6	.86	8.8	.96	30.6	.86
.05 - .1	1.8 - 3.5	8.5	2.61	3.2	2.37	8.5	2.61	11.8	2.65	6.1	2.63	11.8	2.65
.1 - .5	3.5 - 18	14.3	7.47	2.6	5.65	14.3	7.47	25.7	7.38	9.7	5.33	25.7	7.38
.5 - 1	18 - 35	3.9	25.02	0.1	17.97	3.9	25.02	3.6	25.67			3.6	25.67
1 - 5	35 - 180	3.2	73.28	0.3	86.55	3.2	73.28	2.4	60.63			2.4	60.63
5 - 10	180 - 350	0.8	260.34			0.8	260.34	0.1	253.17			0.1	253.17
10+	350+	0.2	395.17			0.2	395.17	0.1	461.96			0.1	461.96

Modified Waste Spectral Files

Since publication of the draft EIS, some relatively minor modifications have been made to the waste spectral files (for background, see sections 5.1 and 5.2 of Appendix D of the draft EIS.). These modifications have been made to allow increased flexibility and expanded consideration of the use of high integrity containers (HIC). These include changes to the waste stability index (I8) and waste processing index (I10) for some of the waste streams, as well as the addition of a fifth and sixth waste spectrum.

For the draft EIS, the waste stability index (I8) could have two values: zero or one. A value I8=0 signified an unstable waste stream while a value I8=1 signified a stable waste stream. For the final EIS, I8 may have the following values:

Index Value	Meaning
0	Unstable waste form
1	Inherently stable waste form
2	Stabilized by placement into HIC
3	Stabilized by another means

As indicated above, all index values greater than 0 indicate a stable waste form. However, the revised values provide some additional information as to how stability has been achieved and could be used, for example, if one wished to consider a time limit for waste stability. An "inherently" stable waste form is one in which either the waste form itself may be considered stable or current packaging techniques typically already achieve a stable waste form. An example of an "inherently" stable waste form is waste solidified in a media such as cement or vinyl ester styrene. A value of I8=2 indicates that stability is achieved through placement of the waste into a high integrity container (HIC). A value of I8=3 indicates that processing is performed to achieve stability in addition to current waste packaging techniques and other than solidification or placement into an HIC. An example would be a waste package containing miscellaneous activated metals in which the interstital voids are filled with an inert incompressible material such as sand.

In the same vein, the values assigned to the waste processing index (I10) have been modified to allow consideration of stabilization using an HIC or by other means. As before, the waste processing index is a four digit number of which the first digit signifies processing resulting in volume reduction, the second digit signifies the type of solidification agent used, the third digit indicates the location of the processing activity, and the fourth digit signifies whether incineration is performed. The modified waste processing index adds two potential values to the second (solidification) digit as shown in Table C.37.

The modified waste spectral file for each of the four waste spectra considered in the draft EIS are presented in the following Tables C.38 through C.41. These modified spectral files reflect the modifications to the I8 and I10 indices as discussed above.

Table C.37 Revised Waste Processing Indices

	Value	Meaning
First Digit	0	No Volume Reduction
	1	Regular Compaction
	2	Improved Compaction
	3	Hydraulic Press
	4	Evaporation
	5	Pathological Incineration
	6	Small Calciner
	7	Large Calciner
Second Digit	0	No Solidification
	1	Solidification Scenario A
	2	Solidification Scenario B
	3	Solidification Scenario C
	4	High Integrity Container
	5	Stabilize by another means
Third Digit	0	No Processing
	1	Processing at the Generator
	2	Processing at the Disposal Site
Fourth Digit	0	No Incineration
	1	Urban Environment
	2	Rural Environment

Table C.38 Revised Waste Form, Processing, and Volume Change Indices for Waste Spectrum 1

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
P-IXRESIN	1.00	1.00	2	1	1	0	0	1	0010
P-CONCLIQ	1.00	1.40	1	1	2	0	1	1	0110
P-FSLUDGE	1.00	1.00	1	3	1	0	0	1	0010
P-FCARTRG	1.00	1.00	2	2	1	0	0	1	0110
B-IXRESIN	1.00	1.00	2	1	1	0	0	1	0010
B-CONCLIQ	1.00	1.40	1	1	2	0	1	1	0110
B-FSLUDGE	1.00	1.00	1	3	1	0	0	1	0010
P-COTRASH	1.00	1.00	3	2	1	0	0	1	0000
P-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
B-COTRASH	1.00	1.00	3	2	1	0	0	1	0000
B-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
F-COTRASH	1.00	1.00	3	2	1	0	0	1	0000
F-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
I-COTRASH	1.00	1.00	3	2	1	0	0	1	0000
I+COTRASH	1.00	1.00	3	2	1	0	0	1	0000
N-SSTRASH	1.00	1.00	2	2	1	0	0	1	0000
N+SSTRASH	1.00	1.00	2	2	1	0	0	1	0000
N-LOTRASH	1.00	1.00	3	2	1	0	0	1	0000
N+LOTRASH	1.00	1.00	3	2	1	0	0	1	0000
F-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
U-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
I-LQSCNVL	1.00	3.00	3	3	1	1	0	1	0010
I+LQSCNVL	1.00	3.00	3	3	1	1	0	1	0010
I-ABSLIQD	1.00	3.00	3	3	1	1	1	1	0010
I+ABSLIQD	1.00	3.00	3	3	1	1	1	1	0010
I-BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
I+BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
N-SSWASTE	1.00	1.00	0	3	1	0	1	1	0000
N-LOWASTE	1.00	1.00	3	3	1	1	0	1	0000

Table C.38 (Continued)

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
N-NFRCOMP	1.00	1.00	0	0	1	0	0	2	0000
L-DECONRS	1.00	2.00	2	0	4	1	1	1	0310
N-ISOPROD	1.00	1.30	1	1	3	1	0	1	0210
N-HIGHACT	1.00	1.00	0	0	1	0	0	3	0000
N-TRITIUM	1.00	1.00	3	3	1	1	1	1	0000
N-SOURCES	1.00	1.00	0	0	1	0	1	2	0000
N-TARGETS	1.00	1.00	0	0	1	0	1	1	0000

Table C.39 Revised Waste Form, Processing, and Volume Change Indices for Waste Spectrum 2

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
P-IXRESIN	1.00	1.65	1	1	3	0	1	1	0210
P-CONCLIQ	6.00	1.82	1	1	3	0	1	1	4210
P-FSLUDGE	1.00	1.65	1	1	3	0	1	1	0210
P-FCARTRG	1.00	1.00	1	1	3	0	1	1	0210
B-IXRESIN	1.00	1.65	1	1	3	0	1	1	0210
B-CONCLIQ	2.40	1.56	1	1	3	0	1	1	0420
B-FSLUDGE	1.00	1.65	1	1	3	0	1	1	0210
P-COTRASH	2.00	1.00	3	2	1	0	0	1	1010
P-NCTRASH	1.00	1.00	0	0	1	0	3	2	0510
B-COTRASH	2.00	1.00	3	2	1	0	0	1	1010
B-NCTRASH	1.00	1.00	0	0	1	0	0	2	0510
F-COTRASH	1.50	1.00	3	2	1	0	0	1	1010
F-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
I-COTRASH	2.00	1.00	3	2	1	0	0	1	1010
I+COTRASH	4.00	1.00	3	2	1	0	0	1	2020
N-SSTRASH	1.50	1.00	2	2	1	0	0	1	1010
N+SSTRASH	3.00	1.00	2	2	1	0	0	1	2020
N-LOTRASH	2.00	1.00	3	2	1	0	0	1	1010
N+LOTRASH	4.00	1.00	3	2	1	0	0	1	2020
F-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
U-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
I-LQSCNVL	1.28	3.00	3	3	1	1	1	1	1010
I+LQSCNVL	1.00	3.00	3	3	1	1	0	1	0210
I-ABSLIQD	1.00	1.65	3	1	3	1	1	1	0210
I+ABSLIQD	1.00	3.00	3	3	1	1	1	1	0010
I-BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
I+BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
N-SSWASTE	1.00	1.00	0	3	1	0	1	1	0000
N-LOWASTE	1.00	1.00	3	3	1	1	0	1	0000
L-NFRCOMP	1.00	1.00	0	0	1	0	3	2	0510

Table C.39 (Continued)

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
L-DECONRS	1.00	2.00	2	0	4	1	1	1	0310
N-ISOPROD	1.00	2.00	1	0	4	1	1	1	0310
N-HIGHACT	1.00	1.00	0	0	1	0	3	3	0510
N-TRITIUM	1.00	1.00	3	3	1	1	1	1	0000
N-SOURCES	1.00	1.00	0	0	1	0	1	2	0000
N-TARGETS	1.00	1.00	0	0	1	0	1	1	0000

Table C.40 Revised Waste Form, Processing, and Volume Change Indices for Waste Spectrum 3

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
P-IXRESIN	1.00	2.00	2	0	4	0	1	1	0310
P-CONCLIQ	6.00	2.00	2	0	4	0	1	1	4310
P-FSLUDGE	1.00	2.00	2	0	4	0	1	1	0310
P-FCARTRG	1.00	1.00	2	0	4	0	1	1	0310
B-IXRESIN	1.00	2.00	2	0	4	0	1	1	0310
B-CONCLIQ	2.40	2.00	2	0	4	0	1	1	4310
B-FSLUDGE	1.00	2.00	2	0	4	0	1	1	0310
P-COTRASH	80.00	2.00	1	0	4	0	1	1	6312
P-NCTRASH	1.00	1.00	0	0	1	0	3	2	0510
B-COTRASH	80.00	2.00	1	0	4	0	1	1	6312
B-NCTRASH	1.00	1.00	0	0	1	0	3	2	0510
F-COTRASH	40.00	2.00	1	0	4	0	1	1	6311
F-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
I-COTRASH	20.00	2.00	1	0	4	0	1	1	5311
I+COTRASH	80.00	2.00	1	0	4	0	1	1	7322
N-SSTRASH	10.00	2.00	1	0	4	0	1	1	5311
N+SSTRASH	40.00	2.00	1	0	4	0	1	1	7322
N-LOTRASH	20.00	2.00	1	0	4	0	1	1	5311
N+LOTRASH	80.00	2.00	1	0	4	0	1	1	7322
F-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
U-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
I-LQSCNVL	4.52	2.00	1	0	4	0	1	1	5311
I+LQSCNVL	1.00	3.00	3	3	1	1	0	1	0010
I-ABSLIQD	1.00	2.00	1	0	4	1	1	1	0310
I+ABSLIQD	1.00	3.00	3	3	1	1	1	1	0010
I-BIOWAST	15.00	2.00	1	0	4	0	1	1	5311
I+BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
N-SSWASTE	1.00	1.00	0	3	1	0	1	1	0000
N-LOWASTE	1.00	1.00	3	3	1	1	0	1	0000
L-NFRCOMP	1.00	1.00	0	0	1	0	3	2	0510

Table C.40 (Continued)

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
L-DECONRS	18.00	2.00	1	0	4	0	1	1	6312
N-ISOPROD	1.00	2.00	1	0	4	1	1	1	0310
N-HIGHACT	1.00	1.00	0	0	1	0	3	3	0510
N-TRITIUM	1.00	1.00	3	3	1	1	1	1	0000
N-SOURCES	1.00	1.00	0	0	1	0	1	2	0000
N-TARGETS	1.00	1.00	0	0	1	0	1	1	0000

Table C.41 Revised Waste Form, Processing, and Volume Change Indices for Waste Spectrum 4

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
P-IXRESIN	18.00	2.00	1	0	4	0	1	1	6312
P-CONCLIQ	8.00	2.00	1	0	4	0	1	1	6312
P-FSLUDGE	5.00	2.00	1	0	4	0	1	1	6312
P-FCARTRG	1.00	1.00	2	0	4	0	1	1	0310
B-IXRESIN	18.00	2.00	1	0	4	0	1	1	6312
B-CONCLIQ	6.40	2.00	1	0	4	0	1	1	6312
B-FSLUDGE	5.00	2.00	1	0	4	0	1	1	6312
P-COTRASH	80.00	2.00	1	0	4	0	1	1	6312
P-NCTRASH	6.00	1.00	0	0	1	0	1	2	3010
B-COTRASH	80.00	2.00	1	0	4	0	1	1	6312
B-NCTRASH	6.00	1.00	0	0	1	0	1	2	3010
F-COTRASH	40.00	2.00	1	0	4	0	1	1	6311
F-NCTRASH	6.00	1.00	0	0	1	0	0	2	3020
I-COTRASH	20.00	2.00	1	0	4	0	1	1	5311
I+COTRASH	80.00	2.00	1	0	4	0	1	1	7322
N-SSTRASH	10.00	2.00	1	0	4	0	1	1	5311
N+SSTRASH	40.00	2.00	1	0	4	0	1	1	7322
N-LOTRASH	20.00	2.00	1	0	4	0	1	1	5311
N+LOTRASH	80.00	2.00	1	0	4	0	1	1	7322
F-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
U-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
I-LQSCNVL	4.52	2.00	1	0	4	0	1	1	5311
I+LQSCNVL	1.00	3.00	3	3	1	1	0	1	0010
I-ABSLIQD	100.00	2.00	1	0	4	1	1	1	5311
I+ABSLIQD	1.00	3.00	3	3	1	1	1	1	0010
I-BIOWAST	15.00	2.00	1	0	4	0	1	1	5311
I+BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
N-SSWASTE	1.00	1.00	0	3	1	0	1	1	0000
N-LOWASTE	1.00	1.00	3	3	1	1	0	1	0000
L-NFRCOMP	1.00	1.00	0	0	1	0	3	2	0510

Table C.41 (Continued)

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
L-DECONRS	18.00	2.00	1	0	4	0	1	1	6312
N-ISOPROD	1.00	2.00	1	0	4	1	1	1	0310
N-HIGHACT	1.00	1.00	0	0	1	0	3	3	0510
N-TRITIUM	1.00	1.00	3	3	1	1	1	1	0000
N-SOURCES	1.00	1.00	0	0	1	0	1	2	0000
N-TARGETS	1.00	1.00	0	0	1	0	1	1	0000

For the final EIS, two additional waste spectra are considered. The fifth waste spectra incorporates high integrity containers to achieve a stabilized waste form. Relative to waste spectrum 1, waste streams other than activated metals which had previously been in an unstable form are stabilized using HICs. Activated metals are assumed to be stabilized by filling interstitial voids in a waste container with a noncompressible material. This could occur either at the waste generator's facility or at the disposal facility. The N-TRITIUM waste stream is already assumed to be stable in waste spectrum 1, but is assumed to be placed into an HIC to help further reduce potential ground water impacts.

Since HIC's are more expensive than normal waste containers, all compressible waste streams are assumed to be subjected to compaction. Waste streams I+COTRASH, N+SSTRASH, N+LOTRASH, and I+LIQSCVL are assumed to be compacted at a centralized processing facility which is assumed to be colocated with the disposal facility. The remaining compressible waste streams are assumed to be compacted at the waste generator's site. These include the P-COTRASH, B-COTRASH, I-COTRASH, N-SSTRASH, and N-LOTRASH waste streams.

Waste spectra processing indices as well as volume reduction and volume increase factors are presented for waste spectrum 5 in Table C.42.

The sixth waste spectrum is a combination of waste spectra 1 and 2, and is used to represent overall waste characteristics that are projected to result without requirements for waste stability and considering the increasing costs for disposal. In this waste spectrum, light water reactor (LWR) process waste streams are disposed in an unstable manner. For example, LWR ion exchange resins and filter sludge are disposed in a dewatered form. Other high activity waste streams such as pressurized water reactor (PWR) cartridge filters, LWR nonfuel reactor core components, and LWR noncompressible trash are also packaged in a manner which could result in disposal cell slumping and other subsidence problems. The waste form and packaging conditions for the above waste streams are the same as those assumed for waste spectrum 1.

Similarly, to waste spectrum 2, however, all compressible waste streams are assumed to be compacted. Given the greatly increased costs for disposal that have been experienced over the last few years, and the expectation that disposal costs will probably continue to increase in the future, there has been a great interest in volume reduction technologies such as compaction. In waste spectrum 6, waste streams I+COTRASH, N+SSTRASH, N+LOTRASH, and +LIQSCVL are assumed to be compated at a centralized processing facility which is assumed to be colocated with the disposal facility. The remaining compressible waste streams are assumed to be compacted at the waste generator's site. These include the P-COTRASH, B-COTRASH, I-COTRASH, N-SSTRASH, and N-LOTRASH waste streams.

Waste spectra processing indices as well as volume reduction and volume increase factors are presented for waste spectrum 6 in Table C.43.

Table C.42 Waste Form Processing, and Volume Change Indices for Waste Spectrum 5

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
P-IXRESIN	1.00	1,00	2	1	1	0	2	1	0410
P-CONCLIQ	1.00	1.40	1	1	2	0	1	1	0110
P-FSLUDGE	1.00	1.00	1	3	1	0	2	1	0410
P-FCARTRG	1.00	1.00	2	2	1	0	2	1	0410
B-IXRESIN	1.00	1.00	2	1	1	0	2	1	0410
B-CONCLIQ	1.00	1.40	1	1	2	0	1	1	0110
B-FSLUDGE	1.00	1.00	1	3	1	0	2	1	0410
P-COTRASH	2.00	1.00	3	2	1	0	1	2	1410
P-NCTRASH	1.00	1.00	0	0	1	0	3	2	0510
B-COTRASH	2.00	1.00	3	2	1	0	2	1	1410
B-NCTRASH	1.00	1.00	0	0	1	0	3	2	0510
F-COTRASH	1.50	1.00	3	2	1	0	2	1	1410
F-NCTRASH	1.00	1.00	0	0	1	0	3	2	0510
I-COTRASH	2.00	1.00	3	2	1	0	2	1	1410
I+COTRASH	4.00	1.00	3	2	1	0	2	1	2420
N-SSTRASH	1.50	1.00	2	2	1	0	2	1	1410
N+SSTRASH	3.00	1.00	2	2	1	0	2	1	2420
N-LOTRASH	2.00	1.00	3	2	1	0	2	1	1410
N+LOTRASH	4.00	1.00	3	2	1	0	2	1	2420

Table C.42 (Continued)

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
F-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
U-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
I-LQSCNVL	1.28	3.00	3	3	1	1	2	1	1410
I+LQSCNVL	1.00	3.00	3	3	1	1	2	1	0420
I-ABSLIQD	1.00	1.65	3	3	1	1	1	1	0010
I+ABSLIQD	1.00	3.00	3	3	1	1	1	1	0010
I-BIOWAST	1.00	1.92	2	3	1	1	2	1	0410
I+BIOWAST	1.00	1.92	2	3	1	1	2	1	0420
N-SSWASTE	1.00	1.00	0	3	1	0	1	1	0000
N-LOWASTE	1.00	1.00	3	3	1	1	2	1	0410
L-NFRCOMP	1.00	1.00	0	0	1	0	3	2	0510
L-DECONRS	1.00	2.00	2	0	4	1	1	1	0310
N-ISOPROD	1.00	2.00	1	1	3	1	2	1	0410
N-HIGHACT	1.00	1.00	0	0	1	0	3	3	0510
N-TRITIUM	1.00	1.00	3	3	1	1	2	1	0410
N-SOURCES	1.00	1.00	0	0	1	0	1	2	0000
N-TARGETS	1.00	1.00	0	0	1	0	2	1	0410

Table C.43 Waste Form, Processing, and Volume Change Indices for Waste Spectrum 6

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
P-IXRESIN	1.00	1.00	2	1	1	0	0	1	0010
P-CONCLIQ	6.00	1.82	1	1	3	0	1	1	4210
P-FSLUDGE	1.00	1.00	1	3	1	0	0	1	0010
P-FCARTRG	1.00	1.00	2	2	1	0	0	1	0110
B-IXRESIN	1.00	1.00	2	1	1	0	0	1	0010
B-CONCLIQ	2.40	1.56	1	1	3	0	1	1	4210
B-SLUDGE	1.00	1.00	1	3	1	0	0	1	0010
P-COTRASH	2.00	1.00	3	2	1	0	0	1	1010
P-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
B-COTRASH	2.00	1.00	3	2	1	0	0	1	1010
B-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
F-COTRASH	1.50	1.00	3	2	1	0	0	1	1010
F-NCTRASH	1.00	1.00	0	0	1	0	0	2	0000
I-COTRASH	2.00	1.00	3	2	1	0	0	1	1010
I+COTRASH	4.00	1.00	3	2	1	0	0	1	2020
N-SSTRASH	1.50	1.00	2	2	1	0	0	1	1010
N+SSTRASH	3.00	1.00	2	2	1	0	0	1	2020
N-LOTRASH	2.00	1.00	3	2	1	0	0	1	1010
N+LOTRASH	4.00	1.00	3	2	1	0	0	1	2020
F-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
U-PROCESS	1.00	1.00	0	3	1	0	1	1	0000
I-LQSCNVL	1.28	3.00	3	3	1	1	1	1	1010
I+LQSCNVL	1.00	3.00	3	3	1	1	0	1	0010
I-ABSLIQD	1.00	1.65	3	1	3	1	1	1	0210
I+ABSLIQD	1.00	3.00	3	3	1	1	1	1	0010
I-BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
I+BIOWAST	1.00	1.92	2	3	1	1	0	1	0010
N-SSWASTE	1.00	1.00	0	3	1	0	1	1	0000
N-LOWASTE	1.00	1.00	3	3	1	1	0	1	0000

Table C.43 (Continued)

Waste Stream	VRF	VIF	Flam I4	Disp I5	Leach I6	Chem I7	Stab I8	Acc I9	Process I10
L-NFRCOMP	1.00	1.00	0	0	1	0	0	2	0000
L-DECONRS	1.00	2.00	2	0	4	1	1	1	0310
N-ISOPROD	1.00	1.30	1	1	3	1	0	1	0210
N-HIGHACT	1.00	1.00	0	0	1	0	0	3	0000
N-TRITIUM	1.00	1.00	3	3	1	1	1	1	0000
N-SOURCES	1.00	1.00	0	0	1	0	1	2	0000
N-TARGETS	1.00	1.00	0	0	1	0	1	1	0000

Wastes From Clean-up of MOX Research Facilities.

To improve the EIS analysis of impacts of transuranic waste disposal, an additional waste stream (F-PUDECON) is added to the 36 considered in the draft EIS. This additional waste stream considers the generation of transuranic-contaminated waste from decontamination of mixed oxide (MOX) fuel research facilities and from burnup studies of irradiated LWR fuel rods.

A brief background of past and possible future transuranic waste generation and disposal practices has been provided in Appendix D of the draft EIS. As discussed in Appendix D, compared to operations conducted by DOE, there have been only relatively small quantities of transuranic (TRU) waste generated by the commercial sector. Major sources of TRU wastes that have been delivered in the past to commercial disposal facilities have included waste from:

- DOE and its predecessors, the Energy Research and Development Administration (ERDA) and the Atomic Energy Commission (AEC);
- DOE, ERDA, and AEC contractors;
- Reprocessing of spent uranium fuel at the West Valley, New York commercial fuel reprocessing plant.
- Research and development of plutonium fuels, including fabrication of small quantities of mixed-oxide (MOX) fuels for test purposes in light water reactors; and
- Research studies of irradiated reactor fuel.

Within the last few years, the amount of transuranic waste delivered to commercial waste disposal facilities has been further reduced to even lower levels and has been finally all but discontinued. This has been caused by a number of factors. One factor was the policy announced by AEC in 1970 whereby AEC-produced TRU waste in concentrations greater than 10 nanocuries per gram (nCi/gm) were consigned to retrievable storage at AEC facilities pending the availability of a repository for the ultimate disposition of the waste. (Some TRU waste generated as a result of AEC (and later DOE) contracts with private companies, however, was still sent to commercial disposal sites.) The only commercial reprocessing facility ever to operate in the United States was the facility operated by Nuclear Fuel Services (NFS) near West Valley, New York. In 1972, this facility was shut down and has not operated since. In 1976, President Carter announced a national policy of deferment of commerical fuel reprocessing. This policy of deferring fuel reprocessing halted most of the mixed oxide fuel research and development work in the commercial sector. (Some research is still being carried on, however, either by or under contract to DOE.) Most commercial mixed oxide fuel fabrication test facilities implemented a program for facility clean-up and decontamination.

In addition, there is currently a lack of disposal capacity for TRU waste disposal. Individual disposal facility license conditions impose a 10 nanocurie per gram disposal limit for TRU waste at all operating commercial low-level

waste disposal facilities.* Although at one time five of the six commercial LLW disposal sites accepted TRU wastes for disposal (the Barnwell, South Carolina facility has never accepted TRU wastes for disposal), this practice has been discontinued. The last commercial facility to accept TRU waste for disposal was the facility located in the center of the Hanford Reservation near Richland, Washington and operated by the Nuclear Engineering Company (NECO, now U.S. Ecology, Inc.). From 1976 to 1979, this facility was the only commercial disposal facility accepting TRU waste for disposal. TRU waste acceptance at this facility in concentrations exceeding 10 nCi/gm was prohibited by the state of Washington in November 1979. This prohibition has severely curtailed decontamination activities at the MOX fuel research facilities discussed above.

Future generations of TRU waste may arise from three basic sources: (1) recycle of spent uranium fuel, (2) decontamination of the existing small plutonium research and fuel fabrication facilities, and (3) burnup studies of irradiated LWR fuel. For a number of reasons which have been discussed in Appendix D of the draft EIS, NRC staff do not expect significant quantities of waste from commercial fuel recycle activities prior to the year 2000. The remainder of this discussion, therefore, addresses the latter two TRU waste sources.

Following the November 1979 prohibition of TRU disposal at the NECO-Richland disposal facility, estimates were made of the volumes of transuranic waste that would be generated from decontamination activities and burnup studies. (Ref. 12, 13). In these estimates, about 4960 m^3 of decontamination waste was projected to be generated over a three-year period, after which about 75 m^3 from burnup studies was projected annually. Since that time, DOE has accepted some of this waste for retrievable storage at DOE surface storage facilities. This includes waste contaminated with plutonium owned by DOE and which has been generated as a result of an ongoing contract with DOE. (Waste generated as a result of previous contracts with AEC, ERDA, or DOE has not been so accepted.) Thus, an updated estimate of the waste projections was required. This was accomplished by means of a survey of NRC licensees potentially generating TRU waste (Ref. 14). Based upon written responses to this survey (Refs. 15-22), previous projections (Ref. 12, 13) and other data (Ref. 23, 24), the projections used for the final EIS were made.

Waste volume projections for the F-PUDECON waste stream are summarized on Table C.44. Shown are the volumes projected to be generated to the year 2000 in each of the 4 regions considered in the EIS, the total volume projected to be generated in the country, and an "average" regional volume for purposes of generic analysis. The projections assume that at present, a negligible quanity of transuranic waste is shipped to disposal facilities. This waste is all less than 10 nCi/gm in TRU activity. However, following the promulgation of the Part 61 rule and assuming that disposal capacity is available, relatively large volumes of waste are shipped over a three-year time period. During this time period, decontamination of the MOX fuel research facilities is assumed to be

*The 10 nCi/gm limitation has been interpreted very strictly by the states. It has been interpreted to include, for example Pu-241 (a beta-emitter) and Cm-244 (a very short lived alpha emitter) in the 10 nCi/gm accounting.

Table C.44 Projected Regional Volumes to the Year 2000 of F-PUDECON Waste Stream

Year	Region 1	Region 2	(volumes in ft^3) Region 3	Region 4	Total	Reference
1983	8,400	24,600	4,300	16,500	53,800	13,450
1984	6,200	16,800	1,150	14,500	38,650	9,663
1985	6,200	16,800	1,150	14,500	38,650	9,663
1986	1,500	160	1,150	160	2,970	743
1987	1,530	163	1,173	163	3,030	758
1988	1,561	166	1,196	166	3,090	773
1989	1,591	170	1,220	170	3,150	788
1990	1,621	173	1,243	173	3,210	803
1991	1,652	176	1,266	176	3,270	818
1992	1,682	179	1,289	179	3,330	833
1993	1,712	183	1,313	183	3,390	848
1994	1,742	186	1,336	186	3,450	863
1995	1,773	189	1,359	189	3,510	878
1996	1,803	192	1,382	192	3,570	893
1997	1,833	196	1,406	196	3,630	908
1998	1,864	199	1,429	199	3,690	923
1999	1,894	202	1,452	202	3,750	938
2000	1,924	205	1,475	205	3,810	953
Total (ft^3)	46,482	60,939	26,290	48,239	181,950	45,488
Total (m^3)	1,316	1,726	745	1,366	5,153	1,288

completed. Also shipped during the first year are quantities of waste which have been accumulated and stored at the waste generator's site. Following this, waste volumes drop to very low levels and are principally due to assumed continued small scale burnup studies of occasional spent fuel rods. Projections of volumes beyond the next few years are somewhat specultive, and are conservatively assumed to increase in a linear manner proportional to the projected increase in LWR electric generating capacity assumed in the EIS to the year 2000. This is likely to be conservative since current indications are that the actual LWR electric generating capacity by the year 2000 will be less than that projected in the EIS.

The radiological, physical, and chemical characteristics of the waste so generated are expected to be quite varied. Waste generated from decontamination operations are expected to be a mixture of compressible and noncompressible material, including such material as paper, miscellaneous trash, glove boxes and concrete rubble. Such waste would be expected to contain at least some quantities of chelating and other decontamination chemicals. Waste from burnup studies would be expected to mainly consist of compressible trash, with smaller traces of oxide residues. The waste form and processing indices assumed for this stream are presented below for each of the 6 waste spectra:

Spec.	VRF	VIF	I4	I5	I6	I7	I8	I9	I10
1	1.0	1.0	2	2	1	1	0	1	0000
2	1.0	1.0	2	2	1	1	2	1	0410
3	1.0	1.0	2	2	1	1	2	1	0410
4	1.0	1.0	2	2	1	1	2	1	0410
5	1.0	1.0	2	2	1	1	2	1	0410
6	1.0	1.0	2	2	1	1	0	1	0000

As shown, no processing is projected for the waste other than emplacement of the waste into high integrity containers. This is mainly due to the heterogenity of the expected waste mixture. Much of the waste from the decontamination operations is not expected to be in a form readily amenable to volume reduction through such techniques as compaction or incineration. The overall volumes of waste that would be amenable to further volume reduction are expected to be quite small in comparison with other waste streams (e.g., P-COTRASH) investigated in this EIS.

Based upon information received in response to the survey of licensees, the activity in the F-PUDECON waste stream is projected in this EIS to be distributed into 3 groups: low, moderate and high. These three groups are listed below, assuming a waste density of 1 gm/cc.

Range	Volume percent in range	Average activity in range
0-10 nCi/cc	40	5 nCi/cc
10-100 nCi/cc	15	50 nCi/cc
100+ nCi/cc	45	500 nCi/cc

This distribution is believed to be conservative, as it is believed to somewhat exaggerate the percentage of the waste occurring in higher activity levels. In addition, the average activity in the waste in the 0 to 10 nCi/cc group is realistically probably much less than 5 nCi/cc. This distribution results in an average activity across the waste stream of 235 nCi/cm^3.

Since most of the waste in this waste stream will be generated from decontamination of MOX research facilities, the isotopic distribution within most of the waste is expected to be similar to that within the fabricated MOX fuel. Burnup studies would generate waste having the same basic plutonium isotopes as the MOX fuel, but in a somewhat different isotopic distribution. A very small volume of waste (about 6 m^3 per year) will be generated from manufacture of plutonium heat sources for use in batteries. This waste will be principally contaminated with Pu-238.

For use in the EIS, then the F-PUDECON waste stream is estimated to have an isotopic distribution similar to that in fuel for the Fast Flux Test Facility (FFTF). This distribution is as follows (Ref. 15):

Isotope	Weight percent
Pu-238	.05
Pu-239	86.8
Pu-240	11.35
Pu-241	1.2
Pu-242	0.3
Am-241	0.3
	100

This distribution was then converted to an equivalent activity per volume. Assuming an average waste density of 1 gm/cm^3, and normalizing to the average gross activity of 0.235 μCi/cm^3, one arrives at the following radionuclide distribution:

Isotope	Concentration (μCi/cm^3)
Pu-238	1.355E-3
Pu-239/40	1.280E-2
Pu-241	2.188 E-1
Pu-242	1.893E-6
Am-241	1.559E-3
	2.345E-1

Wastes From Spent Light Water Reactor Fuel Storage.

Section 6.4 of Appendix D of the draft EIS discussed wastes which could possibly result from construction and use of an independent facility for storage of light water reactor fuel. As discussed in the draft EIS, wastes generated at an independent spent fuel storage facility would primarily arise from treatment of storage basin water, receiving and unloading spent fuel, and maintenance of plant ventilation systems. These wastes would include spent resins, filter sludges and miscellaneous trash, and would be similar in composition to wastes produced from light water reactor operations.

At this time, NRC has not received any application for construction of an independent spent fuel storage facility. The timing for future construction of a storage facility (and associated waste volume generation) is difficult to determine. The Department of Energy (DOE), however, has developed an estimate of the annual volumes and radionuclide concentrations of wastes that could be generated from operation of a large (3000 MTHM) independent spent fuel storage installation, assuming that one is constructed (Ref. 25). These volumes and radionuclide concentrations are listed in Table C.45, and are based upon an operating mode (conservative for purposes of waste generation) in which one-sixth of the storage capacity is replaced each year. In the table, all volumes and concentrations are shown as generated--i.e., trash streams are shown prior to compaction, resins are shown in a dewatered form, and concentrated liquids are shown prior to solidification. As shown, the total volume of waste from a large independent spent fuel storage facility is comparable to the annual generation rate of a single 1000 MW(e) light water reactor. Table C.45 serves to expand the information previously given in Table D.33 of the draft EIS.

Comparison of the radionuclide concentrations in Table C.45 with the radionuclide limits established in the final Part 61 regulation indicates that about 96% of the waste would be classified as Class A while only 4% would be classified as Class B. Class A waste includes combustible trash, ventilation filters, noncombustible trash, and failed equipment. Class B waste includes bead resins, filter precoat sludge, sulfate concentrate, and miscellaneous solution concentrates. This is only an estimate since the activity in the waste streams generated by an actual facility would actually be expected to exhibit a distribution. For example, some fraction of the volume of the filter precoat sludge, sulfate concentrate, and miscellaneous solution concentrate waste strams would probably be classed as Class C waste. No waste, however, is at this time projected to be determined to be unacceptable for near-surface disposal.

Wastes From Recycle of Uranium Fuel.

One potential source of additional wastes could result from recycle of uranium fuel. (Currently, spent uranium fuel removed from nuclear power reactors is stored.) Such wastes could result from reprocessing the spent fuel to recover residual plutonium and uranium and converting the recovered plutonium into an oxide powder. Recovered plutonium oxide could then be mixed with fresh uranium and fabricated into mixed oxide fuel rods for aggregation into fuel assemblies and reuse in nuclear power plants. For a variety of reasons, NRC staff believe that it is unlikely that significant volumes of waste from commercial recycle of uranium will be generated over the next 20 years. It may be of interest,

Table C.45 Estimated Annual Waste Volumes and Radionuclide Concentrations Generated from Assumed Operation of a 3,000 MTHM Spent Fuel Storage Facility

Waste Category	Volume (m^3)	Gross concentration (Ci/m^3)*	Concentration of some individual nuclides (Ci/m^3) Fe-55	Co-60	Sr-90	Cs-137
Compactible and Combustible Wastes:						
• Combustible trash	630	5.9E-2	1.7E-3	1.2E-3	1.8E-4	1.1E-2
• Ventilation filters	23	2.3E-2	6.6E-4	4.8E-4	7.0E-5	4.2E-3
Liquids and Other Wet Wastes						
• Bead resins	2	8.0E+0	2.1E-1	1.5E-1	2.2E-2	1.3E+0
• Filter precoat sludge	8	2.0E+2	6.0E+0	4.4E+0	6.4E-1	3.8E+1
• Sulfate concentrate	7	2.3E+2	6.5E+0	4.8E+0	7.0E-1	4.1E+1
• Miscellaneous solution concentrates	10	2.1E+2	6.3E+0	4.6E+0	6.7E-1	4.0E+1
Noncombustible Material:						
• Noncombustible trash	51	6.2E-2	1.8E-3	1.3E-3	1.9E-4	1.1E-2
• Failed equipment	19	2.2E-3	6.3E-5	2.7E-5	6.8E-6	4.0E-4
Total Volume	750					

*Includes a number of other, mostly short lived, isotopes.

however, to obtain a rough comparison of radionuclide concentrations in potential waste streams with the limits for near-surface disposal developed as part of the Part 61 rulemaking action.

DOE has prepared an estimate of the volumes and contained radionuclide concentrations in waste streams that could be generated from recycle of uranium fuel. Wastes from reprocessing activities are assumed to be generated by a 2000 MTHM/yr plant in which input fuel is assumed to be aged 1.5 years out of reactor. (Note: 2,000 MTHM/yr means a processing capability of 2,000 metric tons of heavy metal (uranium and plutonium) per year.) Wastes from mixed oxide (MOX) fuel fabrication are assumed to be generated by a 400 MTHM/yr plant for which there is assumed to be a one year decay between plutonium recovery at the reprocessing plant and fabrication of MOX fuel. Both plants are of fairly large capacity and are based upon currently available technology. (Ref. 25)

Table C.46 lists annual volumes and associated radionuclide concentrations of 30 waste streams estimated to be generated by the reference 2000 MTHM/yr reprocessing plant. All wastes are shown as generated prior to further processing. Such processing could take the form of incineration or compaction of compressible trash and solidification of liquids. Such processing operations could produce further (relatively smaller) volumes of secondary wastes.

Table C.47 lists annual volumes and associated radionuclide concentrations of six waste streams estimated to be generated by the reference 400 MTHM/yr fuel fabrication facility. Again, all wastes are shown prior to further processing.

Estimated waste concentrations obtained from Tables C.46 and C.47 may be compared against the waste classification limits in the final Part 61 regulation. Based upon this rough comparison, only about 17% (1400 m^3) of the waste generated by the 2000 MTHM/yr reprocessing plant would be classed as being unacceptable for near-surface disposal. This is assuming a limit of 100 nCi/gm for near-surface disposal of alpha-emitting transuranic nuclides (except for Cm-242). Corresponding amounts of other waste classes include Class A: 59% (5030 m^3), Class B: 9% (804 m^3), and Class C: 15% (1200 m^3). If the near-surface disposal limit were 10 nCi/gm for alpha-emitting transuranic radionuclides, however, an additional 1200 m^3 would be classed as unacceptable. The amount determined to be unacceptable would be 31% of the waste volume (2600 m^3). The Class A and B waste volumes would remain the same but the Class C waste volume would be reduced to 44 m^3. All of the waste generated by the 400 MTHM/yr MOX fuel fabrication facility would be classed as being unacceptable for near-surface disposal, whether the transuranic limit is 10 nCi/gm or 100 nCi/gm.

5. MODIFICATIONS TO THE IMPACT ANALYSES METHODOLOGY

This section summarizes the changes to the environmental impact analyses methodology that have been made for the final EIS. In the draft EIS, the impact analysis methodology was presented in Appendix G. The changes discussed mainly involve additions (rather than alterations) to the information contained in Appendix G and in reference 26. Items discussed herein include:

- o revised methodology to consider waste classification impacts;
- o revised treatment of decay chains;
- o addition of a methodology to consider impacts of potential trench overflow and operation of a leachate evaporator;
- o revised pathway dose conversion factors;
- o revised methodology to consider potential operational accidents;
- o additional insights into impacts of disposal of carbon-14 and iodine-129.

Table C.46 Waste Streams From Reference 2000 MTHM/yr Fuel Reprocessing Plant (Ci/m^3)

Isotope	Fuel assy hardware	Fuel residue (hulls)	Main plant ILLW (TRU)	Main Plant silica gel (TRU)	Storage basin bead resins (Non-TRU)	Storage basin filter precoat sludge (Non-TRU)	Storage basin sulfate concentrate (Non-TRU)	Storage basin misc. solns. (Non-TRU)
H-3		2.4E+2	3.8E+0					
C-14	8.9E-1	2.3E-1	5.1E-5					
Fe-55	7.1E+4	3.4E+2			3.5E-1	9.9E+0	1.4E+1	9.2E+0
Co-60	7.1E+4	3.8E+2			2.2E-1	6.2E+0	8.7E+0	5.8E+0
Ni-59	5.4E+1	1.1E-1						
Ni-63	7.4E+3	1.5E+1						
Sr-90	1.8E-2	1.2E+2	5.6E+0		2.8E-2	7.9E-1	1.1E+0	7.4E-1
Nb-94	1.8E-3							
Tc-99	1.3E-1	2.4E-2	1.3E-4					
I-129			9.6E-4					
Cs-135		5.8E-4	2.8E-5					
Cs-137		1.8E+2	8.5E+0		1.7E+0	4.7E+1	6.6E+1	4.4E+1
U-234		6.4E-4	3.1E-3					
U-235		3.0E-5	1.5E-4					
U-236		4.9E-4	2.4E-3					
U-238		6.0E-4	2.9E-3					
Np-237		7.5E-4	3.6E-5					
Pu-236		6.0E-4	2.9E-3	6.4E-6				
Pu-238		1.0E+1	5.1E+1	1.1E-1				
Pu-239		6.8E-1	3.3E+0	7.2E-3				
Pu-240		1.4E+0	6.6E+0	1.5E-2				
Pu-241		3.4E+2	1.6E+3	3.6E+0				
Pu-242		7.3E-3	3.6E-2	7.8E-5				
Am-241		1.3E+0	6.5E-2					
Am-243		8.8E-2	4.5E-3					
Cm-242		1.9E+1	9.0E-1					
Cm-243		1.8E-2	8.8E-4					
Cm-244		1.4E+1	6.6E-1					
Vol (m^3/yr)	112	532	220	10	4	14	10	20
Vol (m^3/MTHM)	056	.266	.11	5E-3	2E-3	7E-3	5E-3	1E-2

U + Pu Recycle Fuel aged 1.5 yrs

Table C.46 (Continued)

Concentration (Ci/m³)

Isotope	UF_6 plant fluorinator bed residues (TRU)	UF_6 plant fluorinator fines (TRU)	UF_6 plant K_2UO_4 mud	UF_6 plant waste dryer discharge (NR)*	Storage basin combus-tible trash (Non-TRU)	Main plant combus-tible trash (TRU)	PuO_2 con-version combus-tible trash (TRU)	UF_6 plant combus-tible trash (Non-TRU)
H-3								
C-14						1.4E-6		
Fe-55					2.7E-3			
Co-60					1.7E-3			
Ni-59								
Ni-63								
Sr-90					2.2E-4	1.5E-1		
Nb-94								
Tc-99						3.3E-5		
I-129								
Cs-135						7.8E-7		
Cs-137					1.3E-2	2.3E-1		
U-234	5.1E-4	1.7E-2	6.3E-3			8.5E-7		3.4E-3
U-235	2.4E-5	8.0E-4	3.0E-4			4.0E-8		1.6E-4
U-236	3.9E-4	1.3E-2	4.8E-3			6.5E-7		2.6E-3
U-238	4.8E-4	1.6E-2	5.9E-3			8.0E-7		3.2E-3
Np-237						1.0E-6		
Pu-236	1.6E-5	1.1E-5				8.0E-7	5.5E-3	
Pu-238	2.8E-1	1.8E-1				1.4E-2	9.2E+1	
Pu-239	1.8E-2	1.2E-2				9.0E-4	6.0E+0	
Pu-240	3.7E-2	2.5E-2				1.8E-3	1.2E+1	
Pu-241	9.0E+0	6.0E+0				4.5E-1	2.8E+3	
Pu-242	2.0E-4	1.3E-4				9.8E-6	6.5E-2	
Am-241						1.8E-3		
Am-243						1.2E-4		
Cm-242						2.5E-2		
Cm-243						2.4E-5		
Cm-244						1.8E-2		
Vol (m³/yr)	8	60	140	1000	1200	800	60	100
Vol (m³/MTHM)	4E-3	3E-2	7E-2	5E-1	0.6	0.4	3E-2	5E-2

*Expected to contain insignificant quantities of radioactive isotopes.

Table C.46 (Continued)

Concentration (Ci/m^3)

Isotope	Storage basin ventilation filters (Non-TRU)	Main plant ventilation filters (TRU)	UF_6 plant ventilation filters (Non-TRU)	PuO_2 conversion ventilation filters (TRU)	IX bead resins (TRU)	Degraded extractant (TRU)	Main plant combustible trash (TRU)	Main plant noncombustible trash
H-3								
C-14		4.0E-5			1.1E-5	7.0E-9	4.7E-10	1.4E-6
Fe-55	1.6E-1							
Co-60	1.0E-1							
Ni-59								
Ni-63								
Sr-90	1.3E-2	4.4E+0			1.2E+0	7.6E-4	5.1E-5	1.5E-1
Nb-94								
Tc-99		9.3E-4			2.6E-4	1.6E-7	1.1E-8	3.3E-5
I-129					1.4E-2	4.4E-4	0	0
Cs-135		2.2E-5			6.2E-6	3.9E-9	2.6E-10	7.8E-7
Cs-137	7.7E-1	6.6E+0			1.9E+0	1.2E-3	7.8E-5	2.3E-1
U-234		2.4E-5	6.8E-4		6.8E-4	4.3E-5	2.8E-10	8.5E-7
U-235		1.1E-6	3.2E-5		3.2E-5	2.0E-6	1.3E-11	4.0E-8
U-236		1.9E-5	5.2E-4		5.2E-4	3.3E-5	2.2E-10	6.5E-7
U-238		2.3E-5	6.4E-4		6.4E-4	4.0E-5	2.7E-10	8.0E-7
Np-237		2.9E-5			8.0E-6	5.0E-5	3.3E-10	1.0E-6
Pu-236		2.3E-5		3.3E-2	6.4E-4	4.0E-3	2.7E-10	8.0E-7
Pu-238		3.9E-1		5.5E+2	1.1E+1	6.9E+1	4.6E-6	1.4E-2
Pu-239		2.6E-2		3.6E+1	7.2E-1	4.5E+0	3.0E-7	9.0E-4
Pu-240		5.2E-2		7.3E+1	1.5E+0	9.1E+0	6.1E-7	1.8E-3
Pu-241		1.3E+1		1.7E+4	3.6E+2	2.3E+3	1.5E-4	4.5E-1
Pu-242		2.8E-4		3.9E-1	7.8E-3	4.9E-2	3.3E-9	9.8E-6
Am-241		5.1E-2			1.4E-2	8.9E-2	5.9E-7	1.8E-4
Am-243		3.4E-3			9.4E-4	5.9E-3	3.9E-8	1.2E-4
Cm-242		7.1E-1			2.0E-1	1.2E+0	8.3E-6	2.5E-2
Cm-243		6.9E-4			1.9E-4	1.2E-3	8.1E-9	2.4E-5
Cm-244		5.1E-1			1.4E-1	9.0E-1	6.0E-6	1.8E-2
Vol (m^3/yr)	20	2.80	10	40	10	16	2400	800
Vol (m^3/MTHM)	1E-2	1.4E-1	5E-3	2E-2	5E-3	8E-3	1.2	4E-1

Table C.46 (Continued)

Concentration (Ci/m³)

Istope	UF_6 plant noncombustible trash	PuO_6 conversion noncombustible trash	Main plant failed equipment	UF_6 plant failed equipment	PuO_2 conversion failed equipment	Storage basin noncombustible trash	Storage basin failed equipment
H-3							
C-14			2.8E-6				
Fe-55						2.8E-3	1.8E-4
Co-60						1.7E-3	1.2E-4
Ni-59							
Ni-63							
Sr-90			3.1E-1			2.2E-4	1.5E-5
Nb-94							
Tc-99			6.5E-5				
I-129							
Cs-135			1.6E-6				
Cs-137			4.7E-1			1.3E-2	8.8E-4
U-234	3.4E-3		1.7E-6	3.4E-4			
U-235	1.6E-4		8.0E-8	1.6E-5			
U-236	2.6E-3		1.3E-6	2.6E-4			
U-238	3.2E-3		1.6E-6	3.2E-4			
Np-237			2.0E-6				
Pu-236		5.5E-3	1.6E-6		1.7E-3		
Pu-238		9.2E+1	2.8E-2		2.8E+1		
Pu-239		6.0E+0	1.8E-3		1.8E+0		
Pu-240		1.2E+1	3.6E-3		3.7E+0		
Pu-241		2.8E+3	9.0E-1		8.5E+2		
Pu-242		6.5E-2	2.0E-5		2.0E-2		
Am-241			3.6E-3				
Am-243			2.4E-4				
Cm-242			5.0E-2				
Cm-243			4.9E-5				
Cm-244			3.6E-2				
Vol (m^3/yr)	20	12	400	20	40	100	20
Vol (m^3/MTHM)	1E-2	6E-3	0.2	1E-2	2E-2	5E-2	1E-2

Table C.47 Waste Streams from Reference 400 MTHM MOX Fuel Fabrication Plant

(1 year decay from reprocessing plant assumed, corresponding to DOE's reference plant)

Concentration (Ci/m^3)	HEPA filters	Combustible trash	Process solutions	Scrap recovery solutions	Non-combustible trash	Failed equipment
U-234	2.7E-3	2.3E-4	2.0E-4	1.1E-4	2.0E-4	2.0E-5
U-235	1.1E-4	9.0E-6	7.5E-6	4.3E-6	7.5E-6	7.5E-7
U-236	5.3E-7	4.5E-8	3.8E-8	2.1E-8	3.8E-8	3.8E-9
U-237	1.1E-1	9.0E-3	7.5E-3	4.3E-3	7.5E-3	7.5E-4
U-238	2.2E-3	1.9E-4	1.6E-4	9.1E-5	1.6E-4	1.6E-5
Np-237	1.1E-6	9.6E-8	8.0E-8	4.6E-8	8.0E-8	8.0E-9
Pu-236	6.3E-3	5.4E-4	4.5E-4	2.6E-4	4.5E-4	4.5E-5
Pu-238	1.3E+2	1.1E+1	9.5E+0	5.4E+0	9.5E+0	9.5E-1
Pu-239	9.1E+0	7.8E-1	6.5E-1	3.7E-1	6.5E-1	6.5E-2
Pu-240	1.8E+1	1.6E+0	1.3E+0	7.4E-1	1.3E+0	1.3E-1
Pu-241	4.1E+3	3.5E+2	2.9E+2	1.7E+2	2.9E+2	2.9E+1
Pu-242	9.8E-2	8.4E-3	7.0E-3	4.0E-3	7.0E-3	7.0E-4
Am-241	6.7E+0	5.8E-1	4.8E-1	5.5E+1	4.8E-1	4.8E-2
Vol (Total in m^3)	40	200	8	140	80	80
Vol (m^3/MTHM)	0.1	0.5	.02	0.35	0.2	0.2

5.1 Revised Methodology to Consider Waste Classification Impacts

During the preparation of the draft EIS, several computer programs were written to calculate impact measures associated with the management of low-level radioactive waste. These computer codes are discussed in Appendix H of the draft EIS and include the codes OPTIONS, GRWATER, INTRUDE, INVERSI, and INVERSW. Three phases of waste management which may result in impacts were considered: waste processing, waste transportation, and waste disposal. The impact measures were calculated utilizing: (1) information on waste characteristics, (2) alternative waste processing and packaging technologies, (3) data and assumptions on alternative disposal technologies and disposal facility site environments, (4) the impact calculational methodologies presented in Reference 26.

For the draft EIS, a waste classification procedure was adopted in the OPTIONS and GRWATER codes in which the characteristics of individual waste streams are fixed (through a choice of a waste spectrum), the intruder impacts of each of the waste streams are calculated and compared to a set of numerical dose limitation criteria (e.g., 500 mrem/year whole body), and then the waste streams are classified. Following this, impact measures such as costs, volume-averaged intruder impacts, and groundwater impacts are determined. The waste classification requirements in the Part 61 rule, however, are presented not in terms of dose limitation criteria, but in terms of radionuclide concentration limits for various waste classes. Depending upon the concentrations of the radionuclides within a particular waste stream, a waste generator may be required to process the waste into a stable form, dispose of it in a stabilized manner at the disposal facility, and possibly stabilize it and dispose of it using an intruder barrier. The waste may even be considered not generally acceptable for near-surface disposal.

A revised waste classification test procedure was therefore developed for the final EIS and incorporated into the OPTIONS and GRWATER computer codes. These modified computer codes have been titled the OPTIONR and GRWATRR codes, respectively.

A flow diagram of the revised waste classification test procedure is provided as Figure C.1. Briefly, the revised waste classification test procedure for a given waste stream operates as follows. First, a waste spectrum is chosen which establishes particular characteristics (particularly radionuclide concentrations and whether the waste stream is in a stable form) for the stream. The radionuclide concentrations are then compared against a set of limiting concentrations for Class A waste disposal. If the waste stream concentrations are less than the limiting Class A concentrations, then a determination is made whether the waste stream (which has been determined to be Class A waste) is stable or unstable. If unstable, it is disposed of in a Class A (unstable) disposal unit. If stable, it is disposed of in a disposal unit along with stable Class B and C wastes. (This is a desirable practice since it increases overall site stability, helps to further reduce potential groundwater migration, and also reduces potential personnel exposures at a disposal facility.)

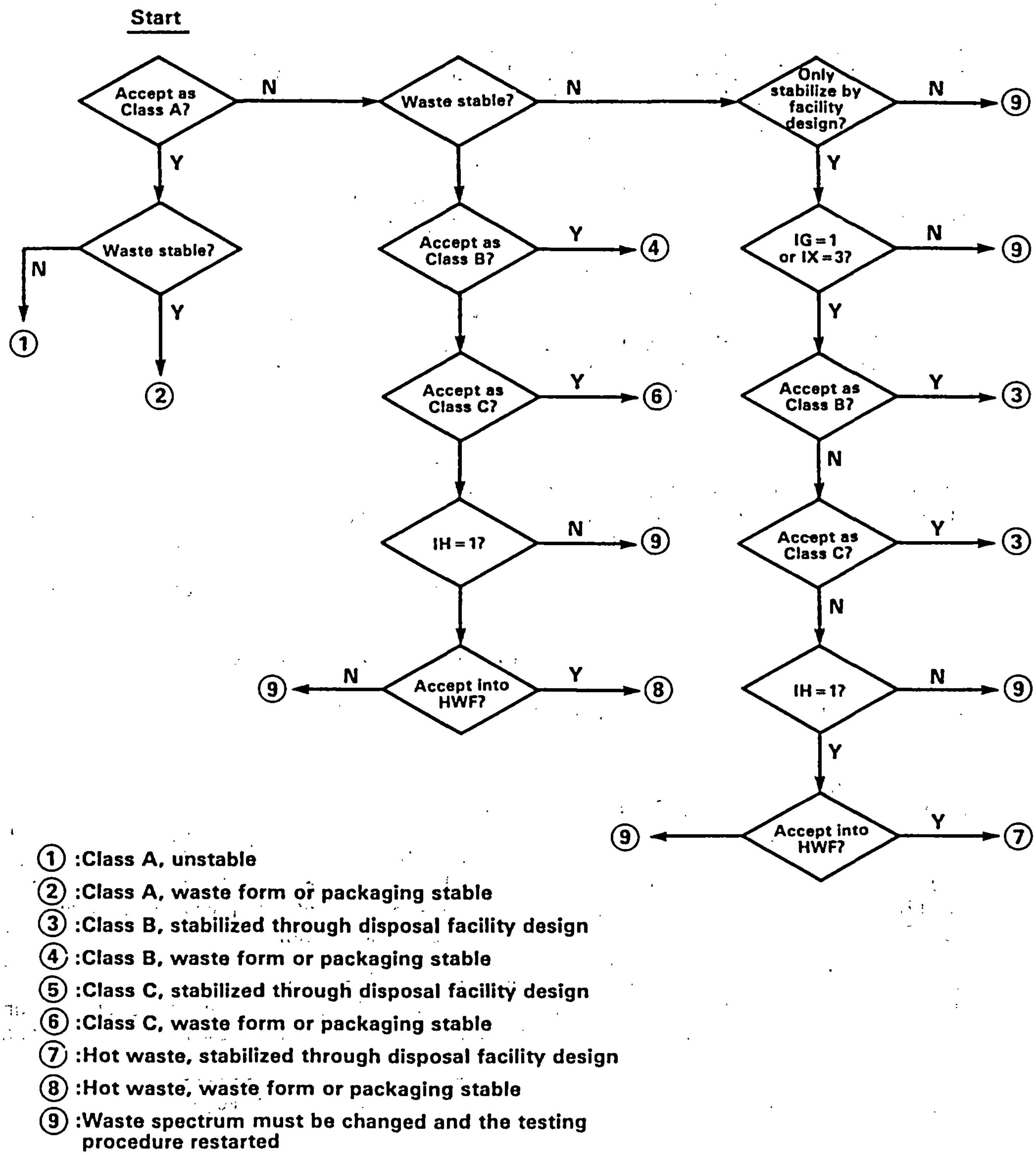


Figure C.1 Revised Waste Classification Test Procedure

If the radionuclide concentrations in the waste stream exceed the limiting Class A waste concentrations, then the waste stream must be stabilized and tested to determine if it meets limiting concentrations for Class B and C wastes. Such waste stabilization may be accomplished for a given waste stream by either specifying a particular improvement in waste form and packaging or by a particular disposal facility design. The test procedure compares the waste radionuclide concentrations against the Class B and C limits using a number of possible stable waste forms and packages or facility designs which achieve stabilization. If there are no such waste forms or packaging techniques which can achieve a stable waste having radionuclide concentrations less than the Class C values, then (with the exception discussed below) the waste stream is considered not acceptable for near-surface disposal.

It may be noted that if the waste stream exceeds the Class C waste limits, then the testing procedure includes the provisions for optional disposal by a disposal method giving greater confinement than near-surface disposal. In the draft EIS and data base, this has been generically referred to as a "hot waste facility." To date, no disposal criteria have been developed by NRC for disposal by such improved methods over near-surface disposal. However, inclusion of this option in the codes at this time will help to develop such future criteria as is necessary in a rapid manner.

As an option, an alternative procedure is also included for determining limiting concentrations for Class A (and other) waste. This alternative is included to provide an assessment of the impacts of existing license conditions at LLW disposal facilities. In this alternative, the normal sum-of-the-fractions rule is not applied. Rather, a limit of 1 μci/cm^3 of nontransuranic isotopes having half-lives greater than 5 years is applied to light water reactor process waste streams (filter sludges, ion exchange resins, solidified concentrated liquids and cartridge filters) as well as waste from isotope production facilities. For such waste streams, if the concentration of any nontransuranic isotope having a half-life greater than 5 years exceeds 1 μCi/cm^3, then the waste stream is not acceptable as Class A waste and must be stabilized prior to disposal. For all other waste streams, no Class A concentration limits are imposed.

Under this alternative, classification of transuranic radionuclides is also modified to conform with existing license conditions. Current license conditions impose a 10 nCi/gm limit on transuranic waste disposal. These license conditions generally allow disposal of transuranics up to the 10 nCi/gm limit as long as the transuranics are homogeneously distributed through the waste. Surface contaminated materials are often prohibited. Occasionally, homogeneously contaminated waste streams such as ion exchange resins are found to exceed the 10 nCi/gm limit, almost always due to short-lived alpha emitters such as Cm-242 (163-day half-life) or to Pu-241, which is a beta-emitter having a 13.2-year half-life. In such cases, waste generators will either dilute such waste with lower activity waste (still retaining a homogeneous mixture) or allow the short-lived radionuclides to decay prior to shipment.

Not to account for the above practices would incorrectly skew the results of the cost-benefit analysis in favor of the final Part 61 requirements. To provide a more accurate analysis under this alternative classification scheme, therefore, the Pu-241 concentrations within LWR process waste streams and isotope production waste are decayed to their alpha-emitting equivalents. No such decay

is performed for trash or other waste streams which may be composed of surface-contaminated materials.

The operational mechanics of the waste classification test procedure involves a number of additional concepts. These are discussed in Section 2 of Appendix D of this final EIS.

5.2 Treatment of Decay Chains

The existing impact analysis methodology calculates radiological impacts to a potential inadvertent intruder as a function of time. Offsite impacts from such intrusion as well as hypothetical impacts from erosion are also calculated. For the final EIS, this impact analysis methodology has been revised to include an improved method of determining radiological impacts associated with certain heavy metal radioisotopes having daughters which are also radioactive.

Basically, the methodology for determining radiological impacts starts by considering, for a given isotope, the concentration of that nuclide in waste. This concentration is multiplied by factors that correspond to radioactive decay and to the transfer of the nuclide through the environment to a biota access location. Given a unit concentration of the nuclide at a biota access location, resulting dose equivalents are determined using "pathway dose conversion factors" (PDCFs). For radioisotopes belonging to decay chains, the revised methodology determines for a given decay time the fractional amounts of respective daughter radionuclides which would be ingrown during the decay time period. These fractions are then multiplied by the respective pathway dose conversion factors for the daughter nuclides, the products summed, and the total added to the pathway dose conversion factor for the parent nuclide. This calculational technique is identical to that used to calculate ingrowth of daughters of the nuclide Rn-222 in the NRC uranium tailings impact code MILDOS (Ref. 27). That is, for nuclides that do <u>not</u> belong to heavy metal decay chains, an entity $f_o \times PDCF$ is used in the calculations. For nuclides which <u>do</u> belong to decay chains, this entity is replaced by the following:

$$f_o \times PDCF_p + (f_{d1} \times PDCF_{d1}) + (f_{d2} \times PDCR_{d2}) + (f_{d3} \times PDCF_{d3}) + \ldots, \text{ where}$$

$f_o = \exp(-\lambda_p T)$

λ_p = decay constant of parent

T = decay time period

$PDCF_p$ = PDCF of parent

f_d = fractional quantity of a given daughter generated from a unit quantity of the parent at a given time

$PDCF_d$ = PDCF for a given daughter.

This additional treatment of decay daughters is discussed in somewhat more detail in Section 3, Appendix D, of this final EIS.

5.3 Radiological Impacts from Trench Overflow and Leachate Evaporation

As part of the work performed in the draft EIS, scenarios were considered in which a disposal facility experiences severe water accumulation problems within disposal trenches. Such water accumulation, it is recognized, could fill upon some of the trenches and overflow, resulting in environmental releases and potential public impacts. It was recognized in the draft EIS that environmental impacts from such overland flow would not be likely to continue for a great time period, if at all. Rather, the principal impacts would most probably result from treatment of leachate pumped from inundated trenches--for example, from leachage evaporation. The long-term economic impacts to the disposal site owner that would result from such leachate treatment activities were emphasized.

Commenters on the draft EIS, however, have suggested that it would be useful to calculate the potential environmental impacts that could result from trench overflow or leachate treatment activities. A calculational procedure has been, therefore, added to the impact analysis methodology to provide an order of magnitude estimate of such impacts.

In this final EIS, impacts from overflow are calculated assuming that each year, a certain activity is released from the disposal trenches and flows into a nearby stream, where contaminated stream water is consumed by an individual. Thus, exposures due to overland flow are calculated as exposures to an individual (in millirem/yr). In addition, the subroutine calculates exposures to the surrounding population (in man-millirem/yr) that could result from pumping leachate from the inundated trenches and processing the leachate through an evaporator. In both cases, one must start with determining the activity released. This is approximated using a method similar to the one described in Appendix G of the draft EIS for calculating a source term for groundwater migration. That is, the total activity released (A_{ij}) is given by:

$$A_{ij} = \sum_{i=i}^{NSTR} \sum_{j=1}^{NNUC} C_{ij} \times f_i \times V_l \times f_c(i,j) \text{ where}$$

NSTR = number of waste streams considered

NNUC = number of radioisotopes considered

C_{ij} = concentration (Ci/m³) of jth radionuclide in ith waste stream

f_i = fraction of waste volume in ith waste stream

V_l = Volume (m³) of leachate annually released or processed

f_c = $M_o \times t_c \times \text{MULT}(I6,I7,IS) \times 10^{(1-I9)}$

M_o = leach fraction of jth radionuclide

t_c = fraction of year that leachate is in contact with the waste, assumed to be equal to 1

MULT (I6,I7,IS) = a multiplier which accounts for reduced leaching of some waste streams due to specific waste stream properties (See Section 3.2.4 of Appendix G of the draft EIS)

$10^{(1-I9)}$ = a correction factor for radioisotopes contained in activated metals.

For overland flow to a stream, the calculated released activity is divided by the flow rate of the stream (4,500,000 m^3/yr for the reference disposal facility), and multiplied by PDCF-7 (see Appendix G of the draft EIS) to obtain a total individual dose in millirem/yr. For airborne impacts to a population, the calculated activity is multiplied by the assumed individual isotope release fractions for the evaporator. These are:

Radionuclide	Release Fractions
H-3	0.90
C-14	0.25
Tc-99	0.001
I-129	0.001
All Others	2.5E-6

This activity released from the evaporator is then multiplied by a factor corresponding to atmospheric dispersion (see section 3.6 of Appendix G of the draft EIS) and finally by PDCF-8 to obtain a population dose in man-millirem/yr.

In the above calculations, the activity released is assumed to be proportional to the volume (V_1) of leachate annually released overland or processed. In this EIS, V_1 is waste volume prorated from a base of one million gallons of leachate, which is the approximate volume of leachate and other contaminated liquids annually processed at the Maxey Flats disposal facility, and from one million m^3 of waste disposed. One million gallons is also the annual volume of leachate assumed for the high cost institutional care scenario (i.e., ICL=13 or 23) discussed in Appendix Q of the draft EIS. In the methodology, V_1 is assumed to be greater than zero only for the condition of a high level of institutional control, and only for very impermeable site soil conditions. For such conditions and if there is no segregation of stable and unstable waste, then V_1 is equal to one gallon per m^3 of waste multiplied by the total volume of waste (in m^3) delivered to the disposal facility. In addition, the leachate is assumed to contact both the stable and unstable waste streams. If there is segregation of stable and unstable waste, then V_1 is taken to be one gallon per m^3 of waste multiplied by the unstable waste volume. In this case, the leachate only contacts the unstable waste streams.

Besides the radiological impact measures, three additional impact measures associated with evaporator operations are calculated. These include annual occupational exposures (in whole body man-rem), evaporator operation costs,

and gallons of propane. These impact measures were determined based upon experience at the Maxey Flats disposal facility (Ref. 28).

5.4 Revised Pathway Dose Conversion Factors

As discussed in the draft EIS, eight sets of pathway dose conversion factors (PDCF) are used to determine potential radiological dose equivalents based upon a unit concentration of a radionuclide at a biota access location. That is, assuming that there exists a unit concentration of a radionuclide at a biota access location (e.g., 1 Ci/m^3 in water obtained from a well), there may be a number of pathways by which exposures to an individual could occur. These could include direct consumption of the water or consumption of food which has been irrigated by the contaminated well water. Airborne resuspension of the contaminated irrigated soil is another potential pathway. PDCFs are used to reduce to a single set of numbers all of the potential pathways from a biota access location and the transfer of radionuclides through these pathways. This is preferable to repetatively calculating all of the pathways and transfer mechanisms through each stage of the impact analysis methodology.

The eight basic groups of uptake pathways leading to human exposures, and the PDCFs corresponding to these pathways, are as follows:

- PDCF-1 : Accident
- PDCF-2 : Intruder-construction-air
- PDCF-3 : Intruder-agriculture-air
- PDCF-4 : Food
- PDCF-5 : Direct Gamma
- PDCF-6 : Well Water
- PDCF-7 : Open Water
- PDCF-8 : Atmospheric Transport

These groups of uptake pathways and the associated PDCFs are illustrated in Figure C.2.

The PDCFs are calculated using the computer code DOSE (Ref. 26). For the draft EIS, PDCFs were calculated for 7 body organs and 23 radionuclides. For the final EIS, PDCFs for an additional 13 radionuclides were determined. All such nuclides are members of heavy metal decay chains as discussed in Section 5.2.

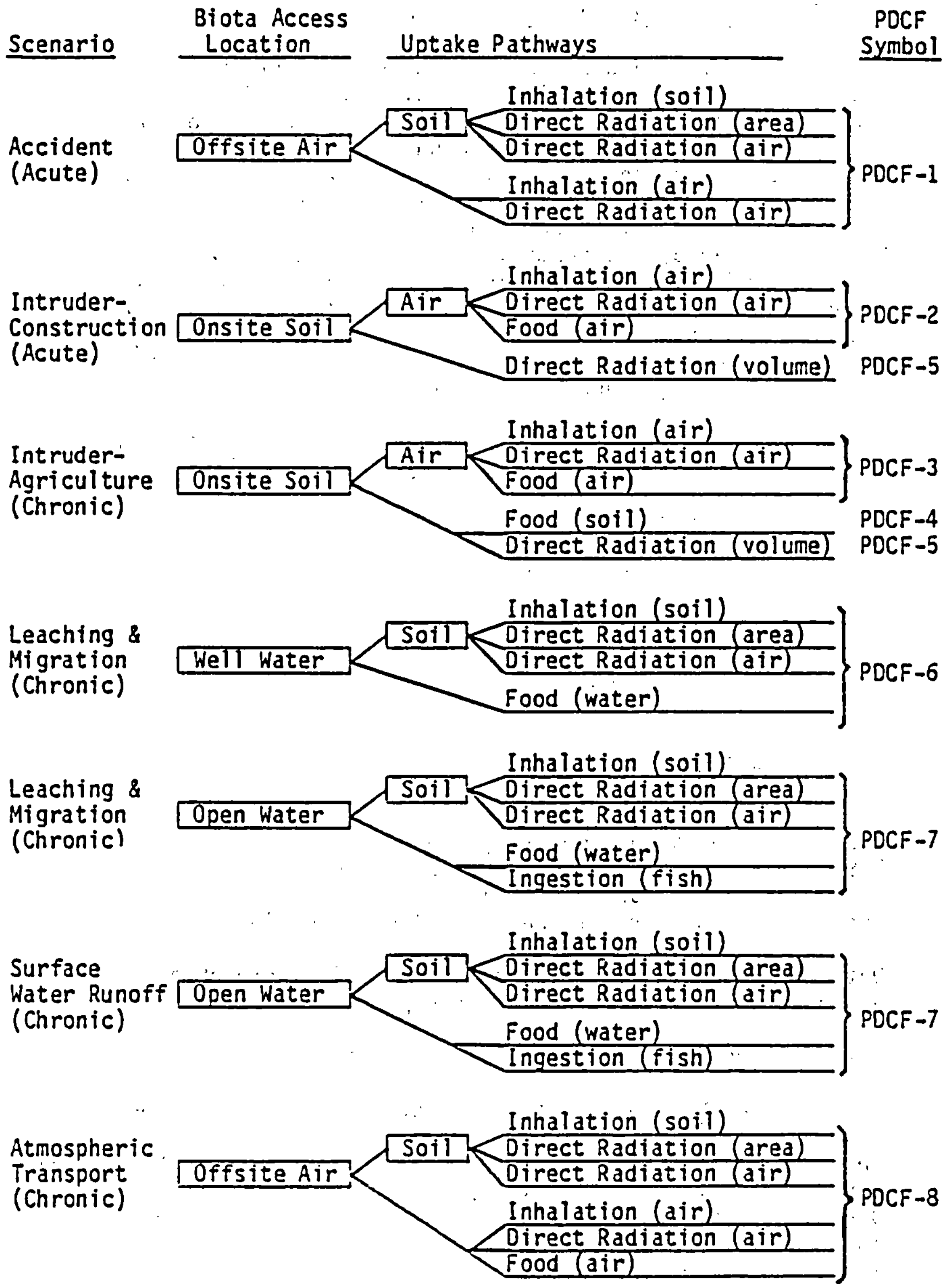
Data for determination of the updated PDCFs were obtained using the same sources as those listed as references in Appendix B of reference 26.

The PDCFs used in the final EIS are summarized in Tables C.48 through C.55.

5.5 Revised Methodology to Consider Potential Operational Accidents

The Part 61 rulemaking action has emphasized generic requirements which would involve reduction of long-term radiological exposures and costs to a site owner. Operational safety is already addressed in the Commission's regulations in 10 CFR Part 20 and relatively few additional requirements aimed at genericly improving operational safety have been implemented. Once sound health physics practices are established at a disposal facility, some flexibility in practices must be maintained so that operational safety may be continuously improved over the operation of the site. In addition, operational impacts are relatively short lived.

Figure C.2 Details of Uptake Pathways



Operational safety was not ignored in the draft EIS, however, and an analysis was performed to determine the effect on operational safety of requirements intended to reduce long-term costs and radiological impacts. In general, it was determined that requirements intended to reduce long-term costs and radiological impacts also tended to improve operational safety.

In the draft EIS, a scenario was considered in which a waste container is assumed to be dropped from a significant height so that the waste container breaks open. A portion of the radioactive contents of the waste package is assumed to be released into the air where it is transported offsite, leading to subsequent potential human exposure. The fraction released was assumed to be given by the following:

$$f_r \times 10^{(1-I9)} \times 10^{(1-I6)}$$

This was meant to reflect the fact that the fraction released would be greatly reduced for improved waste forms. The factor f_r was taken to be equal to .1%, which is a worst case condition. This factor of .1% was obtained from experimental data involving release of powdered PuO_2 under transportation accident conditions.

It was determined that the above relationship did not adequately reflect the variation in waste forms. For the final EIS, the above relationship was replaced by the relationship f_r x Mult. As before, f_r is taken to be equal to 0.1%. Depending upon the waste form, Mult is taken to be the following:

Mult	Waste form
1	dewatered sludge and other misc. powders
.1	trash
.1	dewatered resins
.01	waste solidified in cement
.001	waste solidified in vinyl ester styrene
0	activated metals

6. IMPACTS OF DISPOSAL OF C-14 AND I-129

Two radionuclides considered in the impact analysis methodology and draft EIS included carbon-14 (C-14) and iodine-129 (I-129). Both isotopes are long-lived and both decay by emination of beta particles. Both are believed to be present in a number of LLW streams and are also believed to be fairly mobile in the environment. By far the principal pathways by which humans could receive radiation exposures from these two isotopes involve ingestion. That is, through consumption of contaminated food. Given such ingestion, the principal organ impacted by carbon-14 is the bone. Conversely, the thyroid is the principal organ impacted by ingestion of iodine-129. In fact, the relative dose to the thyroid for a ingestion of a unit concentration of iodine-129 is about 1000 times that for the whole body.

Table C.48 Pathway Dose Conversion Factor 1

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	1.25E+09	5.19E+07	1.25E+09	1.25E+09	1.25E+09	1.25E+09	5.19E+07
C-14	3.17E+09	1.40E+10	3.17E+09	3.17E+09	3.17E+09	3.17E+09	2.53E+09
Fe-55	1.81E+10	1.89E+10	2.41E+10	1.61E+10	1.61E+10	2.08E+11	1.93E+10
Co-60	2.36E+12	2.34E+12	2.35E+12	2.34E+12	2.34E+12	2.63E+13	2.50E+12
Ni-59	3.70E+10	9.38E+10	5.06E+10	2.58E+10	2.58E+10	5.78E+10	2.85E+10
Ni-63	3.06E+10	9.60E+11	6.58E+10	1.56E+08	1.56E+08	8.82E+10	7.44E+09
Sr-90	2.42E+13	9.62E+13	1.67E+11	1.67E+11	1.67E+11	1.98E+11	1.89E+11
Nb-94	6.10E+11	6.11E+11	6.11E+11	6.10E+11	6.11E+10	1.33E+12	6.84E+11
Tc-99	1.18E+09	9.68E+08	2.28E+09	7.60E+08	2.00E+10	7.40E+09	7.88E+09
I-129	9.14E+11	8.52E+11	8.52E+11	5.13E+13	8.52E+11	8.57E+11	8.52E+11
Cs-135	2.37E+10	9.65E+10	8.85E+10	5.08E+08	3.33E+10	1.49E+10	1.00E+09
Cs-137	4.50E+11	6.34E+11	7.78E+11	2.42E+11	4.26E+11	3.30E+11	2.44E+11
Pb-210	8.04E+12	2.56E+14	6.56E+13	3.84E+10	2.08E+14	1.04E+14	4.72E+10
Ra-226	1.52E+15	2.16E+15	8.94E+09	8.94E+09	8.94E+09	8.00E+14	1.77E+11
Ra-228	6.88E+14	6.48E+14	1.14E+08	1.14E+08	1.14E+08	8.80E+15	1.87E+09
Ac-227	3.60E+14	5.68E+15	8.00E+14	1.00E+09	2.56E+14	2.16E+16	1.14E+10
Th-228	2.40E+13	7.12E+14	1.20E+13	1.80E+10	6.80E+13	1.44E+16	2.98E+11
Th-229	1.36E+15	2.80E+16	4.24E+14	2.55E+11	2.08E+15	2.00E+16	2.49E+12
Th-230	5.36E+14	1.76E+16	1.12E+15	1.43E+10	5.28E+15	3.52E+14	2.46E+11
Th-232	2.56E+14	7.44E+15	3.52E+14	1.38E+10	1.68E+15	4.72E+15	2.38E+11
Pa-231	5.60E+14	1.36E+16	5.44E+14	1.10E+11	3.04E+15	5.12E+15	4.22E+11
U-233	2.01E+12	3.28E+13	1.08E+10	1.08E+10	7.69E+12	3.68E+15	2.91E+11
U-234	1.94E+12	3.12E+13	1.75E+10	1.75E+10	7.54E+12	3.60E+15	2.89E+11
U-235	2.06E+12	3.06E+13	2.21E+11	2.21E+11	7.26E+12	3.36E+15	5.17E+11
U-236	1.86E+12	3.04E+13	1.65E+10	1.65E+10	7.30E+12	3.44E+15	2.72E+11
U-238	1.69E+12	2.88E+13	1.45E+10	1.45E+10	6.57E+12	3.12E+15	2.55E+11
Np-237	5.20E+14	1.20E+16	1.12E+15	1.34E+11	3.84E+15	3.60E+14	3.74E+11
Pu-238	2.00E+14	4.08E+15	2.80E+15	1.92E+10	8.80E+14	4.08E+15	3.31E+11
Pu-239	2.24E+14	4.80E+15	3.12E+15	7.40E+09	9.60E+14	3.84E+15	3.03E+11
Pu-240	2.24E+14	4.80E+15	3.12E+15	7.40E+09	9.60E+14	3.84E+15	3.03E+11
Pu-241	3.04E+12	7.44E+13	4.56E+13	4.78E+07	1.44E+13	6.80E+12	5.57E+09
Pu-242	2.16E+14	4.48E+15	3.04E+15	1.44E+10	9.60E+14	3.68E+15	2.94E+11
Am-241	5.04E+14	7.12E+15	6.64E+15	7.87E+10	3.84E+15	4.24E+14	3.59E+11
Am-243	4.96E+14	7.04E+16	6.48E+15	9.10E+10	3.76E+15	4.00E+14	3.63E+11
Cm-243	3.84E+14	6.16E+15	5.60E+15	2.44E+11	1.76E+15	4.40E+14	5.48E+11
Cm-244	2.80E+14	4.40E+15	4.16E+15	1.71E+10	1.28E+15	4.40E+14	3.05E+11

Table C.49 Pathway Dose Conversion Factor 2

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	1.17E+10	5.19E+07	1.17E+10	1.17E+10	1.17E+10	1.17E+10	1.05E+10
C-14	6.68E+10	3.32E+11	6.68E+10	6.68E+10	6.68E+10	6.68E+10	6.61E+10
Fe-55	9.28E+09	4.82E+10	3.94E+10	5.08E+07	5.08E+07	2.10E+11	2.12E+10
Co-60	1.24E+11	2.28E+10	7.60E+10	2.28E+10	2.28E+10	2.40E+13	8.59E+11
Ni-59	3.87E+10	2.33E+11	8.13E+10	5.98E+07	5.98E+07	3.21E+10	1.44E+10
Ni-63	1.04E+11	3.15E+12	2.18E+11	1.56E+08	1.56E+08	8.82E+10	3.91E+10
Sr-90	6.39E+13	2.59E+14	1.76E+09	1.76E+09	1.76E+09	3.30E+10	4.73E+12
Nb-94	1.39E+10	1.51E+10	1.45E+10	1.32E+10	1.45E+10	7.33E+11	4.43E+11
Tc-99	2.96E+09	5.41E+09	8.89E+09	7.60E+08	1.03E+11	6.36E+10	2.24E+11
I-129	2.07E+12	7.12E+11	6.12E+11	1.62E+15	1.32E+12	6.37E+09	9.79E+10
Cs-135	1.57E+11	4.21E+11	3.88E+11	5.08E+08	1.47E+11	4.88E+10	8.01E+09
Cs-137	1.40E+12	1.72E+12	2.35E+12	1.53E+09	8.01E+11	2.94E+11	3.92E+10
Pb-210	1.70E+13	5.09E+14	1.38E+14	3.51E+08	4.11E+14	1.04E+14	9.05E+11
Ra-226	1.65E+15	2.53E+15	5.01E+12	5.01E+12	5.01E+12	8.00E+14	4.24E+12
Ra-228	7.60E+14	8.32E+14	6.51E+12	6.68E+12	6.51E+12	8.80E+15	1.69E+12
Ac-227	3.62E+14	5.71E+15	8.04E+14	1.19E+08	2.57E+14	2.16E+16	1.36E+12
Th-228	2.43E+13	7.20E+14	1.21E+13	1.98E+08	6.88E+13	1.44E+16	9.58E+12
Th-229	1.37E+15	2.81E+16	4.26E+14	1.79E+09	2.09E+15	2.00E+16	1.07E+13
Th-230	5.37E+14	1.76E+16	1.12E+15	1.30E+08	5.29E+15	3.52E+14	1.23E+12
Th-232	2.58E+14	7.48E+15	3.54E+14	1.08E+08	1.69E+15	4.72E+15	1.07E+12
Pa-231	5.63E+14	1.37E+16	5.47E+14	6.59E+08	3.05E+15	5.12E+15	1.50E+12
U-233	2.87E+12	4.72E+13	5.16E+07	5.16E+07	1.10E+13	3.68E+15	1.31E+12
U-234	2.77E+12	4.50E+13	1.14E+08	1.14E+08	1.08E+13	3.60E+15	1.28E+12
U-235	2.64E+12	4.36E+13	1.59E+09	1.59E+09	1.01E+13	3.36E+15	1.59E+12
U-236	2.66E+12	4.36E+12	9.67E+07	9.67E+07	1.04E+13	3.44E+15	1.21E+12
U-238	2.43E+12	4.15E+13	8.57E+07	8.57E+07	9.45E+12	3.12E+15	1.15E+12
Np-237	5.21E+14	1.20E+16	1.12E+15	8.40E+08	3.85E+15	3.60E+14	1.55E+12
Pu-238	2.00E+14	4.09E+15	2.80E+15	8.87E+07	8.81E+14	4.08E+15	1.51E+12
Pu-239	2.24E+14	4.81E+15	3.12E+15	5.17E+07	9.61E+14	3.84E+15	1.39E+12
Pu-240	2.24E+14	4.81E+15	3.12E+15	5.17E+07	9.61E+14	3.84E+15	1.39E+12
Pu-241	3.05E+12	7.47E+13	4.56E+13	4.78E+07	1.44E+13	6.80E+12	2.86E+10
Pu-242	2.16E+14	4.49E+15	3.04E+15	6.93E+07	9.61E+14	3.68E+15	1.35E+12
Am-241	5.05E+14	7.13E+15	6.64E+15	3.80E+08	3.85E+15	4.24E+14	1.51E+12
Am-243	4.97E+14	7.05E+15	6.48E+15	6.09E+08	3.77E+15	4.00E+14	1.71E+12
Cm-243	3.85E+14	6.17E+15	5.60E+15	2.26E+09	1.76E+15	4.40E+14	1.59E+12
Cm-244	2.80E+14	4.41E+15	4.16E+15	7.23E+07	1.28E+15	4.40E+14	1.53E+12

Table C.50 Pathway Dose Conversion Factor 3

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	4.45E+10	5.19E+07	4.45E+10	4.45E+10	4.45E+10	4.45E+10	4.33E+10
C-14	2.66E+11	1.33E+12	2.66E+11	2.66E+11	2.66E+11	2.66E+11	2.65E+11
Fe-55	3.22E+10	1.90E+11	1.38E+11	5.08E+07	5.08E+07	2.64E+11	7.75E+10
Co-60	3.70E+11	2.28E+10	1.87E+11	2.28E+10	2.28E+10	2.40E+13	2.95E+12
Ni-59	1.25E+11	7.48E+11	2.58E+11	5.98E+07	5.98E+07	3.21E+10	5.08E+10
Ni-63	3.34E+11	1.00E+13	6.93E+11	1.56E+08	1.56E+08	8.82E+10	1.38E+11
Sr-90	1.89E+14	7.69E+14	1.76E+09	1.76E+09	1.76E+09	3.30E+10	1.95E+13
Nb-94	1.40E+10	1.55E+10	1.47E+10	1.32E+10	1.46E+10	7.33E+11	1.56E+12
Tc-99	8.55E+09	1.93E+10	2.96E+10	7.60E+08	3.64E+11	2.39E+11	9.01E+11
I-129	8.35E+12	2.94E+12	2.53E+12	6.55E+15	5.43E+12	6.37E+09	4.01E+11
Cs-135	5.73E+11	1.44E+12	1.33E+12	5.08E+08	5.01E+11	1.55E+11	2.99E+10
Cs-137	5.12E+12	5.87E+12	8.03E+12	1.53E+09	2.73E+12	9.35E+11	1.49E+11
Pb-210	4.51E+13	1.30E+15	3.64E+14	3.51E+08	1.05E+15	1.04E+14	3.71E+12
Ra-226	2.07E+15	3.68E+15	2.07E+13	2.07E+13	2.07E+13	8.00E+14	1.70E+13
Ra-228	9.85E+14	1.41E+15	2.69E+13	2.76E+13	2.69E+13	8.80E+15	6.97E+12
Ac-227	3.68E+14	5.81E+15	8.17E+14	1.19E+08	2.61E+14	2.16E+16	5.59E+12
Th-228	2.51E+13	7.46E+14	1.26E+13	1.98E+08	7.12E+13	1.44E+15	3.87E+13
Th-229	1.39E+15	2.85E+16	4.32E+14	1.79E+09	2.12E+15	2.00E+16	3.72E+13
Th-230	5.40E+14	1.77E+16	1.13E+15	1.30E+08	5.32E+15	3.52E+14	4.34E+12
Th-232	2.66E+14	7.60E+15	3.59E+14	1.08E+08	1.71E+15	4.72E+15	3.72E+12
Pa-231	4.71E+14	1.39E+16	3.54E+14	6.59E+08	3.10E+15	5.12E+15	5.20E+12
U-233	5.60E+12	9.22E+13	5.16E+07	5.16E+07	2.15E+13	3.68E+15	4.55E+12
U-234	5.44E+12	8.82E+13	1.14E+08	1.14E+08	2.11E+13	3.60E+15	4.46E+12
U-235	5.15E+12	8.50E+13	1.59E+09	1.59E+09	1.98E+13	3.36E+15	5.62E+12
U-236	5.22E+12	8.50E+13	9.67E+07	9.67E+07	2.03E+13	3.44E+15	4.18E+12
U-238	4.77E+12	8.11E+03	8.57E+07	8.57E+07	1.85E+13	3.12E+15	3.99E+12
Np-237	5.24E+14	1.21E+16	1.13E+15	8.40E+08	3.87E+15	3.60E+14	5.65E+12
Pu-238	2.01E+14	4.13E+15	2.81E+15	8.87E+07	8.85E+14	4.08E+15	5.28E+12
Pu-239	2.25E+14	4.85E+13	3.13E+15	5.17E+07	9.66E+14	3.84E+15	4.83E+12
Pu-240	2.25E+14	4.85E+15	3.13E+15	5.17E+07	9.66E+14	3.84E+15	4.83E+12
Pu-241	3.06E+12	7.55E+13	4.57E+13	4.78E+07	1.45E+13	6.80E+12	1.01E+11
Pu-242	2.17E+14	4.53E+15	3.05E+15	6.93E+07	9.65E+14	3.68E+15	4.72E+12
Am-241	5.08E+14	7.18E+15	6.66E+15	3.80E+08	3.87E+15	4.24E+14	5.36E+12
Am-243	5.00E+14	7.10E+15	6.50E+15	6.09E+08	3.79E+15	4.00E+14	6.22E+12
Cm-243	3.87E+14	6.20E+15	5.62E+15	2.26E+09	1.77E+15	4.40E+14	5.63E+12
Cm-244	2.82E+14	4.43E+15	4.17E+15	7.23E+07	1.29E+15	4.40E+14	5.43E+12

Table C.51 Pathway Dose Conversion Factor 4

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	5.99E+04	0.00E+00	5.99E+04	5.99E+04	5.99E+04	5.99E+04	5.99E+04
C-14	3.72E+05	1.86E+06	3.72E+05	3.72E+05	3.72E+05	3.72E+05	3.72E+05
Fe-55	3.48E+01	2.16E+02	1.49E+02	0.00E+00	0.00E+00	8.33E+01	8.57E+01
Co-60	5.27E+03	0.00E+00	2.39E+03	0.00E+00	0.00E+00	0.00E+00	4.49E+04
Ni-59	3.69E+03	2.21E+04	7.59E+03	0.00E+00	0.00E+00	0.00E+00	1.56E+03
Ni-63	9.88E+03	2.95E+05	2.04E+04	0.00E+00	0.00E+00	0.00E+00	4.26E+03
Sr-90	6.41E+07	2.61E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.54E+06
Nb-94	2.12E+00	7.08E+00	3.94E+00	0.00E+00	3.89E+00	0.00E+00	2.39E+04
Tc-99	6.57E+03	1.64E+04	2.43E+04	0.00E+00	3.06E+05	2.07E+05	7.95E+05
I-129	6.02E+04	2.14E+04	1.84E+04	4.72E+07	3.95E+04	0.00E+00	2.90E+03
Cs-135	8.84E+03	2.16E+04	1.99E+04	0.00E+00	7.53E+03	2.26E+03	4.66E+02
Cs-137	7.90E+04	8.81E+04	1.21E+05	0.00E+00	4.09E+04	1.36E+04	2.33E+03
Pb-210	2.58E+07	7.27E+06	2.08E+06	0.00E+00	5.84E+06	0.00E+00	2.57E+04
Ra-226	1.33E+07	3.66E+07	4.99E+05	4.99E+05	4.99E+05	2.93E+03	4.06E+05
Ra-228	7.15E+06	1.83E+07	6.48E+05	6.65E+05	6.48E+05	4.01E+03	1.68E+05
Ac-227	3.30E+04	5.55E+05	7.36E+04	0.00E+00	2.38E+04	0.00E+00	2.43E+04
Th-228	8.38E+03	2.47E+05	4.19E+03	0.00E+00	2.33E+04	0.00E+00	2.81E+05
Th-229	1.95E+05	3.98E+06	5.94E+04	0.00E+00	2.87E+05	0.00E+00	2.55E+05
Th-230	2.84E+04	1.03E+06	5.84E+04	0.00E+00	2.82E+05	0.00E+00	3.00E+04
Th-232	7.48E+04	1.15E+06	4.99E+04	0.00E+00	2.40E+05	0.00E+00	2.55E+04
Pa-231	4.72E+04	1.22E+06	4.57E+04	0.00E+00	2.57E+05	0.00E+00	2.13E+04
U-233	1.57E+04	2.59E+05	0.00E+00	0.00E+00	6.03E+04	0.00E+00	1.86E+04
U-234	1.53E+04	2.48E+05	0.00E+00	0.00E+00	5.91E+04	0.00E+00	1.82E+04
U-235	1.44E+04	2.38E+05	0.00E+00	0.00E+00	5.55E+04	0.00E+00	2.32E+04
U-236	1.47E+04	2.38E+05	0.00E+00	0.00E+00	5.67E+04	0.00E+00	1.71E+04
U-238	1.35E+05	2.28E+05	0.00E+00	0.00E+00	5.20E+04	0.00E+00	1.63E+04
Np-237	1.64E+04	4.07E+05	3.53E+05	0.00E+00	1 22E+05	0.00E+00	2 36E+04
Pu-238	1.14E+03	4.52E+04	6.37E+03	0.00E+00	4.87E+03	0.00E+00	4.85E+03
Pu-239	1.27E+03	5.23E+04	7.05E+03	0.00E+00	5.39E+03	0.00E.00	4.43E+03
Pu-240	1.27E+03	5.23E+04	7.05E+03	0.00E+00	5.39E+03	0.00E+00	4.43E+03
Pu-241	2.21E+01	1.10E+03	5.61E+01	0.00E+00	1.02E+02	0.00E+00	9.31E+01
Pu-242	1.22E+03	4.85E+04	6.78E+03	0.00E+00	5.19E+03	0.00E+00	4.34E+03
Am-241	3.60E+04	5.45E+05	1.92E+05	0.00E+00	2.71E+05	0.00E+00	4.94E+04
Am-243	3.53E+04	5.44E+05	1.85E+05	0.00E+00	2.65E+05	0.00E+00	5.79E+04
Cm-243	1.11E+04	1.90E+05	7.15E+04	0.00E+00	5.20E+04	0.00E+00	2.32E+04
Cm-244	8.52E+03	1.43E+05	6.15E+04	0.00E+00	3.98E+04	0.00E+00	2.24E+04

Table C.52 Pathway Dose Conversion Factor 5

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	1.54E+07	1.54E+07	1.54E+07	1.54E+07	1.54E+07	1.54E+07	1.54E+07
Ni-59	6.20E+03	6.20E+03	6.20E+03	6.03E+03	6.03E+03	6.03E+03	6.03E+03
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	3.06E+04	3.06E+04	3.06E+04	3.06E+04	3.06E+04	3.06E+04	3.06E+04
Nb-94	9.63E+06	9.63E+06	9.63E+06	9.63E+05	9.63E+06	9.63E+06	9.63E+06
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-129	1.92E+04	1.92E+04	1.92E+04	1.92E+04	1.92E+04	1.92E+04	1.92E+04
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	3.50E+06	3.50E+06	3.50E+06	3.50E+06	3.50E+06	3.50E+06	3.50E+06
Pb-210	6.58E+05	6.58E+05	6.58E+05	6.58E+05	6.58E+05	6.58E+05	6.58E+05
Ra-226	2.94E+07	2.94E+07	2.94E+07	2.94E+07	2.94E+07	2.94E+07	2.94E+07
Ra-228	5.00E+06	5.00E+06	5.00E+06	5.00E+06	5.00E+06	5.00E+06	5.00E+06
Ac-227	1.39E+07	1.39E+07	1.39E+07	1.39E+07	1.39E+07	1.39E+07	1.39E+07
Th-228	2.22E+07	2.22E+07	2.22E+07	2.22E+07	2.22E+07	2.22E+07	2.22E+07
Th-229	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07	1.45E+07
Th-230	2.13E+03	2.13E+03	2.13E+03	2.13E+03	2.13E+03	2.13E+03	2.13E+03
Th-232	4.92E+04	4.92E+04	4.92E+04	4.92E+04	4.92E+04	4.92E+04	4.92E+04
Pa-231	4.56E+05	4.56E+05	4.56E+05	4.56E+05	4.56E+05	4.56E+05	4.56E+05
U-233	4.16E+06	4.16E+06	4.16E+06	4.16E+06	4.16E+06	4.16E+06	4.16E+06
U-234	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05	3.98E+05
U-235	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05	1.50E+05
U-236	5.56E+05	5.56E+05	5.56E+05	5.56E+05	5.56E+05	5.56E+05	5.56E+05
U-238	5.16E+03	5.16E+03	5.16E+03	5.16E+03	5.16E+03	5.16E+03	5.16E+03
Np-237	6.56E+04	6.56E+04	6.56E+04	6.56E+04	6.56E+04	6.56E+04	6.56E+04
Pu-238	1.93E+01	1.93E+01	1.93E+01	1.93E+01	1.93E+01	1.93E+01	1.93E+01
Pu-239	9.39E+01	9.39E+01	9.39E+01	9.39E+01	9.39E+01	9.39E+01	9.39E+01
Pu-240	9.39E+01	9.39E+01	9.39E+01	9.39E+01	9.39E+01	9.39E+01	9.39E+01
Pu-241	3.43E-01	3.43E-01	3.43E-01	3.43E-01	3.43E-01	3.43E-01	3.43E-01
Pu-242	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Am-241	7.71E+04	7.71E+04	7.71E+04	7.17E+04	7.71E+04	7.71E+04	7.71E+04
Am-243	1.86E+05	1.86E+05	1.86E+05	1.86E+05	1.86E+05	1.86E+05	1.86E+05
Cm-243	3.82E+05	3.82E+05	3.82E+05	3.82E+05	3.82E+05	3.82E+05	3.82E+05
Cm-244	5.64E+01	5.64E+01	5.64E+01	5.64E+01	5.64E+01	5.64E+01	5.64E+01

Table C.53 Pathway Dose Conversion Factor 6

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	2.37E+06	1.42E-01	2.37E+06	2.37E+06	2.37E+06	2.37E+06	2.37E+06
C-14	1.44E+07	7.21E+07	1.44E+07	1.44E+07	1.44E+07	1.44E+07	1.44E+07
Fe-55	2.73E+06	1.24E+07	8.86E+06	8.61E+05	8.61E+05	5.33E+06	5.45E+06
Co-60	1.43E+08	1.24E+08	1.33E+08	1.24E+08	1.24E+08	1.24E+08	2.89E+08
Ni-59	8.54E+06	4.42E+07	1.61E+07	1.38E+06	1.38E+06	1.38E+06	4.41E+06
Ni-63	1.92E+07	5.71E+08	3.96E+07	4.28E-01	4.28E-01	2.42E+02	8.26E+06
Sr-90	9.56E+09	3.90E+10	8.83E+06	8.83E+06	8.83E+06	8.83E+06	1.13E+09
Nb-94	3.19E+07	3.20E+07	3.19E+07	3.19E+07	3.19E+07	3.19E+07	1.47E+08
Tc-99	4.19E+05	1.04E+06	1.55E+06	2.08E+00	1.95E+07	1.32E+07	5.07E+07
I-129	4.29E+07	1.76E+07	1.56E+07	3.08E+10	2.94E+07	3.64E+06	5.54E+06
Cs-135	3.32E+07	8.10E+07	7.48E+07	1.39E+00	2.83E+07	8.47E+06	1.75E+06
Cs-137	3.09E+08	3.44E+08	4.66E+08	1.29E+07	1.67E+08	6.39E+07	2.16E+07
Pb-210	2.19E+09	6.16E+10	1.76E+10	2.03E+06	4.96E+10	2.32E+06	2.20E+08
Ra-226	3.26E+10	8.95E+10	1.22E+09	1.22E+09	1.22E+09	9.83E+06	9.93E+08
Ra-228	1.75E+10	4.48E+10	1.59E+09	1.63E+09	1.59E+09	3.39E+07	4.11E+08
Ac-227	4.48E+08	7.54E+09	1.00E+09	4.74E+04	3.23E+08	5.92E+07	3.30E+08
Th-228	6.87E+07	2.00E+09	3.48E+07	9.51E+05	1.89E+08	4.04E+07	2.27E+09
Th-229	1.59E+09	3.22E+10	4.94E+08	1.35E+07	2.33E+09	6.48E+07	2.07E+09
Th-230	2.32E+08	8.34E+09	4.75E+08	7.61E+05	2.29E+09	1.73E+06	2.43E+08
Th-232	6.05E+08	9.28E+09	4.04E+08	7.35E+05	1.95E+09	1.37E+07	2.07E+08
Pa-231	6.47E+08	1.65E+10	6.27E+08	5.84E+06	3.49E+09	1.99E+07	2.94E+08
U-233	2.13E+08	3.51E+09	5.74E+05	5.74E+05	8.18E+08	1.07E+07	2.33E+08
U-234	2.09E+08	3.37E+09	9.29E+05	9.29E+05	8.02E+08	1.08E+07	2.48E+08
U-235	2.07E+08	3.24E+09	1.18E+07	1.18E+07	7.64E+08	2.10E+07	3.26E+08
U-236	2.00E+08	3.22E+09	8.77E+05	8.77E+05	7.70E+08	1.03E+07	2.33E+08
U-238	1.83E+08	3.09E+09	7.74E+05	7.74E+05	7.05E+08	9.32E+06	2.22E+08
Np-237	2.31E+08	5.55E+09	4.88E+08	7.13E+06	1.67E+09	8.11E+06	3.26E+08
Pu-238	7.02E+07	2.74E+09	3.93E+08	1.03E+06	2.97E+08	1.22E+07	2.94E+08
Pu-239	7.77E+07	3.17E+09	4.34E+08	3.93E+05	3.28E+08	1.09E+07	2.68E+08
Pu-240	7.77E+07	3.17E+09	4.34E+08	3.93E+05	3.28E+08	1.09E+07	2.68E+08
Pu-241	1.34E+06	6.64E+07	3.51E+06	1.31E-01	6.18E+06	1.86E+04	5.62E+06
Pu-242	7.52E+07	2.94E+09	4.18E+08	7.67E+05	3.17E+08	1.09E+07	2.63E+08
Am-241	2.25E+08	3.34E+09	1.19E+09	4.19E+06	1.66E+09	5.35E+05	3.05E+08
Am-243	2.21E+08	3.34E+09	1.15E+09	4.84E+06	1.63E+09	5.93E+06	3.57E+08
Cm-243	1.65E+08	2.60E+09	9.97E+08	1.30E+07	7.21E+08	1.42E+07	3.27E+08
Cm-244	1.17E+08	1.95E+09	8.44E+08	9.09E+05	5.43E+08	2.12E+06	3.04E+08

Table C.54 Pathway Dose Conversion Factor 7

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	2.37E+06	1.42E-01	2.37E+06	2.37E+06	2.37E+06	2.37E+06	2.37E+06
C-14	3.76E+07	1.88E+08	3.76E+07	3.76E+07	3.76E+07	3.76E+07	3.76E+07
Fe-55	4.45E+06	2.31E+07	1.63E+07	8.61E+05	8.61E+05	9.45E+06	9.69E+06
Co-60	1.46E+08	1.24E+08	1.34E+08	1.24E+08	1.24E+08	1.23E+08	3.11E+08
Ni-59	9.82E+06	5.20E+07	1.87E+07	1.38E+06	1.38E+06	1.38E+06	4.95E+06
Ni-63	2.26E+07	6.74E+08	4.67E+07	4.28E-01	4.28E-01	2.42E+02	9.74E+06
Sr-90	1.01E+10	4.13E+10	8.83E+06	8.83E+06	8.83E+06	8.83E+06	1.20E+09
Nb-94	3.32E+07	3.32E+07	3.27E+07	3.19E+07	3.26E+07	3.19E+07	4.50E+09
Tc-99	4.24E+05	1.06E+06	1.57E+06	2.08E+00	1.98E+07	1.33E+07	5.14E+07
I-129	4.39E+07	1.79E+07	1.59E+07	3.16E+10	3.00E+07	3.64E+06	5.58E+06
Cs-135	1.44E+08	3.52E+08	3.25E+08	1.39E+00	1.23E+08	3.68E+07	7.60E+06
Cs-137	1.30E+09	1.45E+09	1.98E+09	1.29E+07	6.81E+08	2.35E+08	5.10E+07
Pb-210	2.62E+09	7.37E+10	2.11E+10	2.03E+06	5.93E+10	2.32E+06	2.63E+08
Ra-226	3.73E+10	1.03E+11	1.40E+09	1.40E+09	1.40E+09	1.09E+07	1.14E+09
Ra-228	2.01E+10	5.13E+10	1.82E+09	1.87E+09	1.82E+09	3.54E+07	4.71E+08
Ac-227	4.56E+08	7.68E+09	1.02E+09	4.74E+04	3.29E+08	5.92E+07	3.36E+08
Th-228	8.05E+07	2.35E+09	4.07E+07	9.51E+05	2.22E+08	4.04E+07	2.67E+09
Th-229	1.87E+09	3.79E+10	5.78E+08	1.35E+07	2.74E+09	6.84E+07	2.44E+09
Th-230	2.72E+08	9.80E+09	5.58E+08	7.61E+05	2.69E+09	1.73E+06	2.86E+08
Th-232	7.11E+08	1.09E+10	4.75E+08	7.35E+05	2.29E+09	1.37E+07	2.43E+08
Pa-231	6.59E+08	1.68E+10	6.38E+08	5.84E+06	3.55E+09	1.99E+07	3.00E+08
U-233	2.17E+08	3.57E+09	5.74E+05	5.74E+05	8.32E+08	1.07E+07	2.58E+08
U-234	2.13E+08	3.43E+09	9.29E+05	9.29E+05	8.16E+08	1.08E+07	2.53E+08
U-235	2.11E+08	3.29E+09	1.18E+07	1.18E+07	7.78E+08	2.10E+07	3.32E+08
U-236	2.04E+08	3.28E+09	8.77E+05	8.77E+05	7.84E+08	1.03E+07	2.37E+08
U-238	1.87E+08	3.14E+09	7.74E+05	7.74E+05	7.18E+08	9.32E+06	2.26E+08
Np-237	2.57E+08	6.19E+09	5.44E+08	7.13E+06	1.87E+09	8.11E+06	3.63E+08
Pu-238	7.49E+07	2.93E+09	4.19E+08	1.03E+06	3.17E+08	1.22E+07	3.14E+08
Pu-239	8.29E+07	3.39E+09	4.63E+08	3.93E+05	3.51E+08	1.09E+07	2.86E+08
Pu-240	8.29E+07	3.39E+09	4.63E+08	3.93E+05	3.51E+08	1.09E+07	2.86E+08
Pu-241	1.43E+06	7.09E+07	3.74E+06	1.31E-01	6.60E+06	1.86E+04	6.00E+06
Pu-242	8.02E+07	3.14E+09	4.46E+08	7.67E+05	3.38E+08	1.09E+07	2.81E+08
Am-241	3.72E+08	5.57E+09	1.97E+09	4.19E+06	2.77E+09	5.35E+06	5.07E+08
Am-243	3.65E+08	5.57E+09	1.91E+09	4.84E+06	2.72E+09	5.93E+06	5.94E+08
Cm-243	2.09E+08	3.35E+09	1.28E+09	1.30E+07	9.26E+08	1.42E+07	4.18E+08
Cm-244	1.51E+08	2.52E+09	1.09E+09	9.09E+05	7.00E+08	2.12E+06	3.93E+08

Table C.55. Pathway Dose Conversion Factor 8

	Total Body	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
H-3	4.45E+10	5.19E+07	4.45E+10	4.45E+10	4.45E+10	4.45E+10	4.33E+10
C-14	2.66E+11	1.33E+12	2.66E+11	2.66E+11	2.66E+11	2.66E+11	2.65E+11
Fe-55	4.83E+10	2.06E+11	1.54E+11	1.16E+10	1.61E+10	2.80E+11	9.36E+10
Co-60	2.68E+12	2.34E+12	2.50E+12	2.34E+12	2.34E+12	2.63E+12	5.27E+12
Ni-59	1.50E+11	7.73E+11	2.84E+11	2.58E+10	2.58E+10	5.78E+10	7.65E+10
Ni-63	3.34E+11	1.00E+13	6.93E+11	1.56E+08	1.56E+08	8.82E+10	1.38E+11
Sr-90	1.89E+14	7.69E+14	1.67E+11	1.67E+11	1.67E+11	1.98E+11	1.96E+13
Nb-94	6.10E+11	6.12E+11	6.11E+11	6.10E+11	6.11E+11	1.33E+12	2.15E+12
Tc-99	8.55E+09	1.93E+10	2.96E+10	7.60E+08	3.64E+11	2.39E+11	9.01E+11
I-129	9.20E+12	3.79E+12	3.38E+12	6.55E+15	6.28E+12	8.57E+11	1.25E+12
Cs-135	5.73E+11	1.44E+12	1.33E+12	5.08E+08	5.01E+11	1.55E+11	2.99E+10
Cs-137	5.36E+12	6.11E+12	8.27E+12	2.42E+11	2.97E+12	1.18E+12	3.89E+11
Pb-210	4.52E+13	1.30E+15	3.64E+14	3.84E+10	1.05E+15	1.04E+14	3.75E+12
Ra-226	2.07E+15	3.68E+15	2.07E+13	2.07E+13	2.07E+13	8.00E+14	1.70E+13
Ra-228	9.85E+14	1.41E+15	2.69E+13	2.76E+13	2.69E+13	8.80E+15	6.97E+12
Ac-227	3.68E+14	5.81E+15	8.17E+14	1.00E+09	2.61E+14	2.16E+16	5.59E+12
Th-228	2.52E+13	7.46E+14	1.26E+13	1.80E+10	7.12E+13	1.44E+16	3.87E+13
Th-229	1.39E+15	2.85E+16	4.32E+14	2.55E+11	2.12E+15	2.00E+16	3.75E+13
Th-230	5.40E+14	1.77E+16	1.13E+15	1.43E+10	5.32E+15	3.52E+14	4.36E+12
Th-232	2.66E+14	7.60E+15	3.59E+14	1.38E+10	1.71E+15	4.72E+15	3.73E+12
Pa-231	5.71E+14	1.39E+16	5.55E+14	1.10E+11	3.10E+15	5.12E+15	5.31E+12
U-233	5.61E+12	9.22E+13	1.08E+10	1.08E+10	2.15E+13	3.68E+15	4.56E+12
U-234	5.46E+12	8.82E+13	1.75E+10	1.75E+10	2.11E+13	3.60E+15	4.47E+12
U-235	5.37E+12	8.52E+13	2.21E+11	2.21E+11	2.00E+13	3.36E+15	5.84E+12
U-236	5.24E+12	8.50E+13	1.65E+10	1.65E+10	2.03E+13	3.44E+15	4.20E+12
U-238	4.79E+12	8.11E+13	1.45E+10	1.45E+10	1.85E+13	3.12E+15	4.00E+12
Np-237	5.24E+14	1.21E+16	1.13E+15	1.34E+11	3.87E+15	3.60E+14	5.79E+12
Pu-238	2.01E+14	4.13E+15	2.81E+15	1.92E+10	8.85E+14	4.08E+15	5.30E+12
Pu-239	2.25E+14	4.85E+15	3.13E+15	7.40E+09	9.66E+14	3.84E+15	4.83E+12
Pu-240	2.25E+14	4.85E+15	3.13E+15	7.40E+09	9.66E+14	3.84E+15	4.83E+12
Pu-241	3.06E+12	7.55E+13	4.57E+13	4.78E+07	1.45E+13	6.80E+12	1.01E+11
Pu-242	2.17E+14	4.53E+15	3.05E+15	1.44E+10	9.65E+14	3.68E+15	4.74E+12
Am-241	5.08E+14	7.18E+15	6.66E+15	7.87E+10	3.87E+15	4.24E+14	5.43E+12
Am-243	5.00E+14	7.10E+15	6.50E+15	9.10E+10	3.79E+15	4.00E+14	6.31E+12
Cm-243	3.87E+14	6.20E+15	5.62E+15	2.44E+11	1.77E+15	4.40E+14	5.87E+12
Cm-244	2.82E+14	4.43E+15	4.17E+15	1.71E+10	1.29E+15	4.40E+14	5.45E+12

In the comments on the draft EIS and proposed Part 61 regulation, there was some interest in the concentration limits for and impact calculations involving these two nuclides. Based upon this interest NRC staff determined that a reexamination of the potential radiotoxicity of the two nuclides was warrented. This reexamination was carried out by a contractor (Ref. 29) and the results of this reexamination are summaried here.

In this effort, two basic questions regarding iodine-129 disposal were addressed:

- whether natural iodine will provide a means of limiting exposures (especially thyroid exposures) which may result from the near-surface disposal of waste containing I-129; and
- whether it is possible to provide artificial dilution by disposing certain waste streams together with material containing high concentrations of natural iodine.

Regarding carbon-14, the basic question addressed was:

- whether the exposures calculated through consumption of food (which are dominated by a pathway involving root uptake of C-14 out of soil) are over-conservative.

The remainder of this section is divided as follows. First, C-14 and I-129 isotopic characteristics and projected generation rates are discussed. Second, a short review of available information of environmental characteristics, chemistry, and uptake of these two isotopes is presented. This is followed by a discussion and conclusions.

6.1. Isotope Characteristics and Generation

This section presents a brief discussion of the radio-characteristics of the above two isotopes plus an estimate of their occurrence in waste streams. As discussed elsewhere in this EIS, routine radioactive waste expected to be generated between the years 1980 and 2000 has been separated into 37 waste streams and each waste stream has been characterized in terms of its physical, chemical and radiological properties. These waste streams are summarized in Table C.56.

The concentrations of I-129 and C-14 in the waste streams utilized in the radiological impact assessments performed for the draft EIS were calculated using the methodologies presented in reference 10. Since the publication of reference 10, however, additional information has been compiled on the total radioactivity content of process waste streams generated by light water power reactors (i.e., Group I waste streams in Table C.56). This new information has been discussed in Section 4 of this appendix (Ref. 11). This new information does not alter the comparative concentrations of the radionuclides considered (e.g., the percent of the total activity that is I-129). However, it does indicate an upward adjustment of the average radioactive concentrations presented in reference 10. Both the previous and the updated concentrations of I-129 and C-14 are summarized below.

Table C.56 Waste Streams Considered in Analyses

Waste Stream	Symbol
Group I: LWR* Process Wastes	
PWR** Ion Exchange Resins	P-IXRESIN
PWR Concentrated Liquids	P-CONCLIQ
PWR Filter Sludges	P-FSLUDGE
PWR Filter Cartridges	P-FCARTRG
BWR*** Ion Exchange Resins	B-IXRESIN
BWR Concentrated Liquids	B-CONCLIQ
BWR Filter Sludges	B-FSLUDGE
Group II: Trash	
PWR Compactible Trash	P-COTRASH
PWR Noncompactible Trash	P-NCTRASH
BWR Compactible Trash	B-COTRASH
BWR Noncompactible Trash	B-NCTRASH
Fuel Fabrication Compactible Trash	F-COTRASH
Fuel Fabrication Noncompactible Trash	F-NCTRASH
Institutional Trash (large facilities)	I-COTRASH
Institutional Trash (small facilities)	I+COTRASH
Industrial SS# Trash (large facilities)	N-SSTRASH
Industrial SS Trash (small facilities)	N+SSTRASH
Industrial Low Act. Trash (large facilities)	N-LOTRASH
Industrial Low Act. Trash (small facilities)	N+LOTRASH
Group III: Low Specific Activity Wastes	
Fuel Fabrication Process Wastes	F-PROCESS
UF_6 Process Wastes	U-PROCESS
Institutional LSV## Waste (large facilities)	I-LIQSCVL
Institutional LSV Waste (small facilities)	I+LIQSCVL
Institutional Liquid Waste (large facilities)	I-ABSLIQD
Institutional Liquid Waste (small facilities)	I+ABSLIQD
Institutional Biowaste (large facilities)	I-BIOWAST
Institutional Biowaste (small facilities)	I+BIOWAST
Industrial SS Waste	N-SSWASTE
Industrial Low Activity Waste	N-LOWASTE
Group IV: Special Wastes	
LWR Nonfuel Reactor Core Components	L-NFRCOMP
LWR Decontamination Resins	L-DECONRS
Waste from Isotope Production Facilities	N-ISOPROD
Tritium Production Waste	N-TRITIUM
Accelerator Targets	N-TARGETS
Sealed Sources	N-SOURCES
Industrial High Activity Waste	N-NIGHACT
MOX† Facility Decontamination Waste	F-PUDECON

*LWR: Light Water Reactor
**PWR: Pressurized Water Reactor
***BWR: Boiling Water Reactor
#SS: Source and Special Nuclear Material
##LSV: Liquid Scintillation Vial
†MOX: Mixed Oxide (PuO_2+UO_2)

Iodine-129

Iodine-129 is produced by fission. It decays by beta emission to xenon-129 with a half-life of 1.7×10^7 years. The emitted beta particles have a maximum energy of 0.150 MeV. The beta decay is accompanied by the emission of xenon x-rays and conversion electrons with energies of 0.005 MeV and 0.034 MeV, respectively (Ref. 10).

Fission of U-128, U-235, and Pu-239 is the principal means through which I-129 is generated. Consequently, only wastes associated with light water reactors and wastes generated by medical isotope production facilities are expected to contain significant amounts of I-129. These concentrations and expected generation rates are presented in Table C.57 (Refs. 10, 11).

Utilizing the information in Table C.57 and the I-129 specific activity of 1.63×10^{-4} Ci/g, expected I-129 generation rates may be estimated. These are about 83.44 grams of I-129 per GW(e)-yr for PWRs, 379.75 grams of I-129 per GW(e)-yr for BWRs, and 343.56 grams of I-129 per year from other sources.

Carbon-14

Carbon-14 is produced by neutron capture from nitrogen-14 -- i.e., the reaction [N-14 (n, p) C-14]. Naturally occuring C-14 is produced by cosmic radiation in the upper atmosphere. Carbon-14 decays by beta emission to N-14 with a half-life of 5730 years. The maximum energy of the emitted beta particles is 0.156 MeV. No other radiations are produced (Ref. 10).

Carbon-14 is estimated to be present in most of the waste streams considered in reference 10 and the draft EIS. In addition to waste routinely generated by light-water reactors, it is projected to be present in significant quantities in several institutional waste streams as well as waste streams from industrial sources. These concentrations and expected generation rates are presented in Table C.58.

This table can be utilized to calculate the generation rates of C-14 in routine radioactive waste. Using the specific activity of C-14 of 4.46 Ci/g, assuming that the same L-NFRCOMP volume is generated in both PWRs and BWRs (there is insufficient data for a more accurate estimate), and ignoring the N-SOURCES waste stream since its physical, chemical, and radiological properties are very unrepresentative of the properties of other streams in the group, expected C-14 generation rates may be estimated. These are about 0.8 Ci (0.18 g) per GW(e)-yr for PWRs, 0.575 Ci (0.13 g) per GW(e)-yr for BWRs, and 33.1 Ci (7.46 g) per year from other sources.

6.2 Review of Available Information

This section presents a very brief review of the environmental characteristics, chemistry, and uptake of I-129 and C-14.

6.2.1 Iodine-129

Two matters herein discussed include: (1) the environmental concentrations of natural stable and radioactive iodine, and (2) iodine chemistry and uptake.

Table C.57 Estimated I-129 Generation Rates

Waste stream	Activities (Ci/m³) (Ref. 10)	Activities (Ci/m³) (Ref. 11)	Volumes (m^3 per GW(e)-yr)	Total Activity (Ci/GW(e)-yr)
P-IXRESIN	2.44E-06	5.60E-04	17.6	9.85E-03
P-CONCLIQ	3.16E-06	2.43E-05	123.0	2.99E-03
P-FSLUDGE	2.37E-06	1.72E-05	2.2	3.79E-05
P-FCARTRG	1.06E-06	NC*	11.0	1.17E-05
P-COTRASH	2.78E-07	NC	215.0	6.00E-05
P-NCTRASH	6.41E-06	NC	110.0	6.75E-04
		Totals	478.8	1.36E-02
B-IXRESIN	2.04E-04	2.47E-04	80.7	1.99E-02
B-CONCLIQ	6.65E-06	2.00E-05	223.0	4.47E-03
B-FSLUDGE	1.33E-06	1.42E-04	179.0	2.54E-02
B-COTRASH	7.14E-07	NC	221.0	1.58E-04
B-NCTRASH	1.15E-04	NC	105.0	1.20E-02
		Totals	808.7	5.37E-02

Waste stream	Activities (Ci/m³) (Ref. 10)	Activities (Ci/m³) (Ref. 11)	Volumes** (m^3/year)	Total Activity (Ci/year)
L-DECONRS	3.34E-05	NC	1666	5.56E-02
N-ISOPROD	2.72E-06	NC	148	4.03E-04
		Totals	1814	5.60E-02

Source: References 10 and 11.
*NC: No change
**Volumes are for the year 1980.

Table C.58 Estimated C-14 Generation Rates

Waste stream	Activities (Ci/m^3) (Ref. 10)	(Ref. 11)	Volumes (m^3 per GW(e)-yr)	Total Activity (Ci/GW(e)-yr)
P-IXRESIN	9.74E-05	2.23E-02	17.6	3.92E-01
P-CONCLIQ	1.27E-04	9.77E-04	123.0	1.20E-01
P-FSLUDGE	9.55E-05	6.93E-04	2.2	1.53E-03
P-FCARTRG	4.25E-05	NC	11.0	4.68E-04
P-COTRASH	1.12E-05	NC	215.0	2.40E-03
P-NCTRASH	2.57E-04	NC	110.0	2.83E-02
		Subtotals	478.8	5.45E-01
B-IXRESIN	1.19E-03	1.44E-03	80.7	1.16E-01
B-CONCLIQ	3.89E-05	1.17E-04	223.0	2.60E-02
B-FSLUDGE	7.78E-06	8.31E-04	179.0	1.49E-01
B-COTRASH	1.12E-07	NC	221.0	2.48E-03
B-NCTRASH	2.57E-04	NC	105.0	2.70E-02
		Subtotals	808.7	3.19E-01
L-NFRCOMP	2.59E-01	NC	0.99	2.56E-01

Waste stream	Activities (Ci/m^3) (Ref. 10)	(Ref. 11)	Volumes** (m^3/year)	Total Activity (Ci/year)
L-DECONRS	5.12E-05	NC	1666	8.53E-01
N-ISOPROD	4.51E-05	NC	148	6.68E-03
I-COTRASH	5.26E-03	NC	4014	2.11E+01
N-LOTRASH***	1.64E-03	NC	1445	2.37E+00
I-LQSCNVL***	2.51E-04	NC	1402	3.50E-01
I-ABSLIQD***	8.15E-03	NC	159	1.29E+00
I-BIOWAST***	1.01E-02	NC	448	4.52E+00
N-LOWASTE	9.35E-04	NC	1719	1.61E+00
N-HIGHACT	1.32E-02	NC	74.4	9.82E-01
		Subtotals	11075.4	3.31E+01
N-SOURCES	5.75E+01	NC	5.3	304.75

Source: References 10 and 11.
*NC: No change
**Volumes are for the year 1980.
***Includes wastes from both large and small facilities.

Environmental Concentrations

The distribution of iodine within natural soil and rock is discussed in reference 30. It pointed out in this reference that the average iodine concentrations in volcanic rocks range from 22 to 1900 parts per billion (ppb), and that the average value for igneous rocks probably falls within the range of 75 to 150 ppb. Experiments to leach this iodine from volcanic rocks usually removed less than 20 percent of the total iodine in the rock.

The abundance of iodine in sedimentary rocks, however, is on the order of about 1000 times that of igneous rocks. Table C.59 presents values for iodine as obtained from reference 30. It is also pointed out in reference 30 that while the iodine content of marine sediments depends to a large extent on the carbon content of the sediments, marine sediments are much richer in iodine than sedimentary rocks. Experiments that examined iodine bonding determined that most of the iodine in marine sediments was surface-adsorbed or covalent-bonded to carbon, and that about 23 percent could be extracted with organic solvents (Ref. 30).

Table C.59 Iodine in Sedimentary Rocks

Sedimentary Rock	I, ppm
Sandstones, 11, Bashkiria, USSR	0.15-1.5
Sandstone, white, Klondyke, MO	0.068
Sandstone, red, Potsdam, NY	0.14
Argillaceous sandstone, Portageville, NY	37.6
Argillaceous shale, Rochester, NY	13,0
Calcareous shale, Lima, NY	38.0
Limestones, 6, Paleozoic, OK	4.2
Sediments, SW Barents Sea	405

Source: Reference 30.

There appears to be a marked increase in soil iodine content compared to the rocks that they are derived from. Reference 30 quotes an investigation by Vinogradov (1959) who estimates the average iodine content of soils as being about 5 ppm, and who also suggests that much of the soil iodine is atmospherically derived.

The iodine concentration within surface and groundwaters is also a variable and, except for highly mineralized water or brines, is normally found in tiny concentrations. For example, reference 31 classifies iodine as being a minor constituent in potable water, where in the listed classification system a "minor constituent" is one that falls within a range of 0.0001 to 0.1 ppm.

Measurements of preatomic age materials indicate I-129/I-127 ratios of about 2×10^{-15} for very old iodine rich ores, 3×10^{-12} for chemicals and 1×10^{-10} for biological materials. According to reference 32, a nominal base-figure value of 3×10^{-12} for pre-1945 potassium iodine appears to be in good agreement with the values used by other investigators.

During the early 1950's, the I-129/I-127 radio in the biosphere increased from 3×10^{-12} to 1×10^{-6}, or by about a factor of a million. This was due to atmospheric testing and to insufficient time for I-129 released from this source to come to equilibrium with I-127 in the environment. By the late 1950's and early 1960's, samples of various biological materials gave values for the I-129/I-127 ratios in the range of 1×10^{-10} to 1×10^{-8} (Ref. 32). A more recent EPA measurement of bovine thyroids from Vermont and New Hampshire gave results on the order of 5×10^{-5} uCi/gm of total iodine which equates to an I-129/I-127 ratio of 3×10^{-7} (Ref. 33).

Similar measurements of iodines have been made in more recent studies. One study indicates that around existing nuclear facilities, the atom ratio of I-129 to that of I-127 measured in biota ranges up to 3.9×10^{-5} in thyroid tissues of animals other than bovine (deer around the Hanford Reservation), and up to 1.7×10^{-6} in bovine thyroid tissues (around Northeastern Oregon) (Ref. 34). In yet another study, bovine thyrod tissues have been observed to have an I-129/I-127 atom ratio of 4.5×10^{-7} around the Savannah River Plant (Ref. 35).

Iodine Chemistry and Uptake

Iodine is a nonmetallic element belonging to the halogen family. There are 24 known isotopes of iodine with 18 of these isotopes having half-lives of less than 1 day. The only stable isotope is I-127. Although iodine is known in the -1, +1, +3, +5, and +7 oxidation states, its ususal occurrance is in the -1 (iodide, I^-) state in fresh waters and as iodate (IO_3^-) in marine or similar aqueous environments (Refs. 30, 36). Iodine, like the other halogens, is very active chemically, but is usually less violent in its action. Iodine is also a volatile element, subliming at atmospheric pressures without melting.

A considerable proportion of iodine occurs in organic forms which are much less reactive than elemental iodine (Ref. 37). Most compounds of iodine are very soluble. Some of the insoluble or sparingly soluble compounds include iodides of Pb and Pd, the hypoiodites of Ag and Hg, and Ba periodates (Ref. 30). In normal soils, the concentration of most of the elements (Pb, Pd, Ag, Hg, and Ba) with which iodine forms insoluble compounds is very low. Iodine in aqueous solutions free from oxidizing agents generally exists as iodide (Ref. 30).

Soil-to-plant concentration factors (uptake factors) are obtained from experiments on plants grown in the laboratory or in the field. Concentration factors are also estimated from the statistical correlation between the concentration in a crop and the cumulative ground deposition. The uptake factor of an isotope in a given crop varies in a very complex manner with soil texture and other soil properties such as cation exchange capacity, exchangeable calcium, exchangeable potassium, pH, and organic matter content. It will vary with crop variety, stage of growth, and plant part as well as with experimental conditions such as the manner in which the isotope was introduced into soil.

In general, ions of any element present in the soil will pass into the root system whether or not they are essential for plant growth (Ref. 38). The major factor governing the availability of radionuclides to plants in soils is the solubility of the nuclides in the soil matrix. Plant roots absorb only the soluble species of metals (Ref. 37). Iodine is not concentrated by vegetation and is classified by Menzel (Ref. 39) as in the "not concentrated" class. That is, the ratio of ppm in dry plant material to ppm dry soil is 0.1-10.0. In addition, iodine is not listed among the trace elements (micronutrients) necessary for plant growth (Ref. 39).

The radioiodine uptake by plants from soil is influenced by several factors as with any element. It has been shown with stable iodine that uptake increases with increasing concentration in the substrate, that uptake increases when soil pH was reduced down to about 4 from a higher pH, and that the relative order of uptake by plant species is bean > tomato > barley > Russian thistle (Ref. 38).

Elevated levels of soil iodine have also been shown to be toxic to plants. The most sensitive studied was lettuce which was drastically affected at all levels of applied iodine above 10 ppm. Spinach and radish were also studied and showed a slight depression of shoot growth with added iodine (Ref. 29).

In general, airborne release of I-129 has been considered to be an insignificant source of hazard from the root uptake pathway because of its low activity. However, because of its extremely long half-life, it has the potential for accumulation in the environment from long-term chronic releases (Ref. 38). Generally the root uptake of I-129 from soils by vegetation is considered to be minor relative to that obtained from direct foliar deposition. The contribution of soil I-129 to concentrations of radioiodine in vegetables growing in such contaminated soils would not be significant until several tens of years deposited iodine had accumulated in the soil (Ref. 40).

Also of interest is the amount of iodine that can be present in the thyroid and the exposures resulting from the radioactive component of this iodine. Normally the adult thyroid has an iodine content of 7 to 8 milligrams although this varies greatly in individuals (Ref. 41-43). The normal thyroid takes up approximately 80-100 micrograms of iodide per day (Ref. 47). Most of this iodine in thyroid is expected to be natural iodine which would not result in exposures. A study on I-129 dosages to thyroid as a function of the total I-129 administered indicated that dosages up to 1 nCi resulted in doses of 7 mrem/nCi; however, there was a marked reduction in dose between 10 nCi (5.8 mrem/nCi) and 1000 nCi (0.8 mrem/nCi) (Ref. 44).

It is known that insufficient thyroid iodine content is undesirable and that humans in many parts of the world suffer from goiters due to deficiencies in iodine ingestion from available food sources (Ref. 45). The inverse of this condition (i.e., administration of large amounts of iodine) may also have an upper bound. For many years, one of the mitigative measures used to reduce thyroid exposures to persons potentially exposed to releases of radioiodine has been to administer large amounts of stable iodine, usually in the form of potassium iodine (KI) tablets. The National Council on Radiation Protection and Measurements (NCRP) has published reports on the function of stable iodine as a blocking mechanism, including recommended dosages and possible side effects (Refs. 46, 47).

For example, Ref. 47 states that "toxic reactions from a brief course of iodide treatment should be rare. A few individuals, however, are sensitive and may develop angioedema. Chronic iodide poisoning, or iodism, can also occur but only after ingesting iodides for several weeks or longer. Symptoms and signs include sialadenitis, rhinitis, conjunctivitis, headache, drug fever, and skin rashes. In either acute or chronic toxicity reactions, withdrawal of the medication and supportive care is all that is necessary and symptoms disappear with a few days." Reference 46 states that it has been determined that toxic effects of iodide are not noted with doses of 100 mg of iodine (130 mg of KI) per day given to children over a course of years and that iodide goiter will result only after daily doses of several hundred milligrams of iodide administered for years.

6.2.2 Carbon-14

To calculate impacts from ingestion of carbon-14 through food pathways, two basic mechanism for transfer of C-14 into and onto plants must be considered: (1) airborne settling of C-14 onto plant surfaces and uptake through photosynthesis, and (2) uptake through plant roots. Numerical factors used in the EIS to estimate transfer into plants by these mechanisms were those taken from U.S. NRC Regulatory Guide 1.109 (Ref. 48). A review was made of current work on these pathway mechanisms to determine whether updated transfer factors were appropriate for use within the impacts analysis methodology. This review suggested that a newer "specific activity model" may be a more appropriate model to use in connection with atmospheric releases of carbon-14 (Ref. 29). The review also suggested that the soil-to-plant uptake factors in Regulatory Guide 1.109 (Ref. 48) should be updated but that little or no work was being performed to determine more appropriate uptake factors (Ref. 29). A brief description of the results of this review follows:

Specific Activity Model

The specific activity model (Refs. 49, 50) is a more recent model used by some investigators to calculate total body exposure resulting from all pathways due to airborne C-14. The basic assumption of the model is that the fraction of the carbon pool in man's tissues which is maintained by ingestion approaches equilibrium consistent with the concentrations of airborne carbon at all sites of food production.

The basic structure of the specifc activity model is a multiplicative chain of parameters which relate the atmospheric specific activity (activity of the

radionuclide per mass of stable element) to the specific activity in the body. Dose equivalents are predicted using a dose rate factor appropriate for steady-state conditions when the body specific activity has approached equilibrium (Ref. 50). Under conditions of complete equilibrium:

$$\text{Annual Dose}_{ij} = (SpA)_i (DFR)_{ij}$$

where $(SpA)_i$ is the atmosphere specific activity relative to the radionuclide i of concern and its stable element, and $(DFR)_{ij}$ is the conversion factor that relates the body specific activty of radionuclide i and its stable element to a dose equivalent rate at equilibrium for a given organ tissue or the whole body (g). For C-14 the specific activity may be estimated using:

$$SpA = x/c$$

where x is the ground-level air concentration of C-14 (pCi/m^3), and c is the concentration of airborne carbon (g/m^3). The factor $(DFR)_{ij}$ for C-14 for total-body ingestion is given as 2.1×10^{-1} mrem/yr per pCi/g carbon.

A comparison between the whole body dose equivalent estimates for C-14 is made using the specific activity approach (Ref. 50) and the terrestrial pathway models in Regulatory Guide 1.109 (Ref. 48). A concentration of 1 pCi/m^3 was assumed for ground level atmosphere having a carbon content of 0.16 gm/m^3. This results in a ground level atmospheric specific activity of 6.25 pCi of C-14 per gram carbon. The maximum dose equivalent then becomes 1.3 mrem.

In Regulatory Guide 1.109 (Ref. 48) the specific activity approach is used to estimate the transfer of C-14 from air to vegetation. The concentration of C-14 per mass of vegetation (C_{iv}) is estimated in Regulatory Guide 1.109 by multiplying the vegetation specific activity by the fraction of the total mass of the edible tissue of vegetation assumed to be composed of carbon. For vegetation, 11% of the total fresh mass of edible tissue is assumed to be carbon. Using the Regulatory Guide 1.109 approach, a 1 pCi/m^3 concentration of C-14 in the above-ground atmosphere would result in a calculated vegetation concentration of:

$$\text{C-14} = (1\ \text{pCi/m}^3)(1/0.16\ \text{g/m}^3)(0.11)(100\ \text{g/kg}),$$

$$= 690\ \text{pCi/kg fresh weight.}$$

The terrestrial pathway models addressed in Regulatory Guide 1.109 include: air-vegetables-man, air-vegetation-milk-man, air-vegetation-meat-man, air-all terrestrial pathways-man. The results of these calculations are summarized below along with calculated the dose from the specific acivity model.

Pathway	Annual dose equivalent
Air-vegetables-man	2.3×10^{-1}
Air-vegetation-milk-man	7.3×10^{-2}
Air-vegetation-meat-man	6.7×10^{-2}
Air-all terrestrial pathways-man	3.7×10^{-1}
All pathways	1.3

The above assumes a 1 pCi/m^3 concentration of C-14 in aboveground air. The last entry in the table is the specific activity model estimate which assumes complete equilibrium between the atmospheric specific activity and the human body. Thus, the calculated dose equivalent represents a maximum upper-limit estimate.

The above comparison indicates that the calculated annual dose for all terrestrial pathways using the Regulatory Guide approach is approximately 28% of that using the specific activty model.

The second question which must be addressed, the accuracy and the viability of the soil-to-plant uptake factor utilized in the impact analyses, is not answered by the specific activity model. This uptake factor is implicitly included in the model.

Uptake Through Plant Roots

One of the difficulties in addressing exposures resulting from near-surface disposal of C-14 is that much of the uptake of carbon by a plant is assumed to occur through root uptake and utilizes a conservative soil-to-plant transfer factor (B_{iv}) factor set forth in Regulatory Guide 1.109 (Ref. 48). The soil-to-plant transfer factors (B_{iv}) in Regulatory Guide 1.109 were mainly calculated from the handbook assembled by Ng, et al. (Ref. 51). They were calculated as the ratio of the average concentration in food derived from plants to that in dry soil. While correct for the overwhelming majority of elements for which the soil-root system is the primary pathway (for most, the only pathway) for incorporation of radionuclides into the plant system, the primary pathway for incorporation of carbon in plants is the photosynthesis of CO_2 in air (Ref. 45). Thus, this "transfer factor" for carbon-14 simply represents a ratio of plant carbon to soil carbon and nothing more.

References 52 and 53 confirm that most carbon is obtained by higher plants from the air in the form of CO_2. Reference 53 further quotes a reference (Livingston and Beall, 1934) that concludes that as much as 5 percent or more of the CO_2 used by plants came from the soil. In another quote, reference 53 points out that investigations by Kursanov (1954) estimated that under their conditions, the abount of CO_2 absorbed by the roots is as much as 25 percent of that taken up from the atmosphere by the leaves.

6.3 Discussion and Conclusions

6.3.1 Iodine-129

Discussion

As discussed in the introduction to Section 5.6, there are two basic questions herein addressed. These questions are:

(1) Whether natural iodine will provide a means of limiting exposures (especially thyroid exposures) which may result from the near-surface disposal of waste containing I-129; and

(2) Whether it is possible to provide artificial dilution by disposing certain wastes together with material containing high concentrations of natural iodine.

In addition to the above two questions, there are two additional questions that have an important bearing on the issue of concern. These two questions are:

(3) Whether natural and/or artificially introduced stable iodine will behave chemically in a manner similar to radioiodine in the pathways of concern; and

(4) Assuming that stable and radioactive iodine chemically behave identically, whether the atom ratio I-129/I-127 resulting from either natural or artificially introduced stable iodine will remain approximately constant along the pathways of concern and thereby provide dilution.

Regarding the first question, some interest was raised by Appendix B of reference 54 which stated that provided that the atom ratio of I-129 to natural iodine in the thyroid was less than about 1/48 (0.02), exposures to the thyroid would be inherently limited to levels less than 1500 mrem/yr. Reference 54 then performed a calculation assuming a natural iodine concentration in soil of 1 ppm and delivery of 175 grams of I-129 shipped to a disposal site per year, and concluded that thyroid exposures due to I-129 would be indeed limited to levels less than 1500 mrem/yr. This calculation has been used as a basis by some for stating that I-129 need never be considered a problem in low-level waste disposal.

A calculation similar to the above may be performed using data assembled for the EIS. It was calculated in Section 5.6.1 that the expected generation rates of I-129 in routine radioactive waste are about 83.44 grams of I-129 per GW(e)-yr for PWRs, 379.75 grams of I-129 per GW(e)-yr for BWRs, and 343.56 grams of I-129 per year from other sources. Utilizing the estimated average capacity during the years 1980 to 2000 of 87,798 MW(e) for PWRs and 41,612 MW(e) for BWRs, and accounting for the contribution of other waste sources (a factor of 1.72 is incorporated to account for the assumed linear increase in the generation rate of waste from other sources), an average total generation rate of about 23,718 grams of I-129 per year can be calculated. This value corresponds to an activity of about 3.78 Ci/year. Normalizing these generation rates to the waste volumes assumed in waste spectrum 1 for the reference disposal facility results in a value of 6552 gm/yr (1.04 Ci/yr).

If one assumes that the wastes containing iodine are disposed together, and considering the average annual waste volumes of 42,038 m^3/year from all PWRs, 33,652 m^3/year from all BWRs, and an average of 3120 m^3/year (1814 x 1.72) from other sources (totaling 78,810 m^3/year), one may calculate an average concentration of about 0.30 g/m^3 of I-129 or 4.91×10^{-5} Ci/m^3. This value is about 150 time less than the concentration limit of 0.008 Ci/m^3 for Class A wastes given in the proposed Part 61 rule. However, if the average annual generation rate of all wastes (including those that are not expected to contain I-129) is

considered (about 1.72×10^5 m^3/year), this yields an average concentration of 0.14 g/m^3 of I-129, or 2.24×10^{-5} Ci/m^3.

Soldat (Ref. 43) agrees that an atom ratio of 1:48 for I-129/I-127 is required to limit thyroid exposures to 1500 mrem/year. This results in a concentration of 3.6 μCi of I-129 per gram of total iodine. Utilizing the specific activity of I-129 of 1.63×10^{-4} Ci/g, this yields a ratio of about 22 mg of I-129 per gram of total iodine. It would also be reasonable to assume that if this ratio were 1:960, the thyroid exposures would be limited to 75 mrem/year.

For purposes of illustration, assume an average concentration of total iodine in a soil/waste mixture of 5 ppm (i.e., 5×10^{-6} grams iodine per gram of soil/waste mixture which is not a conservative assumption) and a soil/waste mixture density of 1.6 g/cm^3. This yields a concentration of total iodine of about 8 g/m^3. This value, when used in conjunction with the values previously calculated for I-129 of 0.30 g/m^3 for wastes expected to contain I-129 and 0.14 g/m^3 for all wastes, would result in I-129/I-127 ratios of about 37.5 mg and 17.5 mg of I-129 per gram of stable iodine, respectively.

Further, assuming that I-127 in the soil/waste mixture behaves in a manner chemically similar to the I-129 in the waste, this calculation implies that natural dilution of iodine will not limit exposures to thyroid to levels below 1500 mrem/year if I-129 is assumed to be distributed throughout the wastes expected to contain I-129. However, it will limit exposures to below 1500 mrem/year if it is assumed to be distributed throughout all the wastes expected to be generated, which is a questionable premise. In neither case will natural dilution limit exposures to levels below 75 mrem/yr. Moreover, the assumption that the average concentration of natural iodine in the soil/waste mixture will be as high as 5 ppm is not conservative. The average concentration of natural iodine in soil is highly variable and the actual value is likely to be lower.

One big difference between the above calculation and the one in reference 54 is the assumed amount of I-129 delivered to the disposal site. Appendix B of reference 54 contains an assumption that 175 grams of I-129 is shipped to a disposal site per year. This is considerably different than the above calculated value of 6552 g/year shipped to the reference disposal site. Given this difference, additional information is needed on the actual content of I-129 within waste streams. This is being accomplished through an ongoing NRC contract involving measurements of a number of specific radionuclides (including I-129) within several waste streams.

Another problem is that both the above analysis and the one in reference 54 assume that the I-127 in the soil/waste mixture behaves in a chemically similar manner to the I-129 in the waste. This is a questionable premise since neither the chemical form of the I-129 in the waste nor the chemical form of the I-127 in the waste and soil are known. Assuming that stable iodine is to dilute uptake of I-129, then the stable iodine must be in a form which will dissolve at the same rate as the I-129 in waste and thus pass into groundwater for direct consumption or uptake by plant roots. There is no experimental evidence to support this supposition. In the case of natural iodine in soil, one can't help but suspect that the natural iodine is mostly in an insoluble form, since if it was in a soluble form it would have been long ago leached out of soils. As noted in Section 6.2.1, experiments to leach natural iodine

would have to leach at the same rate and pass through groundwater at the same speed as the radioactive iodine in order to arrive at the biota access location at the same time. Assuming that this is the case, about 15 grams of natural iodine-127 per m^3 of waste would be required to reduce the estimated average I-129 concentrations (about 0.30 grams per m^3 of waste expected to contain I-129) to an I-129/I-127 atom ratio dilution of 1:48 (i.e., a dose limit of 1500 mrem/year). About 300 grams of natrual iodine per m^3 of waste would required to reduce exposures to 75 mrem/yr.

However, the natural iodine thus employed would have to behave in a chemical manner similar to the I-129 contained in the waste. The chemical form of I-129 in the waste is not known at the present time. It appears that due to the complex behavior of iodine both in the plants and soil and the various organic and inorganic compounds it forms, a controlled series of experiments would be useful as a means of testing this approach.

Conclusion

It thus appears from the preceeding discussion that the answer to the first question posed above is probably negative, and the answer to the second question is maybe. It cannot be assumed that natural iodine within waste and soil will automatically in all cases limit thryoid exposures to levels less than 1500 mrem/yr. However, if the chemical form of I-129 in the waste is determined, and if a chemically compatible artificial iodine dilution material is employed, it may be possible to limit thyroid exposures from I-129 to levels consistent with the amount of stable iodine utilized.

The answer to the third and fourth questions posed above are implicit in the above conclusions. It is unlikely that natural iodine in soil will behave in a chemically similar manner to I-129 in the waste (natural iodine would likely have been leached out of the soil long ago if it were easily soluble in water; also see Section 6.2.1 and the solubility of natural iodine). It may be possible, however, to add compounds of iodine that will behave in a chemically similar manner to the contained I-129. The answer to the fourth question is believed to be positive; no evidence would be located to ascertain the opposite conclusion. As long as the solubility and chemical behavior of iodine in the waste and outside the waste are compatible, it is reasonable to assume that they will be present in the pathways to biota (including groundwater) in the same proportion.

In the impact analyses methodologies utilized in this EIS, no credit was assumed due to the presence of stable iodine in the soil/waste mixture. As it is pointed out above, NRC staff believes that prior to taking such credit, the chemical form of the I-129 in the waste and of the I-127 in the soil should be ascertained. Consequently, this question can not be addressed and resolved in this EIS. However, if a fraction of the natural stable iodine in the soil is demonstrated to be similar in solubility and chemical behavior to the I-129 in the waste, then this ratio may be utilized to reduce the calculated exposures.

6.3.2 Carbon-14

Incorporating the specific activity model into the impacts analysis methodology used for this EIS is expected to have a negligible effect on the exposures

calculated for carbon-14. This is because the calculated exposures due to carbon-14 are dominated (by about a factor of 100) by the root-uptake pathway.

Unfortunately there has been relatively little interest by investigators to provide an updated soil-to-plant root transfer factor. Although it is known that most carbon taken up by plants is through leaves, little data could be found to be able to predict the relative fractional amount that would be taken up by roots, and under what physical and chemical conditions. For example, it is known that carbon dioxide will dissolve in groundwater (Ref. 55) (and thus become available for root uptake), but it is difficult to predict the extent of this occurrence.

The limited data that could be collected suggests that from 5 to 25 percent of plant carbon is taken up by plant roots. Assuming that the soil-to-plant transfer factor for C-14 was reduced by a factor of 10, then C-14 exposures due to food pathways would also be reduced by a factor of 10. Similarly, groundwater impacts at the well water access points would be reduced by a factor of 4 while surface water impacts would be reduced by a factor of 1.5. Given the limited data available, however, no credit for the potential reduction in the root uptake transfer factor was taken at this time. It appears that a more detailed study on C-14 uptake under different environmental conditions is warrented.

7. DISPOSAL LIMITS FOR TRANSURANIC ISOTOPES

As part of the work performed for the draft EIS and proposed Part 61 regulation, a waste classification system was developed which involved 3 waste classes: Class A, Class B, and Class C. Limits for a number of individual transuranic isotopes were calculated. These individual isotopic limits were then reduced to a limit for the isotope Pu-241 (a beta emitter) plus a cumulative limit for all alpha emitting transuranic isotopes having half-lives greater than 5 years. These limits were 350 nCi/gm for Pu-241 and 10 nCi/gm for the alpha emitting nuclides.

For the final EIS and Part 61 rule the limits calculated for the classification system have been reassessed. In particular, a more refined method for considering the ingrowth of transuranic daughter products (see Section 5.2) has been incorporated into the impact analysis methodology. In addition, commenters to the proposed Part 61 rule have offered a suggestion that waste which has been disposed as Class C waste will be covered by at least 5 meters of earth and lower activity Class B waste and therefore should still be difficult to contact even after 500 years. Other commenters have suggested that NRC consider dilution by lower activity waste streams. To determine impacts of disposal of larger amounts of transuranic waste, after calculating classification limits based upon the more refined method for determining decay chain ingrowth, the calculated Class C waste disposal limits have been raised by a factor of 10. This additional factor of 10 credit has been assumed for Class C waste disposal to account for the dilution provided by the earth and other waste. The disposal limits thus obtained are listed below in units of nCi/cm^3 for individual radionuclides.

TRU classification limits (nCi/cm³)

Isotope	Class A	Class B	Class C
Np-237	4.1	340	41
Pu-238	28	2300	6800
Pu-239/40	10.4	860	105
Pu-241	270	22,300	4900
Pu-242	11	610	110
Am-241	7.9	920	140
Am-243	6.6	550	68
Cm-243	62	5,100	78,000
Cm-244	540	45,000	41,000

As shown, for many isotopes the limits calculated for Class B disposal exceed those calculated for Class C disposal. These isotopes include Np-237, Pu-239/40, Pu-242, Am-241, Am-243, and Cm-244. This is because the potential hazard of these isotopes outlasts the assumed effectiveness of the improved waste form or packaging. Reliance is instead placed upon the 5 meter (or equivalent) intruder barrier to limit impacts. This means that for these isotopes (and for most waste containing TRU nuclides in concentrations exceeding the Class A limit), there are really no Class B limits. The classification system for transuranics and other long-lived isotopes can be thus simplified to two classes: Class A and Class C. This will ease the effort on the part of licensees to comply with the waste classification system.

Another way to ease the process of compliance with the waste classification system would be to combine the individual isotopic limits into a single limit to be complied with. In general, it is believed that fewer individual limits to compare against (fewer specific isotopes to determine) will result in easier compliance. As before, it is believed that the easiest approach will be to separate the limit for Pu-241 from the limit for the longer-lived transuranic isotopes. Plutonium-241 is a beta emitter having a 13.2 year half-life and decaying to Am-241. It comprises a significant fraction of the transuranic activity observed in waste streams generated by nuclear power plants and other NRC licensees. Another short-lived isotope comprising a significant fraction of the activity observed in the above waste streams is Cm-242. This is an alpha emitter having a 162.5 day half-life and decaying to Pu-238.

Setting separate limits for Pu-241 and Cm-242 is expected to ease compliance for most NRC licensees. Setting out separate limits for other isotopes is not believed at this time to be generally cost effective for most NRC licensees.

The isotopic limits for the remaining longer-lived transuranic isotopes are as follows (in nCi/cm³):

Concentration limits for alpha-emitting TRU isotopes (nCi/cm^3)

Isotope	Class A	Class C
Np-237	4.1	41
Pu-238	28	6800
Pu-239/40	10.4	105
Pu-242	11	110
Am-241	7.9	140
Am-243	6.6	68
Cm-243	62	78,000
Cm-244	540	41,000

One option for reducing the above list of nuclides to a single gross alpha limit would be to assume the limit for the most restrictive isotope. This would be Np-237. This is believed to be overly restrictive, however, since Np-237 is projected to be contained in low-level waste in only very tiny quantities. A better approach would be to consider the isotopic distribution expected to be in typical low-level waste streams. This distribution is expected to be different for individual waste streams. Based upon the data base assembled for the Part 61 EIS, the equivalent gross alpha limits for both waste classes for the waste streams expected to contain the above transuranic nuclides are as follows:

Equivalent gross alpha concentration limits (nCi/cm^3)

Waste stream	Class A	Class C
P-IXRESIN	14.6	230
P-CONCLIQ	14.6	233
P-FSLUDGE	9.6	178
P-FCARTRG	13.1	177
B-IXRESIN	15.6	244
B-CONCLIQ	18.8	571
B-FSLUDGE	17.6	295
P-COTRASH	14.0	207
P-NCTRASH	14.0	207
B-COTRASH	18.1	300
B-NCTRASH	18.1	300
L-DECONRS	13.8	173
N-ISOPROD	25.4	621
F-PUDECON	10.3	113

These numbers were calculated from the relationship:

$$1/\Sigma\left\{\frac{\text{isotopic fraction}}{\text{isotopic class limit}}\right\}.$$

In this relationship, the "isotopic fraction" is the fractional amount of a particular isotope across the total alpha-emitting transuranic isotope distribution within the waste stream considered. The "isotopic class limit" is the classification limit obtained for that particular isotope as summarized above.

As shown, the equivalent Class A gross alpha limit for the waste streams expected to contain transuranics is in a fairly narrow range--i.e., from about 10 to about 20 nCi/cm^3. Only one stream exceeds 20 nCi/cm^3. The spread for Class C waste streams is larger. However, only two waste streams are above 300 nCi/cm^3. The other 12 streams range from 100 to 300 nCi/cm^3. Given the ranges calculated, it is apparent that some judgment is required in converting to working gross alpha limits for the two classes.

Historically, limits for transuranic waste disposal have been given in units of nCi/gm rather than nCi/cm^3. The density of waste streams expected to contain transuranics will fluctuate. This range in densities may be possibly as much as one to six gm/cm^3, but are believed to be typically in the range of one to two gm/cm^3. This would result in a range of 5-20 nCi/gm for Class A waste and 50-300 nCi/gm for Class C waste. An average value of 1.6 gm/cm^3 would result in a range of about 6 to 13 nCi/gm^3 for Class A waste and 60 to 190 nCi/gm for Class C waste.

Thus, it appears from the above considerations that a reasonable generic gross-alpha limit for commercial waste disposal would be 10 nCi/gm for Class A waste and 100 nCi/gm for Class C waste. There may be a number of other considerations which could be cited as rationales for raising or lowering the above limits. These can include differences in waste masses, dilution by lower activity wastes, increased use of volume reduction techniques, "de minimus" waste disposal, improvements in health physics considerations, and site-specific environmental conditions. However, it would appear that there are about an equal number of tendencies one way as another. For example, the potential for dilution by lower activity waste streams may be offset by improvements in health physics, site-specific environmental conditions and increased use of volume reduction.

In the analysis for the Part 61 EIS, NRC staff have determined that the 10 nCi/gm limit for Class A waste and the 100 nCi/gm limit for Class C waste will result in a high probability that the intruder performance objective will not be exceeded at any new site. With the above limits, the waste volume-averaged intruder impacts calculated at 500 years after facility closure ranged in the final EIS from about 8 to 170 mrem per year to bone over the 4 regional disposal sites. The calculated impacts appear to be sufficiently below the 500 mrem/year limit that the intruder performance objective should be achievable at all new disposal sites considering uncertainties.

The 10 and 100 nCi/gm limits also appear to be reasonable from institutional considerations. Commercial disposal sites will be generally located on land owned by the States. Unlike federal installations, the disposal sites will probably not be part of a huge nuclear installation or a national laboratory, but will be a few hundred acres existing by themselves. Thus, inadvertent intrusion may be more likely at commercial sites. The sentiment has been expressed by several persons that the states should really only be responsible for disposal of wastes which are expected to be fairly innocuous after a few hundred years. This means that the sites would be mainly restricted to short to moderately lived radionuclides and contain only small quantities of long-lived toxic radionuclides. The 10 and 100 nCi/gm limits are in keeping with this sentiment. Ten nCi/gm would be the limit for disposal within a very few feet of the earth's surface, where contact by humans has a reasonable possibility of occurrence. An extra requirement of 5 meters disposal depth for Class C waste provides additional protection in compensation for the higher allowable Class C waste transuranic limit.

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APPENDIX D

COMPUTER CODES USED FOR FINAL ENVIRONMENTAL IMPACT STATEMENT CALCULATIONS

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APPENDIX D

COMPUTER CODES USED FOR FINAL ENVIRONMENTAL IMPACT STATEMENT CALCULATIONS

1. INTRODUCTION

This appendix presents two computer codes that were used to perform calculations for the final EIS, as well as the data files used to provide input parameters to the codes. Five computer codes--INTRUDE, OPTIONS, GRWATER, INVERSI, and INVERSW--were prepared and used in the draft EIS and a description of these codes is provided in Appendix H to the draft EIS. This appendix discusses revised versions of the OPTIONS and GRWATER codes, termed the OPTIONR and GRWATRR codes, respectively. These two revised codes are very similar to the existing OPTIONS and GRWATER codes in terms of subroutines, variable names, and calculational procedures. The principal difference from the existing OPTIONS and GRWATER codes is in the manner in which the waste classification test procedure is handled. Another difference is the ability in the two revised codes to address wastes having distributed activities.

The remainder of this appendix discusses in more detail the waste classification test procedure used in the two revised codes, followed by a brief discussion of other features of the revised codes. The structure of the data files read to both codes is then discussed, followed by a presentation of the input variables required to run the codes. Finally, listings of the codes and accompanying data files are presented.

2. REVISED WASTE CLASSIFICATION TEST PROCEDURE

In the existing OPTIONS and GRWATER computer codes, a waste classification test procedure is used in which the characteristics of individual waste streams are first fixed (through a choice of a waste spectrum), the intruder impacts of each of the waste streams are calculated for different disposal technologies (e.g., regular disposal, layering, use of a hot waste facility), the resulting impacts compared to a numerical dose limitation criterion (e.g., 500 mrem/yr whole body), and the waste streams finally classified. Following this, impact measures such as costs, volume-averaged intruder impacts, and groundwater impacts are calculated. This waste classification test procedure is described in Section 1.4, Appendix H, of the draft EIS, and was particularly useful during the analyses performed in the draft EIS to determine performance objectives for low-level waste disposal.

The two revised computer codes--OPTIONR and GRWATRR--are very similar to OPTIONS and GRWATER but utilize a different waste classification test procedure. This was done to increase the flexibility of the impact analysis methodology and to provide a more refined analysis of particular Part 61 technical criteria. Rather than comparing potential inadvertent intruder exposures to a set of dose limitation criteria, the revised test procedure compares individual radionuclide concentrations in waste streams to a set of limiting radionuclide concentrations in particular waste classes. The waste stream is then classified (e.g., as Class A, Class B, or Class C). Depending upon the classification status of

the waste, there may be a requirement to process the waste into a stable form, dispose of it in a stabilized manner at a disposal facility, or stabilize the waste and dispose of it using an intruder barrier. The waste stream may even be classified as being not generally acceptable for near-surface disposal.

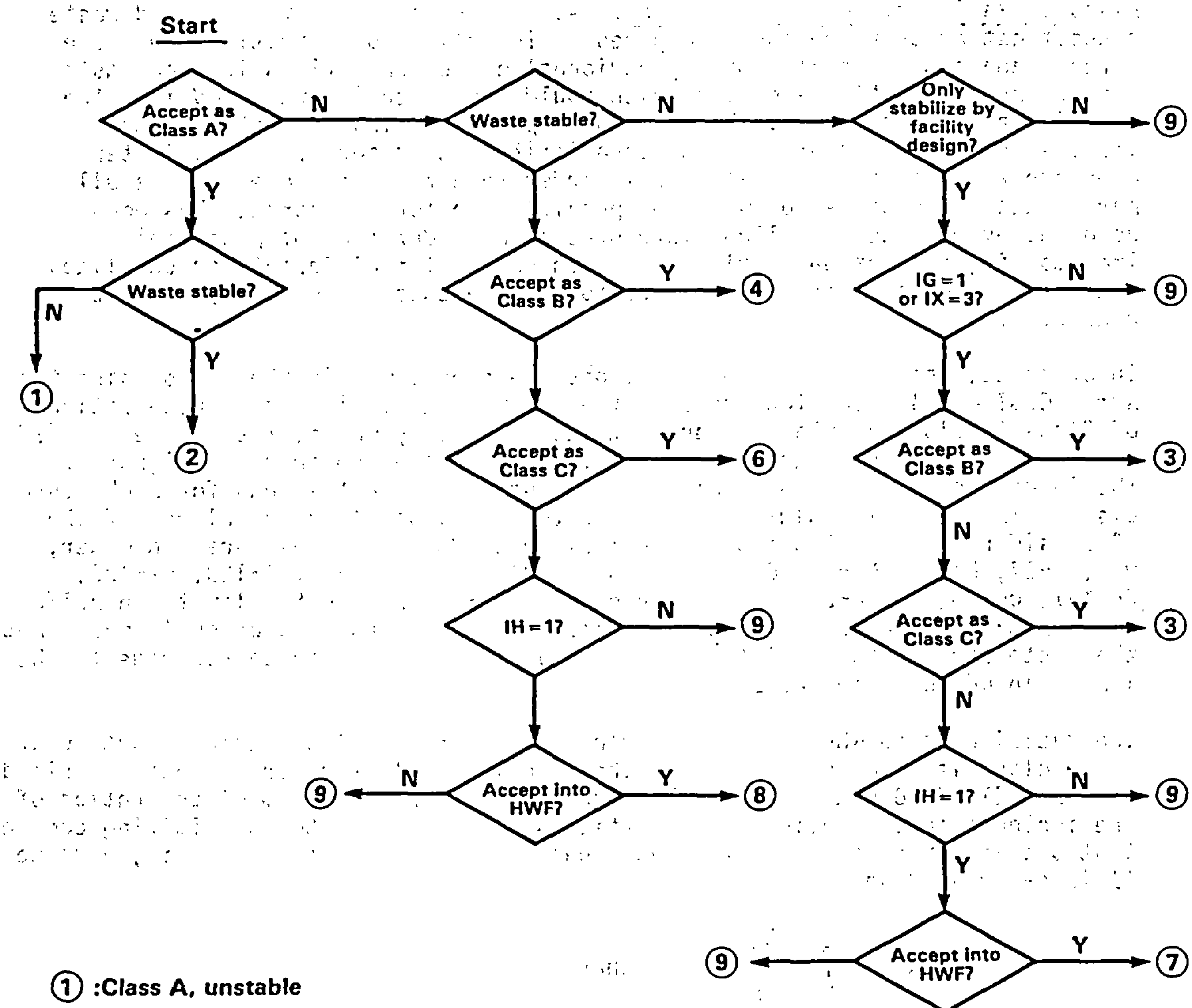
A flow diagram of the waste classification test procedure used in the OPTIONR and GRWATRR computer codes is provided as Figure D.1. Briefly, the test procedure operates as follows. First, a waste spectrum is chosen which establishes particular characteristics for each waste stream, particularly the radionuclide concentrations and whether the waste stream is in a stable form. The radionuclide concentrations for each waste stream are then compared against a set of limiting concentrations for Class A waste disposal. If the waste stream concentrations are less than the limiting Class A waste concentrations, then the waste stream is classified as Class A waste and a determination must be made as to whether the waste stream is stable or unstable. If unstable, it is disposed of into a Class A unstable waste disposal unit. If stable, it is disposed of into a disposal unit along with stable Class B and C wastes.

If the radionuclide concentrations in the waste stream exceed the limiting Class A waste concentrations, then the waste stream must be stabilized and tested to determine if it meets limiting concentrations for Class B and C wastes. Such waste stabilization may be accomplished for a given waste stream by either specifying a particular improvement in waste form and packaging or by a particular disposal facility design. The test procedure compares the waste radionuclide concentrations against the Class B and C limits using a number of possible stable waste forms and packages or facility designs which achieve stabilization. If there are no such waste forms, packaging techniques, or facility designs which can achieve a stable waste having radionuclide concentrations less than the Class C values, then the waste stream is considered not acceptable for near-surface disposal.

It may be noted that if the waste stream exceeds the Class C waste limits, then the testing procedure includes the provision for optional disposal by a disposal method giving greater confinement than near-surface disposal. In the draft EIS and data base, this has been generically referred to as a "hot waste facility." To date, no disposal criteria has been developed by NRC for disposal by such improved methods over near-surface disposal. However, inclusion of this option in the codes at this time will help to develop future such criteria (as necessary) in a rapid manner.

The mechanisms of the test procedure involves a number of concepts, including:

- The use of lists of limiting radionuclide concentrations.
- Use of a waste classification alternative based upon existing disposal facility license conditions.
- Optional stabilization through disposal facility design.
- Optional stabilization through waste form or packaging.
- Use of the IMOD array to track the classification status of waste streams.



(1) :Class A, unstable
(2) :Class A, waste form or packaging stable
(3) :Class B, stabilized through disposal facility design
(4) :Class B, waste form or packaging stable
(5) :Class C, stabilized through disposal facility design
(6) :Class C, waste form or packaging stable
(7) :Hot waste, stabilized through disposal facility design
(8) :Hot waste, waste form or packaging stable
(9) :Waste spectrum must be changed and the testing procedure restarted

Figure D.1 Revised Waste Classification Test Procedure

- Waste streams having distributed activities.

- Use of two different disposal technologies at the same disposal facility.

Lists of Radionuclide Concentrations. As discussed above, the revised waste classification test procedure compares radionuclide concentrations in waste streams against lists of limiting radionuclide concentrations in each waste class. An alternative approach which could have been incorporated into the classification scheme would be to compare potential inadvertent intruder impacts against a set of limiting dose limitation criteria. (This latter approach was used in the draft EIS in order to arrive at preferred overall performance objectives for waste disposal.) The former approach has been used, however, since it allows more precise consideration of potential impacts of different waste classification values for different radionuclides and it is also more directly related to requirements to be met by a waste generator.

In practice, the limiting concentrations are stored within the codes using the array CLST(4,16). The four rows of the array signify limiting concentrations of Class A, Class B, Class C, and hot waste facility waste, respectively. (If there is no hot waste facility--i.e., IH=0--then the fourth row is ignored.) The 16 columns signify the limiting radionuclide concentrations for each waste class. The first 14 columns correspond to the first 14 radionuclides of the 23 considered in the EIS impacts analysis methodology. These are, in order, H-3, C-14, Fe-55, Ni-59, Co-60, Ni-63, Nb-94, Sr-90, Tc-99, I-129, Cs-135, Cs-137, U-235, and U-238. The 15th column corresponds to the limit (in $\mu Ci/cm^3$) for alpha-emitting transuranic nuclides. (Generally an assumption is made that the waste density is equal to 1.6 gm/cm^3.) The 16th column corresponds to the limit (in $\mu Ci/cm^3$) for Pu-241.

The decision as to whether a particular waste stream falls within a particular waste class is made using a sum-of-the-fractions rule similar to that described in Table II of 10 CFR Part 20. This rule states that the sum of the ratios of the isotopic concentrations in a particular waste stream to the limiting concentrations in a particular waste class shall not exceed unity. That is, a value A1 is calculated which is equal to:

$$A1 = \frac{C_a}{C_a'} + \frac{C_b}{C_b'} + \frac{C_c}{C_b'} + \ldots, \text{ where}$$

C_a, C_b, and C_c = concentrations in waste of isotopes a, b, and c; and

C_a', C_b', and C_c' = limiting concentrations in a given waste class for isotopes a, b, and c.

If $A1 \leq 1$, then the waste stream is classified as being acceptable for the waste class considered. If $A1 > 1$, then the waste stream is classified as being unacceptable for the waste class considered.

Use of a Waste Classification Alternative. As an option, an alternative procedure is included for determining limiting concentrations for Class A waste. This alternative is included to provide an assessment of the impacts of existing license conditions at LLW disposal facilities. In this alternative, the normal

sum-of-the-fractions rule is not applied. Rather, a limit of 1 μCi/cm³ of non-transuranic isotopes having half lives greater than 5 years is applied to light water reactor (LWR) process waste streams (filter sludges, ion exchange resins, solidified concentrated liquids, and cartridge filters) as well as waste from isotope production facilities. For such waste streams, if the concentration of any nontransuranic isotope having a half life greater than 5 years exceeds 1 μCi/cm³, then the waste stream is not acceptable as Class A waste and must be stabilized prior to disposal. For all other waste streams, no Class A concentration limits are imposed.

Under this alternative, classification of transuranic radionuclides is also modified. Current license conditions impose a 10 nCi/gm limit on transuranic waste disposal. These license conditions generally allow disposal of transuranics up to the 10 nCi/gm limit as long as the transuranics are homogeneously distributed through the waste. Surface contaminated materials are often prohibited. Occasionally, homogeneously contaminated waste streams such as ion exchange resins are generated which exceed the 10 nCi/gm limit, almost always due to short-lived alpha emitters such as Cm-242 (163 day half life) or to Pu-241, which is a beta-emitter having a 13.2 year half life. In such cases, waste generators will either dilute such waste with lower activity waste (still retaining a homogeneous mixture) or allow the short lived radionuclides to decay to levels less than 10 nCi/gm prior to shipment.

Not to account for the above practices would incorrectly skew the results of the cost-benefit analysis in favor of the final Part 61 requirements. To provide a more accurate analysis under this alternative classification scheme, therefore, the Pu-241 concentrations within LWR process waste streams and isotope production waste are decayed to their alpha-emitting equivalents. No such decay is performed for trash or other waste streams which cannot be assumed to be homogeneously contaminated and may be composed of surface-contaminated materials.

The manner in which the above classification alternative is triggered in the computer codes is discussed in Section 6 of this Appendix (See Table D.2).

Stabilization through disposal facility design. One option for waste stabilization is through disposal facility design--for example, by grouting the waste mass, using extreme compaction techniques on the disposed waste, or by disposal into a hot waste facility--rather than the more common method of improved waste form and packaging. This option may be specified for a particular waste stream through use of an array, NDXS(I), which is read into the program and which has a number of other functions besides signifying stabilization through facility design. A valve for NDXS is assigned to each waste stream as follows:

NDXS (ISTR) =	Meaning
2	Normal waste stream, stabilize through disposal facility design
1	Normal waste stream
0	Exclude stream from analysis
-1	Distributed waste stream
-2	Distributed waste stream, stabilize through disposal facility design

As shown, if a waste stream has a value NDXS (ISTR) = ±2, then it is to be stabilized through a special disposal facility design (e.g., setting the stable waste IRDC indices ID=2, or IG=1, or IX=3, or IH=1). If no such design is specified, the programs will automatically fall back on the procedure (discussed below) of achieving waste stabilization through waste form and packaging. As shown, the NDXS array has other functions which consist of (1) flagging waste streams for which the radionuclide concentrations are given as a distribution rather than an average across the stream (NDXS < 0), and (2) flagging waste streams which are to be excluded from analysis. The former function is discussed in more detail below. This latter function is useful for assessing the relative impacts of one or a group of selected waste streams.

Stabilization Through Waste Form or Packaging. As discussed above, if a waste stream is in an unstable form and exceeds Class A waste limitations, it must be placed into a stable form and tested against the Class B and Class C limits. This is accomplished in the codes by changing the waste spectrum for the stream and comparing the resulting waste radionuclide concentrations which would result from the processing option associated with the new waste spectrum against the class limits. The order in which the successive waste spectra are considered is read into the codes as an input variable. This procedure can be illustrated by using an example.

Consider the possible processing options considered in the EIS for PWR ion exchange resins. In waste spectra 1 and 6, the resins are dewatered, in waste spectrum 2 half of the resin volume is solidified in cement and half in vinyl ester styrene, and in waste spectrum 3 the resins are all solidified in vinyl ester styrene. In waste spectrum 4 the resins are incincerated prior to solidification in vinyl ester styrene, and in waste spectrum 5 the resins are placed into high integrity containers (HICs). Now assume that when the resins are in an unstable dewatered form (waste spectrum 1) the concentration of a particular radionuclide is 100 Ci/m^3. The concentration of this radionuclide in each of the other spectra is, after the appropriate waste processing techniques are employed:

	Spectrum 1	Spectrum 2	Spectrum 3	Spectrum 4	Spectrum 5	Spectrum 6
Stability:	unstable	stable	stable	stable	stable	Unstable
VRF:*	1.0	1.0	1.0	18.0	1.0	1.0
VIF:	1.0	1.65	2.0	2.0	1.0	1.0
Conc. (Ci/m^3)	100	61	50	900	100	100

*VRF: Volume reduction factor
VIF: Volume increase factor

Further assume that the limiting concentrations for this radionuclide are Class A: 0.1 Ci/m^3, Class B: 55 Ci/m^3, and Class C: 800 Ci/m, and that there is no "hot waste facility" at the disposal site. For this example, the order of the waste spectra to be considered is taken to be spectrum 1 followed by spectra 2, 3, 4, 5, and 6. Now using the classification test procedure shown in Figure D.1, the classification procedure would first determine that the waste stream is unstable and furthermore, exceeds the radionuclide concentration limit

for Class A waste. The program would then switch to waste spectrum 2 for this stream and determine that it qualifies as Class C waste. An alternative example waste spectra order could have been 1, 3, 2, 4, 5, and 6. In this case, the waste stream would have been disposed as Class B waste according to the waste concentration given by waste spectrum 3. Finally, consider the waste spectrum order 4, 1, 5, 2, 3, 6. In this case, the waste stream would have initially (waste spectrum 4) exceeded Class C concentrations. The program would have switched to waste spectrum 1, only to determine that the waste stream exceeds Class A concentrations. The program would have then switched to waste spectrum 5 and determined that the waste could be disposed in an HIC as Class C waste.

This test procedure is carried out for each waste stream. The waste spectrum that each waste stream eventually falls into is retained and used when determining overall impact measures.

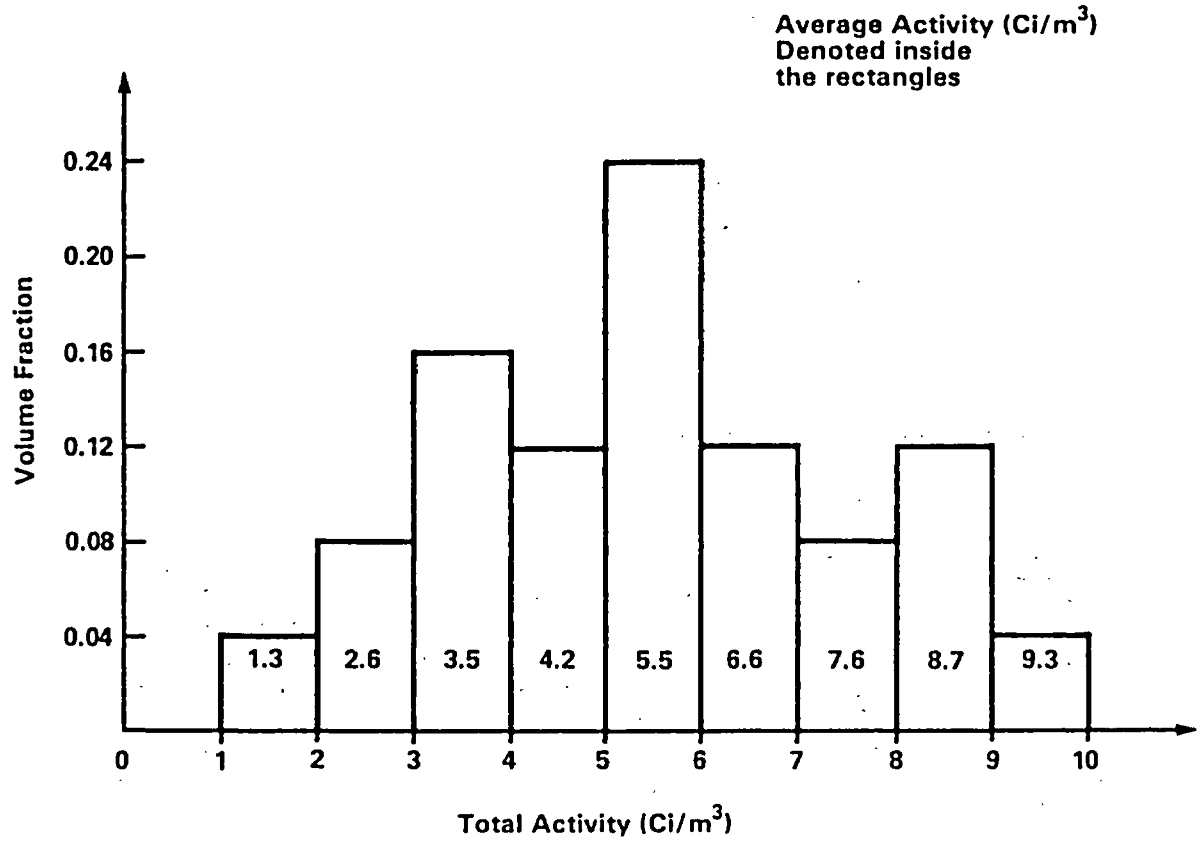
In the OPTIONR and GRWATRR codes, the order that the waste spectra are considered is provided as an input variable through use of the six-member integer array IORDD.

The IMOD Array. The IMOD array is an array used to keep track of the classification status of a given waste stream within the OPTIONR and GRWATRR codes. Values assigned to the array are integers ranging from 1 to 9 as shown on Figure G.1. An IMOD value equal to zero signifies that the waste stream has been determined to be unacceptable for near-surface disposal.

Distributions. It is recognized in the draft EIS and the accompanying data base that in practice there exists a wide variation in the average total activity of almost all of the waste streams shipped for disposal. This variation results from many factors including different waste management practices by the waste generator, different ages and designs of waste generating facilities, and so forth. One of the more desirable changes to the impact calculation codes would be the capability to consider an arbitrary variation in the total activity of individual waste streams (as opposed to the technique of assuming a fixed average radionuclide activity over a waste stream).

The variation in these waste streams can be expected to follow a rough gaussian- or poisson-type distribution with less waste at the extreme high and low ends of the total activity, and an aggregation of the waste volumes at the middle of the distribution. The significance of this distribution is the fact that some portion of the waste (at the lower end) may be acceptable for disposal as unstable Class A waste, some portion of the waste may be acceptable as Class B waste, another portion of the waste may be acceptable as Class C waste, and some may not be considered generally acceptable for near-surface disposal.

To illustrate the data needed to determine activity distributions, as well as to illustrate how the activity distributions are stored and used in the OPTIONR and GRWATRR codes, a hypothetical example distribution is presented in Figure D.2. For this hypothetical example, data are assumed to have been collected which show that the gross activity of the waste stream ranges from 1 to 10 Ci/m^3. Based upon this data, the range of possible activities has been divided into 10 increments--e.g., 1-2 Ci/m^3, 2-3 Ci/m^3, etc. For each increment the fraction of the total waste volume which has an activity falling within the increment is determined, as well as the average activity of the waste within



ARRAYS

CL	0	1	2	3	4	5	6	7	8	9	10
PV	0	0	.04	.12	.28	.40	.64	.76	.84	.96	1.0
AA	0	0	1.3	2.17	2.93	3.31	4.13	4.52	4.81	5.30	5.46

Figure D.2 Example Total Activity Distribution

the increment. For example, 24% of the waste is shown to fall within an increment of between 5 and 6 Ci/m^3 and have an average activity of 5.5 Ci/m^3.

Based upon this data, three one-dimensional arrays are specified which contain the following information:

(1) The array CL, which contains for each increment the upper value of the activity within the increment;

(2) The array PV, which contains for each increment the cumulative fraction of the waste which have activities less than the upper value of the particular increment; and

(3) The array AA, which contains for each increment the average activity across the cumulative fraction of waste defined by the array PV.

These three arrays, and the values assigned to the arrays according to the example, are shown in Figure D.2.

This procedure is general--that is, it can be applied to any waste stream for which an activity distribution is known. For the final EIS, such information is available for 6 light water reactor (LWR) process waste streams: pressurized water reactor (PWR) ion-exchange resins, PWR filter sludge, PWR concentrated liquids, boiling water reactor (BWR) ion-exchange resins, BWR filter sludge, and BWR concentrated liquids. Distribution data used for the 6 LWR waste streams are presented in Table C.36 (see Appendix C). Using this data, 14 activity increments are used from 0.00018 Ci/m^3 to 350+ Ci/m^3. A distributed waste source is also assumed for the mixed oxide (MOX) facility decontamination stream (F-PUDECON). Data for this MOX facility decontamination stream are presented in Section 4 of Appendix C. Three activity increments are assumed for this stream ranging from 0.001 Ci/m^3 to 0.1+ Ci/m^3.

The fact that the activity of some of the waste streams is given as a distribution rather than as an average over the stream complicates the waste classification test procedure described above. This results from the likelihood that a certain fraction of a distributed waste stream may be determined to be Class A, another fraction may be determined to be Class B, and so forth. In addition, each time that a fraction of a waste stream is classified, the distribution of activity across the remaining fraction must be recalculated.

Briefly, the classification test procedure for distributed waste streams works as follows:

(1) obtain an upper total activity value by comparing to a set of radionuclide concentrations which will permit disposal of the waste in the waste class for which it is being considered,

(2) based on the array CL defined above, identify the fraction of the waste acceptable in this class (interpolating where necessary),

(3) take out the fraction which has been found to be acceptable from the distribution and redefine the waste distributions, and

(4) reconsider the new distribution for further classification.

One point of note concerns the manner in which the fraction of the waste volumes in a distribution that are found to be unacceptable during a given classification test are considered. These unacceptable waste volumes are classified as an additional new waste stream and considered separately.

The interpolation and redistribution scheme can be mathematically illustrated in the following manner. Assume that the following data exists regarding the distribution of activity within a given waste stream:

Range	Volume Fraction	Avg. Activity in Range
$0-c_1$	v_1	a_1
c_1-c_2	v_2	a_2
c_2-c_3	v_3	a_3
c_3-c_4	v_4	a_4
etc.	etc.	etc.

As discussed above, this data may be stored in 3 arrays--CL(I), PV(I), and AA(I)--in the following manner:

Maximum in Range	Cumulative Fraction	Average Activity to Maximum in Range
CL(1) 0	PV(1) 0	AA(1) 0
CL(2) C_1	PV(2) $V_1=v_1$	AA(2) $A_1=a_1$
CL(3) C_2	PV(3) $V_2=v_1+v_2$	AA(3) $A_2 = \frac{v_1a_1 + v_2a_2}{v_1 + v_2}$
(C^*)	(V^*)	(A^*)
CL(4) C_3	PV(4) $V_3 = \sum_{i=1}^{3} v_i$	AA(4) $A_3 = \frac{\sum_{i=1}^{3} v_ia_i}{\sum_{i=1}^{3} v_i}$
CL(4) C_4	PV(5) $V_4 = \sum_{i=1}^{4} v_i$	AA(5) $A_4 = \frac{\sum_{i=1}^{4} v_ia_i}{\sum_{i=1}^{4} v_i}$
etc.	etc.	etc.

As shown, the first member in each array is equal to zero, and the total number of members in each array is 16.

Over all levels of activity, the ratio of the concentration of one isotope to the next is assumed to be constant. Given this, assume that the concentration of a given isotope is given by X_i and the limiting concentration of that isotope for a given waste class is given by Y_i. Then the limiting gross activity of that stream for the given waste class is found by the following:

$$C^* = \frac{\sum_{i=1}^{NNUC} X_i}{\sum_{i=1}^{NNUC} \frac{X_i}{Y_i}}, \text{ where}$$

NNUC = number of radioisotopes.

The range into which C* falls may be then determined and the corresponding cumulative fraction and average activity up to the value C* may be determined through interpolation.

For example, assume that $C_2 < C^* < C_3$. Then, the corresponding cumulative fraction (V*) up to C* is given by:

$$V^* = V_2 + \frac{(V_3 - V_2)(C^* - C_2)}{(C_3 - C_2)}$$

The average activity (A*) up to C* is given by:

$$A^* = A_2 + \frac{(A_3 - A_2)(C^* - C_2)}{(C_3 - C_2)}$$

The fraction of the waste stream having an activity between zero and C* Ci/m^3 is removed and classified as falling into the waste class tested for. The average concentration of individual radionuclides within this fraction may be readily determined and environmental impacts calculated. However, prior to testing the remaining fraction of the waste stream against the radionuclide concentration limits for a higher waste class, the activity distribution across the remaining fraction of the waste stream is recalculated. Again using the above examples, the values for the CL, PV, and AA arrays are recalculated as follows:

Maximum in Range		Cumulative Fraction		Average Activity to Maximum in Range	
CL(1)	0	PV(1)	0	AA(1)	0
CL(2)	0	PV(2)	0	AA(2)	0
CL(3)	C*	PV(3)	V*	AA(3)	A*
CL(4)	C_3	PV(4)	$V_3 - V^*$	AA(4)	$\frac{V_3A_3 - V^*A^*}{V_3 - V^*}$
CL(5)	C_4	PV(5)	$V_4 - V^*$	AA(5)	$\frac{V_4A_4 - V^*A^*}{V_4 - V^*}$

The above process is repeated for the next classification text.

For calculational convenience in the computer codes, the above three one-dimensional arrays are merged into a single three-dimensional array DIST(I,J,K).

Different Disposal Technologies

This feature involves the practical fact that unstable wastes (i.e., that portion of the Class A group that are unstable) may be disposed of using different disposal practices than stable wastes, and will likely involve different levels of long-term environmental releases and site maintenance. The primary effect of considering two different disposal technologies at the same disposal facility is during the calculation of certain impact measures such as costs, transportation impacts, etc.

In the GRWATRR and OPTIONR codes two different sets of disposal technology indices (see Table D.2) are read in, and two different sets of impact measures are calculated. For example, in the GRWATRR code, groundwater migration impacts are first calculated for unstable waste streams and then for stable waste streams; finally total impacts over all waste streams are calculated. A similar approach is taken in the OPTIONR code for impact measures such as occupational exposures, transportation impacts, land use, costs, and so forth. In particular, disposal and post-operational costs are calculated according to the following procedure:

(1) All the lump-sum capital expenditure items for the disposal technologies are waste volume prorated into two waste groups: stable and unstable waste. For example, if there are 600,000 m^3 of unstable waste acceptable for disposal using the unstable disposal technology indices, and if there are 400,000 m^3 of waste acceptable for disposal using the stable disposal technology indices, then the base capital expenditure (not the alternative disposal technologies which are considered below) is divided 60 percent and 40 percent between the two cases.

(2) The capital expenditures involving the alternative disposal technologies (e.g., grouting option, segregation option, etc.) are volume prorated if both sets of disposal technology indices include the option; if only one of the disposal technology sets include the option, the capital expenditure is included entirely in that portion of the impact measures.

(3) The base case operational impact measures are volume prorated similar to the capital expenditures base case example given above.

(4) Additional operational alternatives depend on the waste volume or parameters such as the disposed waste surface area. It is straightforward to consider these additional impact measures for each disposal technology cases.

(5) Postoperational impacts are also volume prorated in an exclusionary mode--i.e., in the above example, if the first disposal technology requires a high level of institutional care, only 40 percent of the base impact measures are included as part of the impacts due to the first disposal technology. Contingency costs are also volume prorated even though they may be relatively independent of the fraction of the disposed volume that require emergency actions.

(6) Radiological and other impact measures (e.g., ground water migration, transportation impact measures, waste processing impact measures, etc.) are calculated for each waste stream. Therefore the calculation of these impact measures into two groups is straightforward.

3. OTHER FEATURES OF THE COMPUTER CODES

As discussed above, the most significant feature of the revised OPTIONR and GRWATRR codes compared to the OPTIONS and GRWATER computer codes is the test procedure by which waste streams are classified. A number of other features have also been incorporated into the OPTIONR and GRWATRR codes in order to increase the accuracy of the analysis, increase the flexibility of the codes, and in response to comments made on the draft EIS. These features include the following:

- a revised method to determine unit disposal costs;
- revised costs for alternative disposal technologies and post-operational activities;
- calculation of impacts from decay chain daughters;
- trench overflow and leachate treatment impacts;
- a revised method to calculate operational impacts from accidents; and
- revised data files.

Unit disposal costs.

As discussed in Section 2 of Appendix C of this final EIS, the methodology used to calculate unit disposal costs ($\$/m^3$ of waste disposed) has been altered since

the draft EIS. To these unit disposal costs would be added costs for disposal facility closure, observation and maintenance, and institutional control. The calculational routine presented in Section 2, Appendix C, uses a present value analysis to determine unit disposal costs and has been implemented in the OPTIONR computer code.

In the code, calculations are performed by the subroutine COSTS which is called from the subroutine ECON. ECON calculates total capital, operational, and depreciable costs in 1980 dollars, and passes these costs to COSTS. COSTS returns with unit disposal costs. Constants which are used in COSTS, such as tax rates and interest rates, are provided as data statements in COSTS.

Revised unit costs for alternative disposal technologies.

The basis for the revised unit costs for the reference disposal facility, alternative disposal technologies, and post-operational costs is set forth in Section 3, Appendix C, of this final EIS. These revised costs are incorporated into the ECON subroutine of the OPTIONR code.

Calculation of impacts from decay chain daughters.

The existing computer codes INTRUDE and OPTIONS include subroutines which calculate radiological impacts to a potential inadvertent intruder as a function of time. The revised code OPTIONR, which incorporates a revised logic for classifying wastes for disposal, also calculates potential inadvertent intruder exposures as a function of time. For the final EIS, OPTIONR includes an improved method of determining radiological impacts associated with certain heavy metal radioisotopes having daughters which are also radioactive. This methodology is applied to calculations involving exposures to individual inadvertent intruders, off-site exposures to populations due to the intrusion, and hypothetical impacts from erosion.

Basically, the methodology for determining radiological impacts starts by considering, for a given nuclide, the concentration of that nuclide in waste. This concentration is multiplied by factors that correspond to radioactive decay and to the transfer of the nuclide through the environment to a biota access location. Given a unit concentration of the nuclide at a biota access location, resulting dose equivalents are determined using "pathway dose conversion factors" (PDCFs). For radioisotopes belonging to decay chains, the revised methodology determines for a given decay time the fractional amounts of respective daughter radionuclides which would be ingrown during the decay time periods. These fractions are then multiplied by the respective pathway dose conversion factors for the daughter nuclides, the products summed, and the total added to the pathway dose conversion factor for the parent nuclide.

That is, for nuclides that do not belong to heavy metal decay chains, an entity f_o x PDCF is used in the calculations, where f_o is the time delay factor. (See Appendix G of the draft EIS.) For nuclides belonging to decay chains, this entity is replaced by the following:

$$f_o \times PDCF_p + (f_{d1} \times PDCF_{d1}) + (f_{d2} \times PDCF_{d2}) + (f_{d3} \times PDCF_{d3}) + \ldots, \text{ where}$$

$f_o = \exp(-\lambda_p T)$

λ_p = decay constant of parent

T = decay time period

$PDCF_p$ = PDCF of parent

f_d = fractional quantity of a given daughter generated from a unit quantity of the parent at a given time

$PDCF_d$ = PDCF for a given daughter.

In the analysis, the following radionuclides are set out into four decay chains:

Decay chains

4n	4n+1	4n+2	4n+3
Cm-244	Pu-241	Pu-242	Cm-243
Pu-240	Am-241	Pu-238	Am-243
U-236	Np-237	U-238	Pu-239
Th-232	U-233	U-234	U-235
Ra-228	Th-239	Th-230	Pa-231
Th-228		Ra-226	Ac-227
		Pb-210	

Use of the decay chain methodology involved only relatively minor changes to the existing calculational procedure, principally the addition of two small subroutines CHNS and CALC. Incorporating the chain calculations has also involved modifying the data files used for the draft EIS. This involved determining additional values for the decay constants (AL), leachate partition rations (FMF), retardation coefficients (RET(INUC,1) and RET(INUC,4)), and pathway dose conversion factors (PDCF). The first three items are presented below. Pathway dose conversion factors for all isotopes are listed in Section 8 of this appendix.

Isotope	INUC*	AL(INUC)**	FMF(INUC)	RET(INUC,1)	RET(INUC,4)
Pb-210	24	3.40E-2	4.11E-3	840	7200
Ac-227	25	3.21E-2	4.11E-3	300	2500
Ra-226	26	4.33E-4	4.11E-3	30	250
Th-228	27	3.63E-1	4.11E-3	840	7200
Ra-228	28	1.03E-1	4.11E-3	30	250
Th-229	29	9.44E-5	4.11E-3	840	7200
Th-230	30	8.66E-6	4.11E-3	840	7200
Pa-231	31	2.13E-5	4.11E-3	840	7200
Th-232	32	4.92E-11	4.11E-3	840	7200
U-233	33	4.28E-6	1.25E-4	840	7200
U-234	34	2.81E-6	1.25E-4	840	7200
U-236	35	2.90E-8	1.25E-4	840	7200
Pu-240	36	1.05E-4	4.67E-4	840	7200

*Indicates the order in which the isotopic information is stored in the data files and considered in the codes. The first 23 values of INUC correspond to the 23 other isotopes considered in the data base.

**In yr^{-1}

Trench Overflow and Leachate Treatment Impacts

In the OPTIONR code, the subroutine OVERFLO is used to provide an order of magnitude analysis of the impacts that could result from trench overflow and leachate evaporation at a disposal facility having severe water accumulation problems. The calculational methodology used by the subroutine is described in Section 5.3, Appendix C, of this final EIS.

In the subroutine, impacts from overflow are calculated assuming that each year, a certain activity is released from the disposal trenches and flows into a nearby stream, where contaminated stream water is consumed by an individual. Thus, exposures due to overland flow are calculated as exposures to an individual (in millirem). In addition, the subroutine calculates exposures to the surrounding population (in man-millirem/yr) that could result from pumping leachate from the inundated trenches and processing the leachate through an evaporator.

In the calculations, one of the critical parameters is the volume (V_1) of leachate annually released overland or processed. In this EIS, V_1 is waste volume prorated from a base of one million gallons of leachate, which is the approximate volume of leachate and other contaminated liquids annually processed at the Maxey Flats disposal facility, and from one million m^3 of waste disposed. One million gallons is also the annual volume of leachate assumed for the high

cost institutional care scenario (i.e., ICL=3). In the methodology, V_1 is assumed to be greater than zero <u>only</u> for the condition of a high level of institutional control, and only for very impermeable disposal site soil conditions (IR=1 or IR=6). If ICL=3 and there is no segregation of stable and unstable waste, then V_1 is equal to one gallon per m^3 of waste times the total volume of waste (in m^3) delivered to the disposal facility. If there is segregation of stable and unstable waste, then V_1 is taken to be one gallon per m^3 of waste multiplied by the unstable waste volume.

Besides the radiological impact measures, three additional impact measures associated with evaporator operations are calculated. These include annual occupational exposures (in whole body man-millirem), evaporator operation costs, and gallons of propane. These impact measures were determined based upon experience at the Maxey Flats disposal facility.

Revised Methodology to Consider Potential Operational Accidents

The OPTIONR computer code contains a subroutine ACCEXP which (among other things) calculates potential impacts from operational accidents at the reference disposal facility. The operational accidents considered in the subroutine include a scenario in which a waste container is assumed to be dropped from a significant height so that the waste container breaks open. A portion of the radioactive contents of the waste package is assumed to be released into the air where it is transported offsite, leading to subsequent potential human exposure. For the final EIS, ACCEXP incorporates a revised technique to estimate the fraction of the waste contents released from this accident. The assumed release functions are given in Section 5.5, Appendix C, of this final EIS.

Revised data files.

Revisions have been made to the data files used for the draft EIS. One reason for these revisions is to minimize the number of different data files required for operating the codes. For example, the codes may be used to perform impact calculations on either a generic or on a regional basis. In the draft EIS, a separate set of data files were required for each region. For the final EIS, the different information contained in these files has been incorporated into three data files (IN1FIL, GW2FIL, IN2FIL) which are input into the two computer programs used in the final EIS. These files are modified versions of the DATA, DATAD, and SPECTRUMS files used for the draft EIS. Other changes were made to accommodate the expanded calculational methodology. These include, for example, additional pathway dose conversion factors for decay daughters (IN1FIL file), a 37th waste stream (F-PUDECON) considering waste from decontamination of mixed oxide (MOX) fuel research facilities (IN1FIL, GW2FIL files), and addition of a 5th and 6th waste spectra (IN2FIL file). A number of alternative lists of waste classification limiting concentrations are also read in through the IN2FIL file.

To summarize, input data for the computer codes used in the final EIS are contained in three data files: IN1FIL, GW2FIL, and IN2FIL. IN2FIL is used by both codes. IN1FIL is used by the OPTIONR code while GW2FIL is used by the GRWATRR code. Listings of the three data files are provided in Section 8 of this appendix.

4. STRUCTURE OF INPUT AND OUTPUT FILES

The two impact analysis programs used in the final EIS utilize the logical units 1 through 5 according to the assignments in Table D.1. Logical unit 1 is used for inputting the contents of either the IN1FIL or GW2FIL file. Logical unit 2 is used for inputting the contents of the IN2FIL file. Output in a summary form is printed onto paper using logical unit 4. Logical unit 5 is used for inputting data other than that contained in logical units 1 and 2. The format for inputting data through logical unit 5 is discussed in the following Sections 5 through 7 of this appendix.

Table D.1 Assignments for Logical Units

Code name:	Logical unit 1 (TAPE1)	Logical unit 2 (TAPE2)	Logical unit 4 (TAPE4)	Logical unit 5 (TAPE5)
GRWATRR	GW2FIL	IN2FIL	OUTPUT	INPUT
OPTIONR	IN1FIL	IN2FIL	OUTPUT	INPUT

5. INPUT

Input for the five programs is read in in "sets." Each "set" consists of the necessary input to execute the program one time.

Input for an execution of the GRWATRR and OPTIONR codes generally consists of (1) a title for the execution, (2) several input indices, (3) two sets of disposal technology indices (IRDC) as described in Appendix G of the draft EIS and updated in Appendix C of this final EIS, and (4) the order of the waste spectra considered in the programs.

6. INPUT INDICES

Table D.2 shows the IRDC (disposal technology indices) parameters, optional values to choose from, and the explanation of each. These thirteen indices are the major inputs for both codes. Appendix D of the draft EIS presents information explaining further what each index means. Two sets of IRDC indices are read in for both the OPTIONR and GRWATRR codes.

Table D.3 shows ISPC (waste form behavior indices) parameters 14 through 19, optional values to choose from, and an explanation of each. These six indices are input through the IN2FIL file but are included here as background. Appendix D of the DEIS and Appendix C of this final EIS explain further the meanings of the index values.

Additional variables read into the GRWATRR and OPTIONR codes include the IORDD array and the CLST array. IORDD is a six member integer array presenting the order in which waste spectra are considered in the codes. Integer values in

Table D.2 Disposal Technology Indices (IRDC)

Variable	Parameter	Optional values	Explanation
IR*	REGION	1	Northeast regional site
		2	Southeast regional site
		3	Midwest regional site
		4	Southwest regional site
		5	Southeast site with sandy soil (faster ground water velocity)
		6	Southeast site with clayey soil (slower ground water velocity)
ID	DESIGN	1	Regular shallow land burial trenches
		2	"Concrete-walled" trenches
IC	COVER	1	Regular cover
		2	"Thick" cover
		3	"Intruder barrier" cover
IX	STABILIZATION	1	No special procedures
		2	Moderately extensive procedures
		3	Very extensive procedures
IE	EMPLACEMENT	1	Random
		2	Stacked
		3	Decontainerized
		4	Random with sand backfill
		5	Stacked with sand backfill
IS	SEGREGATION	0	No segregation
		1	Segregation of unstable waste
		2	Segregation of waste containing chemical agents
		3	Segregation of unstable waste as well as waste containing chemical agents
IL	LAYERING	0	No layering
		1	Layering of waste streams
IG	GROUTING	0	No grouting
		1	Grouting of interstices between disposed waste packages
IH	HOT WASTE FACILITY	0	No special disposal of high-activity waste
		1	Special disposal operations for high activity waste
IQ	CLOSURE	1	2 year modest closure effort
		2	4 year closure period incorporating complete site restabilization program
ICL	CARE LEVEL	1	Low care level
		2	Moderate care level
		3	High care level

Table D.2 (continued)

Variable	Parameter	Optional values	Explanation
IPO	POST-OPERA-TIONAL PERIOD	2-99**	Number of years between cessation of waste disposal of waste and transfer of title to site owner
IIC	INSTITUTIONAL CONTROL PERIOD	0-999	Number of years between transfer of title to site owner and the assumed loss of institutional controls

*In the codes, two sets of IRDC indices are read in. Setting IR=0 in the second set of IRDC indices signifies using an alternative method for classifying waste based upon existing license conditions at disposal facilities.

**IPO must be greater than or equal to 2 when IQ is equal to 1 and must be greater than or equal to 4 when IQ is equal to 2.

Table D.3 Waste Form Behavior Indices (ISPC)

Variable	Parameter	Optional values	Explanation
I4	FLAMMABILITY	0	Non-flammable
		1	Low flammability
		2	Burns if heat supplied
		3	Flammable
I5	DISPERSIBILITY	0	Near zero
		1	Slight to moderate
		2	Moderate
		3	Severe
I6	LEACHABILITY	1	Unsolidified waste form
		2	Type A solidification
		3	Type B solidification
		4	Type C solidification
I7	CHEMICAL CONTENT	0	No chelating agents or organic chemicals
		1	Chelating agents or organic chemicals likely present
I8	STABILITY	0	Structurally unstable waste form
		1	Structurally stable waste form (inherent to waste form)
		2	Stabilized using a high intensity container
		3	Stabilized by other means
I9	ACCESSIBILITY	1	Readily accessible
		2	Moderately accessible
		3	Accessible with difficulty

each member of the array may be 1, 2, 3, 4, 5, or 6, corresponding to the identification numbers of the waste spectra. Normally, all waste streams are considered in the order given by IORDD. However, an option is provided by which a different order may be imposed for given waste streams. This option is triggered by setting the variable NORD greater than zero, where the value of NORD indicates the number of waste streams for which this option is implemented. If NORD is greater than zero, then the appropriate stream identification number (NK) is read in. This is followed by 6 integer values of the index NORDD(I) giving the order in which the waste spectra are considered for the particular waste stream.

The CLST(4,16) array is used to read in limiting waste classification radionuclide concentrations. Each of the four rows correspond to a set of limiting concentrations for a particular waste class (i.e., for CLST(I,J), I = 1 corresponds to Class A waste limits; I = 2, Class B limits; I = 3, Class C limits; and I = 4, "hot waste facility" limits). The 16 columns correspond to limiting values for the following radionuclides (in order): H-3, C-14, Fe-55, Ni-59, Co-60, Ni-63, Nb-94, Sr-90, Tc-99, I-129, Cs-135, Cs-137, U-235, U-238, alpha emitting long-lived transuranic nuclides, and Pu-241. Reading in the CLST array is optional and is implemented only when NLST = 0. Otherwise, a reference set of CLST concentrations are used corresponding to the value of NLST.

The other indices needed to execute the impact analysis codes are explained below and summarized in Table D.4. Each code does not need every index for execution. Therefore, with each explanation below, the code(s) that use(s) the index is(are) listed, and the table shows the codes that use each index.

The input formats in the next section will demonstrate the location of each index in the input fields.

The NBEST index is used to take credit in certain calculations within the OPTIONR code for improvements in the waste form for reducing impacts to inadvertent intruders. NBEST = 1 results in taking the credit, NBEST = 0 does not (refer to Vol. 2 of the draft EIS, Section 4.3.4.1). NBEST is only used in the OPTIONR code.

The NTHIC index is used in the GRWATRR code and is the number of years of expected lifetime of a high integrity container.

The NOPTW index is used in the GRWATRR code and indicates whether the boundary well (NOPTW = 1) or the intruder well (NOPTW = 0) is to be analyzed. The resultant output will indicate which well was chosen.

In the codes, two input indices (NNDX and NHIC) are used which signify the total number of waste streams to be treated differently than the regular analysis. In all the codes, each of the 37 waste streams is identified by an integer corresponding to its position in the data file. Table D.5 shows the identification number for the waste streams and the description of the streams. An index value is then assigned to each stream identifying the treatment it is to receive.

In the codes, an array NDXS is maintained in which an index value equal to 1 is automatically assigned for each waste stream except for distributed waste streams. These latter waste streams (P-IXRESIN, P-CONCLIQ, P-FSLUDGE, B-IXRESIN, B-CONCLIQ, B-FSLUDGE, F-PUDECON) are automatically assigned an index value equal

Table D.4 Other Indices for Impacts Codes

Index	Optional values	Explanation	Codes where used
NBEST	0	No credit in waste form for reducing intruder impacts	OPTIONR
	1	Take credit	
NOPR	0-6	0 = perform generic analysis 1 = perform regional analysis for region 1 2 = perform regional analysis for region 2 3 = perform regional analysis for region 3 4 = perform regional analysis for region 4 5 = perform regional analysis for region 2 assuming sandy soil 6 = perform regional analysis for region 2 assuming clayey soil	GRWATRR OPTIONR
NLST	0-6	0 = read in a set of waste classification lists 1 = use reference waste classification list 1 2 = use reference waste classification list 2 3 = use reference waste classification list 3 4 = use reference waste classification list 4 5 = use reference waste classification list 5 6 = use reference waste classification list 6	GRWATRR OPTIONR
NORD	0-37	Total number of waste streams for which classification will be tested in a different order than that given by IORDD	GRWATRR OPTIONR
NNDX	0-37	Total number of waste streams to treat differently from the regular analysis	GRWATRR OPTIONR
NHIC	0-37	Total number of waste streams to place in a high integrity container or stabilize	GRWATRR OPTIONR
NTHIC	0-1000	Lifetime (in years) of high integrity container	GRWATRR
NOPTW	0	Intruder well case	GRWATRR
	1	Boundary well case	
NDXS	-2, -1, 0, 1, or 2	2 = normal waste stream, stabilize through disposal facility design 1 = normal waste stream 0 = remove from analysis -1 = distributed waste stream -2 = distributed waste stream, stabilize through disposal facility design	GRWATRR OPTIONR

Table D.4 (continued)

Index	Optional values	Explanation	Codes where used
If NNDX > 0:			
IDIFF	1-37	Identification number of waste streams to treat differently	GRWATRR OPTIONR
NDXD	-2, -1, 0, 1, or 2	Index value identifying special treatment 2 = normal waste stream, stabilize through disposal facility design 1 = normal waste stream 0 = remove from analysis -1 = distributed waste stream -2 = distributed waste stream, stabilize through disposal facility design	
If NHIC > 0:			
IDIF	1-37	Identification number of waste streams to place in a high integrity container or stabilize	GRWATRR OPTIONR
NHCD	1 or 2	Index value identifying stream treatment 1 = place in a high integrity container 2 = stabilize by other means	
If NORD > 0:			
NK	1-37	Identification number of waste stream for which waste classification spectrum order will be different than given by IORDD	GRWATRR OPTIONR
NORDD	1-6	Index values (6 will be read) giving spectral order considered by waste stream	

Table D.5 Waste Streams

Identification Number	Stream	Data file name
1	PWR Ion Exchange Resins#	P-IXRESIN
2	PWR Concentrated Liquids#	P-CONCLIQ
3	PWR Filter Sludges#	P-FSLUDGE
4	PWR Filter Cartridges	P-FCARTRG
5	BWR Ion Exchange Resins#	B-IXRESIN
6	BWR Concentrated Liquids#	B-CONCLIQ
7	BWR Filter Sludges#	B-FSLUDGE
8	PWR Compactible Trash	P-COTRASH
9	PWR Noncompactible Trash	P-NCTRASH
10	BWR Compactible Trash	B-COTRASH
11	BWR Noncompactible Trash	B-NCTRASH
12	Fuel Fabrication Compactible Trash	F-COTRASH
13	Fuel Fabrication Noncompactible Trash	F-NCTRASH
14	Institutional Trash (large facilities)	I-COTRASH
15	Institutional Trash (small facilities)	I+COTRASH
16	Industrial SS* Trash (large facilities)	N-SSTRASH
17	Industrial SS* Trash (small facilities)	N+SSTRASH
18	Industrial Low Trash (large facilities)	N-LOTRASH
19	Industrial Low Trash (small facilities)	N+LOTRASH
20	Fuel Fabrication Process Wastes	F-PROCESS
21	UF_6 Process Wastes	U-PROCESS
22	Institutional LSV** Waste (large facilities)	I-LIQSCVL
23	Institutional LSV** Waste (small facilities)	I+LIQSCVL
24	Institutional Liquid Waste (large facilities)	I-ABSLIQD
25	Institutional Liquid Waste (small facilities)	I+ABSLIQD
26	Institutional Biowaste (large facilities)	I-BIOWAST
27	Institutional Biowaste (small facilities)	I+BIOWAST
28	Industrial SS* Waste	N-SSWASTE
29	Industrial Low Activity Waste	N-LOWASTE
30	LWR Nonfuel Reactor Core Components	L-NFRCOMP
31	LWR Decontamination Resins	L-DECONRS
32	Waste from Isotope Production Facilities	N-ISOPROD
33	Tritium Production Waste	N-TRITIUM
34	Accelerator Targets	N-TARGETS
35	Sealed Sources	N-SOURCES
36	High Activity Waste	N-HIGHACT
37	MOX Research Facility Decontamination Waste#	F-PUDECON

*SS = Source and special nuclear material.

**LSV = Liquid scintillation vial.

#Waste streams for which the contained activities are given as distributions rather than averages.

to -1. The total number of waste streams which will be assigned different index values is equal to NNDX. If NNDX is greater than zero, the identification number of each waste stream receiving a different index value is input, followed by the value of the index. Possible index values are as follows:

"-2" = normal waste stream, stabilize through disposal facility design

"-1" = normal waste stream

"0" = exclude waste stream from analysis

"1" = distributed waste stream

"2" = distributed waste stream, stabilize through disposal facility design

Waste streams initially assigned an index equal to 1 may only be reassigned a value of 0 or 2. Similarly, waste streams initially assigned an index equal to -1 may only be reassigned a value of 0 or -2.

The option to place a stream in a high integrity container or to stabilize by some other means is handled by the NHIC variable and the following procedure. The index value of "0" is automatically assigned to every stream in OPTIONR and GRWATRR. If NHIC is greater than zero (0), the appropriate stream identification number is input together with an index value of "1" to identify that the stream is to be placed into a high integrity container or a value of "2" identifying that the stream is to be stabilized by some other means.

When NNDX is greater than zero (0), the identification number of the streams to receive special treatment is input by the index named IDIFF and the index value identifying the new treatment is input by NDXD (see Table D.4).

When NHIC is greater than zero (0), the identification number of the streams to be placed in a high integrity container or otherwise stabilized is input by the index named IDIF, and the index value is read in by NHCD (see Table D.4).

The NOPR index is used in all five codes and is used to distinguish whether a generic or regional analysis is to be performed. Possible values for and consequences of this index are listed in Table D.4.

The NLST index is used in the GRWATRR and OPTIONR codes to specify which set of reference waste classification limits are used in the analysis. In the codes the reference sets of classification limits are read in through the IN2FIL file and stored in the array FLST(6,4,16). Index values of 1 through 6 correspond to the sets listed in Table D.6. An index value equal to zero indicates that the reference sets of waste classification limits are ignored. Rather, the classification limits are read in by the user.

7. INPUT FORMATS

7.1 GRWATRR

Input for the GRWATRR code consists of the desired number of data sets. Each data set consists of a minimum of 5 cards as follows:

Table D.6 List of Reference CLST sets

	Set 1				Set 2			
	A	B	C	HWF	A	B	C	HWF
H-3	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
C-14	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Fe-55	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Ni-59	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Co-60	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Ni-63	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Nb-94	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Sr-90	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Tc-99	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
I-129	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Cs-135	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
Cs-137	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
U-235	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
U-238	10^9	10^9	10^9	10^9	10^9	10^9	10^9	10^9
TRU	10^9	10^9	10^9	10^9	1.6E-2	1.6E-2	1.6E-2	1.6E-2
Pu-241	10^9	10^9	10^9	10^9	1.6E-2	1.6E-2	1.6E-2	1.6E-2

	Set 3				Set 4			
	A	B	C	HWF	A	B	C	HWF
H-3	1.	10^9	10^9	10^9	4.E+1	10^8	10^9	10^9
C-14	1.	10^9	10^9	10^9	8.E-1	8.E-1	8.E-1	8.E+0
Fe-55	10^9	10^9	10^9	10^9	7.E+2	7.E+4	10^9	10^9
Ni-59	1.	10^9	10^9	10^9	2.2E+0	2.2E+0	2.2E+0	2.2E+1
Co-60	1.	10^9	10^9	10^9	7.E+2	7.E+4	10^9	10^9
Ni-63	1.	10^9	10^9	10^9	3.5E+0	7.E+1	7.E+1	7.E+2
Nb-94	1.	10^9	10^9	10^9	2.E-3	2.E-3	2.E-3	2.E-2
Sr-90	1.	10^9	10^9	10^9	4.E-2	1.5E+2	7.E+2	7.E+3
Tc-99	1.	10^9	10^9	10^9	3.E-1	3.E-1	3.E-1	3.E+0
I-129	1.	10^9	10^9	10^9	8.E-3	8.E-3	8.E-3	8.E-2
Cs-135	1.	10^9	10^9	10^9	8.4E+1	8.4E+1	8.4E+1	8.4E+2
Cs-137	1.	10^9	10^9	10^9	1.E+1	4.4E+1	4.6E+3	4.6E+4
U-235	1.	10^9	10^9	10^9	4.E-2	4.E-2	4.E-2	4.E-1
U-238	1.	10^9	10^9	10^9	5.E-2	5.E-2	5.E-2	5.E-1
TRU	1.6E-2	1.6E-2	1.6E-2	1.6E-2	1.6E-2	1.6E-2	1.6E-2	1.6E-1
Pu-241	1.6E-2	1.6E-2	1.6E-2	1.6E-2	5.6E-1	5.6E-1	5.6E-1	5.6E+0

	Set 5				Set 6			
	A	B	C	HWF	A	B	C	HWF
H-3	4.E+1	10^9	10^9	10^9	0.	10^9	10^9	10^9
C-14	8.E-1	8.E-1	8.E+0	8.E+1	0.	8.E-1	8.E+0	8.E+1
Fe-55	7.E+2	10^9	10^9	10^9	0.	10^9	10^9	10^9
Ni-59	2.2E+0	2.2E+0	2.2E+1	2.2E+2	0.	2.2E+0	2.2E+1	2.2E+2
Co-60	7.E+2	10^9	10^9	10^9	0.	10^9	10^9	10^9
Ni-63	3.5E+0	7.E+1	7.E+2	7.E+3	0.	7.E+1	7.E+2	7.E+3
Nb-94	2.E-3	2.E-3	2.E-2	2.E-1	0.	2.E-3	2.E-2	2.E-1
Sr-90	4.E-2	1.5E+2	7.E+3	7.E+4	0.	1.5E+2	7.E+3	7.E+4
Tc-99	3.E-1	3.E-1	3.E+0	3.E+1	0.	3.E-1	3.E+0	3.E+1
I-129	8.E-3	8.E-3	8.E-2	8.E-1	0.	8.E-3	8.E-2	8.E-1
Cs-135	8.4E+1	8.4E+1	8.4E+2	8.4E+3	0.	8.4E+1	8.4E+2	8.4E+3
Cs-137	1.E+0	4.4E+1	4.6E+3	4.6E+4	0.	4.4E+1	4.6E+3	4.6E+4
U-235	4.E-2	4.E-2	4.E-1	4.E+0	0.	4.E-2	4.E-1	4.E+0
U-238	5.E-2	5.E-2	5.E-1	5.E+1	0.	5.E-2	5.E-1	5.E+1
TRU	1.6E-2	1.6E-2	1.6E-1	1.6E+0	0.	1.6E-2	1.6E-1	0.6E+0
Pu-241	5.6E-1	5.6E-1	5.6E+0	5.6E+1	0.	5.6E-1	5.6E+0	5.6E+1

Card	Columns	Format	Index	Definition
1	1-20	2A10	NOTE	Title of execution
2	1-2	I2	NOPR	Generic or regional analysis
	3-4	I2	NNDX	Number of streams excluded, distributed, or stabilized through facility design
	5-6	I2	NORD	Number of waste streams considered in a different order than that given by IORDD
	7-8	I2	NLST	Identity of reference waste classification list set
	9-10	I2	NHIC	Number of streams to go into HIC or stabilized
	11-12	I2	NOPTW	Choice of well, boundary or intruder
	13-16	I4	NTHIC	Lifetime of HIC (years)
3	1-2	I2	IR1	IRDC values for set 1
	3-4	I2	ID1	
	5-6	I2	IC1	
	7-8	I2	IX1	
	9-10	I2	IE1	
	11-12	I2	IS1	
	13-14	I2	IL1	
	15-16	I2	IG1	
	17-18	I2	IH1	
	19-20	I2	IQ1	
	21-22	I2	ICL1	
	23-27	I5	IPO1	
	28-32	I5	IIC1	
4	1-2	I2	IR2	IRDC values for set 2
	3-4	I2	ID2	
	5-6	I2	IC2	
	7-8	I2	IX2	
	9-10	I2	IE2	
	11-12	I2	IS2	
	13-14	I2	IL2	
	15-16	I2	IG2	
	17-18	I2	IH2	
	19-20	I2	IQ2	
	21-22	I2	ICL2	
	23-27	I5	IPO2	
	28-32	I5	IIC2	
5	1-2	I2	IORDD(1)	Order of considering waste spectra
	3-4	I2	IORDD(2)	
	5-6	I2	IORDD(3)	
	7-8	I2	IORDD(4)	
	9-10	I2	IORDD(5)	
	11-12	I2	IORDD(6)	

However, if NLST = 0, NNDX > 0, NHIC > 0, or NORD > 0 for a given set, then additional cards will be read for that set as follows:

If NLST = 0, then 8 cards follow with the format:

Card	Columns	Format	Variable	Definition
1	1-10	E10.3	CLST(1,1-8)	Waste classification limits
	11-20	E10.3		
	21-30	E10.3		
	31-40	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		
2	1-10	E10.3	CLST(1, 9-16)	
	11-20	E10.3		
	21-30	E10.3		
	31-40	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		
3	1-10	E10.3	CLST(1, 1-8)	
	11-20	E10.3		
	21-30	E10.3		
	31-40	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		
4	1-10	E10.3	CLST(2, 9-16)	
	11-20	E10.3		
	21-30	E10.3		
	31-40	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		

cards 5-8 are read similarly

If NNDX > 0, then NNDX cards follow with the following format:

Card	Columns	Format	Index	Definition
All	1-2	I2	IDIFF	Identification number of stream
	3-4	I2	NDXD	Option to exclude from analysis, treat as a distributed waste stream, or stabilize only using disposal facility design. ($-2 \leq NDXD \leq 2$)

If NHIC > 0, then NHIC cards follow with the format:

Card	Columns	Format	Index	Definition
All	1-2	I2	IDIF	Identification number of stream
	3-4	I2	NHCD	Index to identify treatment (1 or 2)

If NORD > 0, then NORD cards follow with the following format:

Card	Columns	Format	Index	Definition
All	1-2	I2	NK	Identification number of waste stream
	3-4	I2	NORDD(1)	Order in which waste spectra are considered for the particular stream
	5-6	I2	NORDD(6)	
	7-8	I2	NORDD(6)	
	9-10	I2	NORDD(6)	
	11-12	I2	NORDD(6)	
	13-14	I2	NORDD(6)	

7.2 OPTIONR

Input for the OPTIONR code consists of the desired number of data sets. Each data set consists of a minimum of 5 cards as follows:

Card	Columns	Format	Index	Definition
1	1-20	2A10	NOTE	Title of execution
2	1-2	I2	NOPR	Generic or regional analysis
	3-4	I2	NNDX	Number of streams excluded, distributed, or stabilized through facility design
	5-6	I2	NORD	Number of waste streams considered in a different order than that given by IORDD
	7-8	I2	NLST	Identity of reference waste classification list set
	9-10	I2	NHIC	Number of streams to go into HIC or stabilized
	11-12	I2	NBEST	Credit for waste form to reduce intruder impacts
3	1-2	I2	IR1	IRDC values for set 1
	3-4	I2	ID1	
	5-6	I2	IC1	
	7-8	I2	IX1	
	9-10	I2	IE1	
	11-12	I2	IS1	
	13-14	I2	IL1	
	15-16	I2	IG1	
	17-18	I2	IH1	
	19-20	I2	IQ1	
	21-22	I2	ICL1	
	23-27	I5	IP01	
	28-32	I5	IIC1	
4	1-2	I2	IR2	IRDC values for set 2
	3-4	I2	ID2	
	5-6	I2	IC2	
	7-8	I2	IX2	
	9-10	I2	IE2	
	11-12	I2	IS2	
	13-14	I2	IL2	
	15-16	I2	IG2	
	17-18	I2	IH2	
	19-20	I2	IQ2	
	21-22	I2	ICL2	
	23-27	I5	IP02	
	28-32	I5	IIC2	
5	1-2	I2	IORDD(1)	Order of considering waste spectra
	3-4	I2	IORDD(2)	
	5-6	I2	IORDD(3)	
	7-8	I2	IORDD(4)	
	9-10	I2	IORDD(5)	
	11-12	I2	IORDD(6)	

However, if NLST = 0, NNDX > 0, NHIC > 0, or NORD > 0 for a given set, then additional cards will be read for that set as follows:

If NLST = 0, then 8 cards follow with the format:

Card	Columns	Format	Index	Definition
1	1-10	E10.3	CLST(1,1-8)	Waste classification limits
	11-20	E10.3		
	21-30	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		
2	1-10	E10.3	CLST(1,9-16)	
	11-20	E10.3		
	21-30	E10.3		
	31-40	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		
3	1-10	E10.3	CLST(2,1-8)	
	11-20	E10.3		
	21-30	E10.3		
	31-40	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		
4	1-10	E10.3	CLST(2,9-16)	
	11-20	E10.3		
	21-30	E10.3		
	31-40	E10.3		
	41-50	E10.3		
	51-60	E10.3		
	61-70	E10.3		
	71-80	E10.3		

Cards 5-8 are read similarly

If NNDX > 0, then NNDX cards follow with the following format:

Card	Columns	Format	Index	Definition
All	1-2	I2	IDIFF	Identification number of stream
	3-4	I2	NDXD	Option to exclude from analysis treat as a distributed waste stream, or stabilize only using disposal facility design. ($-2 \leq$ NDXD ≤ 2)

If NHIC > 0, then NHIC cards follow with the format:

Card	Columns	Format	Index	Definition
All	1-2	I2	IDIF	Identification number of stream
	3-4	I2	NHCD	Index to identify treatment (1 or 2)

If NORD > 0, then NORD cards follow with the following format:

Card	Columns	Format	Index	Definition
All	1-2	I2	NK	Identification number of waste stream
	3-4	I2	NORDD(1)	Order in which waste spectra are considered for the particular stream
	5-6	I2	NORDD(2)	
	7-8	I2	NORDD(3)	
	9-10	I2	NORDD(4)	
	11-12	I2	NORDD(5)	
	13-14	I2	NORDD(6)	

8. LISTING OF COMPUTER CODES AND DATA FILES

This section presents a listing of the computer codes and data files used in the final EIS. The computer codes are listed in the following order:

- GRWATRR
- OPTIONR

The data files follow in the following order:

- IN1FIL
- GW2FIL
- IN2FIL

GRWATRR Code

```
      PROGRAM GRWATRR
C
C*****************************************************************
C     THIS IS THE MODIFIED GROUNDWATER IMPACTS CODE.  IT FINDS    *
C     THE DOSE FROM GROUNDWATER MIGRATION OF RADIONUCLIDES FOR    *
C     THREE CASES: THE INTRUDER WELL, THE POPULATION WELL, AND    *
C     SURFACE WATER.  HOWEVER, WHEN NOPTW=1, THE BOUNDARY WELL    *
C     IS SUBTITUTED FOR THE INTRUDER WELL.  SEE APPENDIX D OF     *
C     FEIS FOR DETAILS                                            *
C*****************************************************************
C
      CHARACTER*10 BASN(90),NUC(36),NOTE(2),DES(3)
      COMMON/BAST/BAS(90,32,2),ISPC(6,90,10),DCF(36,7,8),FICRP(7)
     +       /CHRC/BASN,NUC
     +       /NUCS/AL(36),FMF(36),RET(36,5)
     +       /DTNX1/IRDC1(13)/DTNX2/IRDC2(13)
     +       /DTIS/FSC(6),FSA(6),PRC(6,2),GFC(6,3),TTM(6,3),TPC(6,3),
     +             RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPO(6,2),NRET(6)
     +       /VOLS/VRG1,VRG2,VLAY,VHOT,VNOT,RVOL(4,36)
     +       /IMPS/DZD(23,22,21),DZ(7,3,22),DZT(7,3,22)
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16),NLST
      DIMENSION IORDD(6),TYM(22),NORDD(6)
C
C*****************************************************************
C     THE ABOVE MATRICES AND ARRAYS ARE BRIEFLY EXPLAINED BELOW.  *
C     MORE DETAILED EXPLANATIONS CAN BE FOUND IN THE DEIS&FEIS.   *
C                                                                 *
C     BASN   = NAME OF THE WASTE STREAMS                          *
C     NUC    = NAME OF THE RADIONUCLIDES CONSIDERED               *
C     NOTE   = TITLE OF THE PROBLEM                               *
C     DES    = DESCRIPTIONS OF PATHWAYS                           *
C     BAS    = BASIC DATA MATRIX OF VOLUMES & CONCENTRATIONS      *
C     ISPC   = WASTE SPECTRUM INFORMATION                         *
C     DCF    = PATHWAY DOSE CONVERSION FACTORS                    *
C     FICRP  = ICRP WEIGHTING FACTORS FOR ORGANS                  *
C     AL     = DECAY CONSTANTS OF RADIONUCLIDES                   *
C     FMF    = PARTITION RATIOS BETWEEN WASTE AND LEACHATE        *
C     RET    = RETARDATION COEFFICIENTS OF RADIONUCLIDES          *
C     IRDC1  = DISPOSAL TECHNOLOGY INDICES FOR UNSTABLE WASTES    *
C     IRDC2  = DISPOSAL TECHNOLOGY INDICES FOR STABLE WASTES      *
C     FSC    = SOIL-TO-AIR TRANSFER FACTOR - CONSTRUCTION         *
C     FSA    = SOIL-TO-AIR TRANSFER FACTOR - AGRICULTURE          *
C     GFC    = DILUTION FACTORS FOR GROUNDWATER SCENARIOS         *
C     TTM    = TRAVEL TIME(YEARS) FOR GW SCENARIOS                *
C     TPC    = PECLET NUMBERS FOR GW SCENARIOS                    *
C     RGF    = GEOMETRIC REDUCTION FACTORS FOR GW SCENARIOS       *
C     POP    = POPULATION FACTORS FOR ACCIDENT SCENARIOS          *
C     DTTM   = TRAVEL TIME BETWEEN DISPOSAL SITE SECTORS          *
C     DTPC   = PECLET NUMBER BETWEEN DISPOSAL SITE SECTORS        *
C     TPO    = X/Q WEIGHTED POPULATION SUM-DISTRIBUTIONS          *
C     NRET   = RETARDATION COEFFICIENT SET FOR THE DISPOSAL SITE*
C     RVOL   = REGIONAL VOLUMES OF WASTE GENERATED                *
C     DZD    = DUMMY DOSE MATRIX CALCULATED INTERNALLY            *
C     DZ     = DUMMY DOSE MATRIX CALCULATED INTERNALLY            *
C     DZT    = DUMMY DOSE MATRIX CALCULATED INTERNALLY            *
C     NDXS   = INDEX ON STATUS OF WASTE STREAM                    *
C     IMOD   = CALCULATED DISPOSAL MODE OF WASTE STREAM           *
C     ISPEC  = CURRENT SPECTRUM FOR THE WASTE STREAM              *
C     IHIC   = HIGH INTEGRITY CONTAINER INDEX                     *
C     CLST   = LISTS OF WASTE CLASSIFICATION CONCENTRATIONS       *
C     DIST   = ACTIVITY DISTRIBUTIONS OF CERTAIN WASTE STREAMS    *
C     IORD   = ORDER IN WHICH WASTE SPECTRUMS ARE CONSIDERED      *
```

```
C     FLST    = GENERAL LISTS OF WASTE CLASS CONCENTRATIONS          *
C     TYM     = YEARS AT WHICH THE IMPACTS ARE CALCULATED            *
C     IORDD   = BASIC ORDER FOR SPECTRUM CONSIDERATION               *
C     NORDD   = DUMMY ORDER FOR SPECTRUM CONSIDERATION               *
C*********************************************************************
C
      DATA NTYM/22/
      DATA TYM/40.,50.,60.,70.,80.,90.,100.,120.,200.,300.,400.,
     *         500.,600.,700.,800.,900.,1000.,2000.,4000.,6000.,
     *         8000.,10000./
      DATA DES/' BOU-WELL ',' POP-WELL ',' POP-SURF '/
C
C     NEXT SECTION READS ALL THE BASIC INFORMATION
C
   10 REWIND 1
      REWIND 2
      CALL READIN
C
C     NEXT SECTION READS BASIC AND CONDITIONAL INFORMATION
C     FROM TAPE5.  PROGRAM QUITS WHEN THERE ARE NO MORE CASES
C     TO BE CONSIDERED.  CONDITIONAL INFORMATION IS USED TO
C     ALTER THE BASIC INFORMATION DEPENDING ON THE CASE.
C
      READ(5,102,END=100)NOTE
   12 READ(5,103)NOPR,NNDX,NORD,NLST,NHIC,NOPTW,NTHIC
      READ(5,104)(IRDC1(I),I=1,13)
      READ(5,104)(IRDC2(I),I=1,13)
      READ(5,104)(IORDD(I),I=1,6)
      IF(NLST.EQ.0)READ(5,105)((CLST(I,J),J=1,16),I=1,4)
  102 FORMAT(2A10)
  103 FORMAT(6I2,I4)
  104 FORMAT(11I2,2I5)
  105 FORMAT(8E10.3)
      DO 14 I=1,NSTR
      ISPEC(I)=1
   14 NDXS(I)=1
      DO 16 I=1,3
      NDXS(I)=-1
   16 NDXS(I+4)=-1
      IF(NNDX.EQ.0)GO TO 20
      DO 18 I=1,NNDX
      READ(5,104) IDIFF,NDXD
   18 NDXS(IDIFF)=NDXD
   20 DO 22 I=1,NSTR
   22 IHIC(I)=0
      IF(NHIC.EQ.0)GO TO 26
      DO 24 I=1,NHIC
      READ(5,104) IDIF,NHCD
   24 IHIC(IDIF)=NHCD
   26 DO 28 I=1,NSTR
      DO 28 J=1,6
   28 IORD(J,I)=IORDD(J)
      IF(NORD.EQ.0)GO TO 34
      DO 32 I=1,NORD
      READ(5,104) NK,(NORDD(J),J=1,6)
      DO 30 J=1,6
   30 IORD(J,NK)=NORDD(J)
   32 CONTINUE
   34 IF(NLST.EQ.0)GO TO 39
      DO 36 J=1,4
      DO 36 K=1,16
      IF(FLST(NLST,J,K).LT.1.E-7)FLST(NLST,J,K)=1.E-7
   36 CLST(J,K)=FLST(NLST,J,K)
```

```
   38 IF(NOPR.EQ.0)GO TO 42
      IRR=IRDC1(1)
      IF(IRR.GT.4)IRR=2
      DO 40 ISTR=1,NSTR
      BAS(ISTR,3,1)=RVOL(IRR,ISTR)
   40 BAS(ISTR,3,2)=RVOL(IRR,ISTR)
C
C     THIS IS THE REAL BEGINNING OF THE CODE.
C     FIRST BASIC INFO IS PRINTED, THEN ARRAYS ARE ZEROED OUT.
C
   42 WRITE(4,1001) NOTE
      N1=1
      WRITE(4,1002) N1,IRDC1
      N1=2
      WRITE(4,1002) N1,IRDC2
      WRITE(4,1003) NOPR,NNDX,NORD,NLST,NHIC,NOPTW,NTHIC,
     *               (IORDD(I),I=1,6)
      VNOT=0.0
      VRG1=0.0
      VRG2=0.0
      VLAY=0.0
      VHOT=0.0
      THIC=NTHIC
C
C     NEXT SECTION IS THE OPEN DO LOOP THAT DETERMINES THE
C     STATUS OF THE WASTE STREAMS.
C
      ISTR=0
   44 ISTR=ISTR+1
      IF(ISTR.GT.NSTR) GO TO 66
      IF(NDXS(ISTR).NE.0) GO TO 46
      WRITE(4,1009)BASN(ISTR)
      IMOD(ISTR)=0
      GO TO 44
   46 IHC=IHIC(ISTR)
      IF(IHC.NE.0)WRITE(4,1011)BASN(ISTR)
      IF(IRDC1(1).NE.4.OR.ISTR.GT.37) GO TO 50
      DO 48 J=1,6
   48 ISPC(J,ISTR,5)=ISPC(J,ISTR,5)-1
   50 IMOD(ISTR)=1
      CALL RCLAIM(ISTR,NOPR)
      II=IMOD(ISTR)+1
C
C     AFTER DETERMINING THE STATUS AND IMPACTS OF THE WASTE
C     STREAMS, VOLUMES ARE STORED APPROPRIATELY.
C
      GO TO (52,54,56,56,56,58,58,62,62),II
   52 VNOT=VNOT+BAS(ISTR,3,1)
      GO TO 44
   54 VRG1=VRG1+BAS(ISTR,3,1)
      GO TO 44
   56 VRG2=VRG2+BAS(ISTR,3,1)
      GO TO 44
   58 VLAY=VLAY+BAS(ISTR,3,1)
      GO TO 44
   62 VHOT=VHOT+BAS(ISTR,3,1)
      GO TO 44
C
C     THIS IS THE END OF THE OPEN DO LOOP TO CLASSIFY THE
C     WASTE STREAMS.  NEXT SECTION PRINTS WASTE VOLUMES
C
   66 IF(NHIC.NE.0)WRITE(4,1012) NTHIC
      WRITE(4,1004) VRG1,VRG2,VLAY,VHOT,VNOT
```

```
      DO 70 I=1,NSTR
   70 WRITE(4,1007) BASN(I),BAS(I,3,1),BAS(I,3,2),IMOD(I),ISPEC(I)
C
C     AFTER CLASSIFICATION BASED ON THE PROPERTIES OF THE
C     WASTE STREAM, THE CLASSIFICATION STATUS MAY BE CHANGED
C     IN SUBROUTINE MODIF DEPENDING ON THE DISPOSAL TECHNOLOGY
C     INDICES.
C
      CALL MODIF
      WRITE(4,1008)
      DO 72 I=1,NSTR
   72 WRITE(4,1007) BASN(I),BAS(I,3,1),BAS(I,3,2),IMOD(I),ISPEC(I)
   68 CALL ZERO(DZT,462)
C
C     NEXT SECTION CALCULATES AND PRINTS IN TWO STEPS (UNSTABLE
C     AND STABLE WASTES) GROUNDWATER MIGRATION IMPACTS
C
      DO 92 ICN=1,2
      CALL ZERO(DZD,10626)
      CALL GWATER(NTYM,TYM,THIC,ICN,NOPTW)
      CALL ZERO(DZ,462)
C
C      LOOP 85 SUMS THE DOSES OVER ALL NUCLIDES
C
      DO 84 ITYM=1,NTYM
      DO 84 K=1,3
      KK=(K-1)*7
      DO 84 J=1,7
      DO 82 INUC=1,NNUC
   82 DZ(J,K,ITYM)=DZ(J,K,ITYM)+DZD(INUC,ITYM,KK+J)
   84 DZT(J,K,ITYM)=DZT(J,K,ITYM)+DZ(J,K,ITYM)
C
C      LOOP 90 OUTPUTS GROUNDWATER DOSES FOR 7 ORGANS, 3 PATHWAYS,
C      AND 22 TIMESTEPS.
C
      IF(ICN.EQ.1)WRITE(4,1013)
      IF(ICN.EQ.2)WRITE(4,1014)
      DO 90 ITYM=1,NTYM
      TYMD=TYM(ITYM)
      WRITE(4,1005)TYMD
      DO 88 K=1,3
      A1=0.0
      DO 86 J=1,7
   86 A1=A1+DZ(J,K,ITYM)*FICRP(J)
   88 WRITE(4,1006) DES(K),(DZ(J,K,ITYM),J=1,7),A1
   90 CONTINUE
   92 CONTINUE
      WRITE(4,1015)
      DO 98 ITYM=1,NTYM
      TYMD=TYM(ITYM)
      WRITE(4,1005) TYMD
      DO 96 K=1,3
      A1=0.
      DO 94 J=1,7
   94 A1=A1+FICRP(J)*DZT(J,K,ITYM)
   96 WRITE(4,1006) DES(K),(DZT(J,K,ITYM),J=1,7),A1
   98 CONTINUE
      GO TO 10
  100 STOP
 1001 FORMAT(1H1/2X,2A10)
 1002 FORMAT(//2X'IRDC GRP 'I2//2X'DISPOSAL TECHNOLOGY INDICES'/2X
     *           'IR ='I2'  ID ='I2'  IC ='I2'  IX ='I2/2X
     *           'IE ='I2'  IS ='I2'  IL ='I2'  IG ='I2/2X
```

```
     *             'IH ='I2'  ICL='I2'  INS='I2'  IPD='I2'  IIC='I5)
1003 FORMAT(//2X'NOPR='I2,2X'NNDX='I2,2X'NORD='I2,2X/
     *          2X'NLST='I2,2X'NHIC='I2,2X'NOPT='I2,2X'NTHIC='I4/
     *          2X'IORD 1-6 ARE: '6I2)
1004 FORMAT(/1P,2X' VRG1 ='E9.2' VRG2 ='E9.2' VLAY ='E9.2,
    +' VHOT ='E9.2' VNOT ='E9.2)
1005 FORMAT(/2X'YR ='F6.0'   BODY       BONE      LIVER'
    *2X'  THYROID   KIDNEY     LUNG   G-I TRACT    ICRP')
1006 FORMAT(1P,2X,A10,8E10.3)
1007 FORMAT(2X,A10,2E10.3,2I5)
1008 FORMAT(//2X'RECLASSIFIED WASTE STREAMS')
1009 FORMAT(/2X'WASTE STREAM NOT INCLUDED IS :'2X,A10)
1011 FORMAT(/2X'WASTE STREAM USING H.I.C.  IS :'2X,A10)
1012 FORMAT(2X,'H.I.C. HAS A LIFE OF '
     I4' YEARS')
1013 FORMAT(//2X,'IMPACTS FROM UNSTABLE WASTE STREAMS')
1014 FORMAT(//2X,'IMPACTS FROM STABLE WASTE STREAMS')
1015 FORMAT(//2X,'TOTAL IMPACTS')
     END
C
C**********************************************************************
C
     SUBROUTINE READIN
C
C    ALL THE BASIC INFORMATION CONTAINED IN TAPES 1 AND 2
C    IS READ IN THROUGH THIS SUBROUTINE.
C
     CHARACTER*10 BASN(90),NUC(36)
     COMMON/BAST/BAS(90,32,2),ISPC(6,90,10),DCF(36,7,8),FICRP(7)
    +      /CHRC/BASN,NUC
    +      /NUCS/AL(36),FMF(36),RET(36,5)
    +      /DTIS/FSC(6),FSA(6),PRC(6,2),QFC(6,3),TTM(6,3),TPC(6,3),
    +            RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPO(6,2),NRET(6)
    +      /VOLS/VRG1,VRG2,VLAY,VHOT,VNOT,RVOL(4,36)
    +      /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
    +      /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16)
     READ(1,101) NSTR,NNUC,FICRP
     DO 20 I=1,NSTR
  20 READ(1,102)BASN(I),(BAS(I,J,1),J=2,27)
     DO 25 I=1,NSTR
  25 READ(1,102)BASN(I),(BAS(I,J,2),J=2,27)
     NN=NNUC+13
     DO 40 I=1,NN
     READ(1,104)NUC(I),AL(I),FMF(I),RET(I,1),RET(I,4)
     DO 30 K=1,8
  30 READ(1,106)(DCF(I,J,K),J=1,7)
  40 CONTINUE
     DO 50 I=1,6
     READ(1,105)FSC(I),FSA(I),(PRC(I,J),J=1,2),(QFC(I,J),J=1,3),
    +           (TTM(I,J),J=1,3),(TPC(I,J),J=1,3),
    +           (RGF(I,J),J=1,3),(POP(I,J),J=1,3),NRET(I),
    +           DTTM(I),DTPC(I),(TPO(I,J),J=1,2)
  50 CONTINUE
     DO 55 I=1,4
  55 READ(1,108) (RVOL(I,J),J=1,NSTR)
     DO 60 K=1,6
     DO 60 I=1,NSTR
  60 READ(2,103) (ISPC(K,I,J),J=1,10)
     DO 70 K=1,7
     DO 70 I=1,3
  70 READ(2,107) (DIST(I,J,K),J=1,16)
     DO 80 I=1,6
     DO 80 K=1,16
  80 READ(2,109) (FLST(I,J,K),J=1,4)
```

```
      DO 85 INUC=1,NNUC
      A2=RET(INUC,4)
      A1=(A2/RET(INUC,1))**0.334
      RET(INUC,5)=A2*A1
      RET(INUC,3)=A2/A1
   85 RET(INUC,2)=RET(INUC,1)*A1
  101 FORMAT(2I5,7F5.2)
  102 FORMAT(A10,2E10.3/10X,6E10.3/10X,6E10.3/10X,6E10.3/10X,6E10.3)
  103 FORMAT(10X,10I5)
  104 FORMAT(A10,4E10.3)
  105 FORMAT(10X,7E10.3/10X,6E10.3/10X,6E10.3,I5/10X,4E10.3)
  106 FORMAT(10X,7E10.3)
  107 FORMAT(8E10.3)
  108 FORMAT(10X,6E10.3/10X,6E10.3/10X,6E10.3/10X,6E10.3/
     +10X,6E10.3/10X,6E10.3)
  109 FORMAT(10X,4E10.3)
      RETURN
      END
C
C**************************************************************************
C
      SUBROUTINE COMBYN(ISTR,NOPR)
C
C     THIS SUBROUTINE IS CALLED FROM SUBROUTINE RCLAIM AND
C     CHANCES WASTE SPECTRUMS & MODIFIES ACTIVITY DISTRIBUTIONS
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32,2),ISPC(6,90,10),DCF(36,7,8),FICRP(7)
     +       /CHRC/BASN,NUC
     +       /NUCS/AL(36),FMF(36),RET(36,5)
     +       /NBAS/NSTR,NNUC,NOXS(90),IMOD(90),ISPEC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16)
      DIMENSION DEC(2,2)
      DATA DEC/.9,.75,.9,.25/
      AA5=3.62
      IF(NOPR.GT.0)AA5=1.0
      IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
C
C     IF THIS IS CALLED FOR THE FIRST TIME (IDR=1) THEN THE ROUTINE
C     PROCEEDS TO STATEMENT 20 (THE MAIN SECTION). HOWEVER, IF
C     IDR > 1, THEN IT MUST FIRST UNDO THE PREVIOUS MODIFICATION.
C
      IF(IDR.EQ.1)GO TO 20
      ISP=IORD(IDR-1,ISTR)
      A1=ISPC(ISP,ISTR,2)
      A1=A1/ISPC(ISP,ISTR,3)
      BAS(ISTR,3,1)=BAS(ISTR,3,1)*A1*AA5
      BAS(ISTR,3,2)=BAS(ISTR,3,2)*A1*AA5
      DO 12 I=4,27
      DO 12 J=1,2
   12 BAS(ISTR,I,J)=BAS(ISTR,I,J)/A1
      IF(NDXS(ISTR).GE.0)GO TO 16
      IJK=BAS(ISTR,2,1)+0.1
      DO 14 I=1,16
      DIST(1,I,IJK)=DIST(1,I,IJK)/A1
   14 DIST(3,I,IJK)=DIST(3,I,IJK)/A1
   16 IP=ISPC(ISP,ISTR,10)/1000
      IF(IP.LT.5) GO TO 20
      J=2
      IF(IP.EQ.5) J=1
      BAS(ISTR,5,1)=BAS(ISTR,5,1)/(1.-DEC(1,J))
      BAS(ISTR,6,1)=BAS(ISTR,6,1)/(1.-DEC(2,J))
```

```
      BAS(ISTR,5,2)=BAS(ISTR,5,2)/(1.-DEC(1,J))
      BAS(ISTR,6,2)=BAS(ISTR,6,2)/(1.-DEC(2,J))
C
C     MAIN SECTION STARTS HERE.  FIRST THE WASTE GENERATOR
C     IMPACTS ARE SET EQUAL TO ZERO, THEN THE VOLUMES AND
C     CONCENTRATIONS ARE MODIFIED.
C
   20 A1=ISPC(NSPC,ISTR,2)
      A1=A1/ISPC(NSPC,ISTR,3)
      A2=BAS(ISTR,3,1)/AA5
      A3=A2/A1
      BAS(ISTR,3,1)=A3
      BAS(ISTR,3,2)=A3
      DO 22 I=4,27
      DO 22 J=1,2
   22 BAS(ISTR,I,J)=BAS(ISTR,I,J)*A1
      IF(NDXS(ISTR).GE.0)GO TO 26
      IJK=BAS(ISTR,2,1)+0.1
      DO 24 I=1,16
      DIST(1,I,IJK)=DIST(1,I,IJK)*A1
   24 DIST(3,I,IJK)=DIST(3,I,IJK)*A1
   26 IP=ISPC(NSPC,ISTR,10)/1000
      IF(IP.LT.5)RETURN
      J=2
      IF(IP.EQ.5) J=1
      BAS(ISTR,5,1)=(1.-DEC(1,J))*BAS(ISTR,5,1)
      BAS(ISTR,6,1)=(1.-DEC(2,J))*BAS(ISTR,6,1)
      BAS(ISTR,5,2)=(1.-DEC(1,J))*BAS(ISTR,5,2)
      BAS(ISTR,6,2)=(1.-DEC(2,J))*BAS(ISTR,6,2)
      RETURN
      END
C
C*************************************************************************
C
      SUBROUTINE RCLAIM(ISTR,NOPR)
C
C     THIS SUBROUTINE CLASSIFIES THE WASTE STREAMS IF THEY DONT
C     HAVE A DISTRIBUTION, AND CLASSIFIES THE PORTION OF THE
C     DISTRIBUTION (AS APPROPRIATE).
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32,2),ISPC(6,90,10),DCF(36,7,8),FICRP(7)
     +       /CHRC/BASN,NUC
     +       /NUCS/AL(36),FMF(36),RET(36,5)
     +  /DTNX1/IR1,ID1,IC1,IX1,IE1,IS1,IL1,IG1,IH1,IQ1,ICL1,IPO1,IIC1
     +  /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2,IQ2,ICL2,IPO2,IIC2
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16)
      NFG=0
C
C     NEXT STATEMENT IS THE STARTING POINT AFTER EACH SPECTRUM
C     CHANGE AS WELL AS FOR THE FIRST TIME - IN EFFECT AN OPEN
C     ENDED DO-LOOP UNTIL ALL, SOME, OR NONE OF THE WASTE IS
C     CLASSIFIED.  SEE COMMENTS UNDER STATEMENT 29.
C     THE LOGIC OF THE SECTION FOLLOWS FIGURE 3 OF APPENDIX C
C     OF THE FEIS.
C
   10 IF(NDXS(ISTR).EQ.0)GO TO 34
      IF(ISTR.LE.37)CALL COMBYN(ISTR,NOPR)
      IDR=ISPEC(ISTR)
      ISP=IORD(IDR,ISTR)
      I8=ISPC(ISP,ISTR,8)
      IF(IHIC(ISTR).GT.0)I8=1+IHIC(ISTR)
```

```
      IF(ISTR.GT.37.AND.NFG.EQ.0)GO TO 29
      CALL LISTS(ISTR,1,NX)
      IF(NX.EQ.1) GO TO 21
      IF(I8.GT.0)GO TO 16
      IF(IABS(NDX8(ISTR)).NE.2) GO TO 29
      IF(IG2.EQ.1.OR.IX2.EQ.3) GO TO 12
      IF(IH2.EQ.1) GO TO 14
      GO TO 29
   12 CALL LISTS(ISTR,2,NX)
      IF(NX.EQ.1) GO TO 23
      IF(IL2.EQ.0)GO TO 13
      CALL LISTS(ISTR,3,NX)
      IF(NX.EQ.1) GO TO 25
   13 IF(IH2.EQ.0) GO TO 29
   14 CALL LISTS(ISTR,4,NX)
      IF(NX.EQ.1) GO TO 27
      GO TO 29
   16 CALL LISTS(ISTR,2,NX)
      IF(NX.EQ.1) GO TO 24
      IF(IL2.EQ.0)GO TO 17
      CALL LISTS(ISTR,3,NX)
      IF(NX.EQ.1) GO TO 26
   17 IF(IH2.EQ.0) GO TO 29
      CALL LISTS(ISTR,4,NX)
      IF(NX.EQ.1) GO TO 28
      GO TO 29
   21 IMOD(ISTR)=1
      IF(I8.NE.0) IMOD(ISTR)=2
      GO TO 36
   23 IMOD(ISTR)=3
      GO TO 36
   24 IMOD(ISTR)=4
      GO TO 36
   25 IMOD(ISTR)=5
      GO TO 36
   26 IMOD(ISTR)=6
      GO TO 36
   27 IMOD(ISTR)=7
      GO TO 36
   28 IMOD(ISTR)=8
      GO TO 36
   29 IF(IDR.EQ.6) GO TO 34
      NFG=1
      IDR=IDR+1
      ISPEC(ISTR)=IDR
      IF(ISTR.GT.37)CALL COMBYN(ISTR,NOPR)
      GO TO 10
C
C      THIS IS THE END OF THE OPEN ENDED DO LOOP TO CLASSIFY
C      ALL OR SOME OF THE WASTE STREAMS.  IF THE WASTE IS NOT
C      ACCEPTABLE, THEN STATEMENT 34 IS CALLED.  IF SOME OF
C      THE WASTE IS ACCEPTABLE, THE ACCEPTABLE PORTION IS LEFT
C      IN ITS ORIGINAL ORDER, AND THE REST OF THE STREAM IS
C      DESIGNATED AS THE NSTR+1 STREAM.  SEE SUBROUTINE LISTS.
C
   34 IMOD(ISTR)=0
   36 RETURN
      END
C
C**********************************************************************
C
      SUBROUTINE LISTS(ISTR,NQ,NX)
C
```

```
C     THIS SUBROUTINE COMPARES THE CONCENTRATIONS OF THE ISTR WASTE
C     STREAM WITH THE CONCENIRATION FOR REGULAR (NQ=1), STABLE
C     (NQ=2), LAYERED (NQ=3), OR HOT (NQ=4) WASTE DISPOSAL, AND
C     MANIPULATES THE WASTE ACTIVITY DISTRIBUTIONS, IF NECESSARY.
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32,2),ISPC(6,90,10),DCF(36,7,8),FICRP(7)
     +      /CHRC/BASN,NUC/DTNX2/IR2
     +      /NUCS/AL(36),FMF(36),RET(36,5)
     +      /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +      /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16),NLST
      NX=0
      A1=0.
      INDEX=0
      IF(IR2.NE.0.OR.NQ.NE.1)GO TO 4
      IF(ISTR.GT.7.AND.ISTR.NE.32)GO TO 4
      INDEX=1
C
C     THE SECTION BETWEEN HERE AND STATEMENT 16 IS FOR WASTE
C     STREAMS WITHOUT AN ACTIVITY DISTRIBUTION.
C
    4 IDR=ISPEC(ISTR)
      ISP=IORD(IDR,ISTR)
      I9=ISPC(ISP,ISTR,9)
      A11=CLST(NQ,16)
      IF(IR2.NE.0)GO TO 6
      IF(NLST.GT.3.AND.NQ.NE.1)GO TO 6
      IJK=BAS(ISTR,2,1)+0.1
      IF(ISTR.LE.7.OR.ISTR.EQ.32.OR.ISTR.GT.37)A11=A11*35.0
      IF(IJK.EQ.7)A11=CLST(NQ,16)
    6 IF(NDXS(ISTR).LT.0) GO TO 16
      IF(INDEX.EQ.0)GO TO 8
C
C     SUBROUTINE BARN PERFORMS A SPECIAL SUMMATION OF THE
C     ACTIVITIES AND CLASSIFICATION BASED ON THE CURRENT
C     LLW DISPOSAL FACILITY LICENSE CONDITIONS.
C     ONLY UNSTABLE WASTES ARE SUBJECTED TO THIS TEST,
C     AND ONLY IF IR2=0.
C
      CALL BARN(ISTR,A2,A3,NX)
      RETURN
    8 DO 10 I=19,27
   10 A1=A1+BAS(ISTR,I,1)
      A1=(A1-BAS(ISTR,22,1))/CLST(NQ,15)+BAS(ISTR,22,1)/A11
      IF(IR2.EQ.0.AND.NQ.EQ.1)GO TO 14
      DO 12 I=1,14
      A2=1.0
      IF(I9.EQ.1)GO TO 12
      IF(I.EQ.2.OR.I.EQ.4.OR.I.EQ.6.OR.I.EQ.7)A2=10.
   12 A1=A1+BAS(ISTR,I+4,1)/(CLST(NQ,I)*A2)
   14 IF(A1.GT.1.0) RETURN
      NX=1
      RETURN
C
C     THIS SECTION STARTS THE TESTING AND CLASSIFICATION FOR
C     WASTE STREAMS WITH AN ACTIVITY DISTRIBUTION.  FIRST THE
C     TOTAL ACTIVITY THAT WOULD PERMIT A PORTION OF THE WASTE
C     TO BE DISPOSED AS CLASS NQ IS DETERMINED, THEN THE VOLUME
C     OF THE WASTE CORRESPONDING TO THAT ACTIVITY IS CLASSIFIED.
C
   16 IF(INDEX.EQ.0)GO TO 18
      CALL BARN(ISTR,A2,A3,NX)
      GO TO 26
```

```
   18 DO 20 I=19,27
   20 A1=A1+BAS(ISTR,I,1)
      A2=A1
      A1=(A1-BAS(ISTR,22,1))/CLST(NQ,15)+BAS(ISTR,22,1)/A11
      IF(IR2.EQ.0.AND.NQ.EQ.1)GO TO 23
      DO 22 I=1,14
      A3=1.0
      IF(I9.EQ.1)GO TO 22
      IF(I.EQ.2.OR.I.EQ.4.OR.I.EQ.6.OR.I.EQ.7)A3=10.
   22 A1=A1+BAS(ISTR,I+4,1)/(CLST(NQ,I)*A3)
   23 DO 24 I=1,14
   24 A2=A2+BAS(ISTR,I+4,1)
      A3=A2/A1
C
C     AT THIS POINT A3 IS THE MAXIMUM PERMISSIBLE TOTAL ACTIVITY
C     FOR WASTE CLASS NQ.  IT IS TESTED AGAINST DIST(1,I,IJK),
C     AND THE FRACTION OF WASTE VOLUME DETERMINED.
C
   26 IJK=BAS(ISTR,2,1)+0.1
      DO 28 I=2,16
      IF(A3.LT.DIST(1,I,IJK)) GO TO 30
   28 CONTINUE
C
C     SUCCESS OF DO LOOP 30 MEANS ALL OF THE WASTE IS ACCEPTABLE
C     UNDER THE CLASSIFICATION NQ.
C
      NX=1
      A1=1.
      A5=DIST(3,16,IJK)
      GO TO 38
   30 A4=(A3-DIST(1,I-1,IJK))/(DIST(1,I,IJK)-DIST(1,I-1,IJK))
      A1=DIST(2,I-1,IJK)+A4*(DIST(2,I,IJK)-DIST(2,I-1,IJK))
      IF(A1.LT.1.E-3) RETURN
      IF(A1.GT.0.999) GO TO 36
C
C     AT THIS POINT SOME OF THE WASTE IS FOUND TO BE ACCEPTABLE
C     UNDER CLASSIFICATION NQ; THE PORTION THAT IS FOUND UNACCEPT-
C     ABLE MUST BE DESIGNATED AS A NEW WASTE STREAM.  THUS, A NEW
C     WASTE STREAM DENOTED NSTR+1 IS CREATED, AND PROPERTIES OF
C     THE ISTR WASTE STREAM IS STORED ONTO THE PROPERTIES OF NSTR.
C
      NSTR=NSTR+1
      BASN(NSTR)=BASN(ISTR)
      BAS(NSTR,2,1)=BAS(ISTR,2,1)
      BAS(NSTR,2,2)=BAS(ISTR,2,2)
      BAS(NSTR,3,1)=BAS(ISTR,3,1)*(1.-A1)
      BAS(NSTR,3,2)=BAS(ISTR,3,2)*(1.-A1)
      DO 32 J=4,27
      DO 32 K=1,2
   32 BAS(NSTR,J,K)=BAS(ISTR,J,K)
      DO 34 K=1,6
      IORD(K,NSTR)=IORD(K,ISTR)
      DO 34 J=1,10
   34 ISPC(K,NSTR,J)=ISPC(K,ISTR,J)
      ISPEC(NSTR)=ISPEC(ISTR)
      NDXS(NSTR)=NDXS(ISTR)
      IHIC(NSTR)=IHIC(ISTR)
C
C     THE FINAL STEPS IN THE CLASSIFICATION OF THE DISTRIBUTION
C     WASTE STREAM CONSIST OF ADJUSTING THE VOLUMES, TOTAL AND
C     RADIONUCLIDE ACTIVITIES, WASTE GENERATOR IMPACTS, AND
C     MODIFYING THE DIST (DISTRIBUTIONS) TO REFLECT THAT A
C     FRACTION HAS BEEN CLASSIFIED.
```

```
C
   36 A5=DIST(3,I-1,IJK)+A4*(DIST(3,I,IJK)-DIST(3,I-1,IJK))
   38 A6=A5*A1
      A7=A5/A2
      BAS(ISTR,3,1)=BAS(ISTR,3,1)*A1
      BAS(ISTR,3,2)=BAS(ISTR,3,2)*A1
      BAS(ISTR,4,1)=A5
      BAS(ISTR,4,2)=A5
      DO 46 J=5,27
      DO 46 K=1,2
   46 BAS(ISTR,J,K)=BAS(ISTR,J,K)*A7
      IF(NX.EQ.1)RETURN
      DO 50 J=I,16
      A7=DIST(2,J,IJK)*DIST(3,J,IJK)-A6
      A8=DIST(2,J,IJK)-A1
      DIST(2,J,IJK)=A8
   50 DIST(3,J,IJK)=A7/A8
      DO 55 J=2,I
      DIST(2,J-1,IJK)=0.
   55 DIST(3,J-1,IJK)=0.
      DIST(1,I-1,IJK)=A3
      DO 65 J=1,16
   65 DIST(2,J,IJK)=DIST(2,J,IJK)/DIST(2,16,IJK)
      NX=1
      RETURN
      END
C
C*************************************************************************
C
      SUBROUTINE MODIF
C
C     THIS ROUTINE MODIFIES THE DISPOSAL STATUS OF THE WASTE
C     (WHICH IS BASED ON WASTE PROPERTIES) BY TAKING INTO
C     ACCOUNT THE DISPOSAL PRACTICES
C
      COMMON/DTNX1/IR1,ID1,IC1,IX1,IE1,IS1
     +      /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IC2,IH2
     +      /NBAS/NSTR,NNUC,NDXS(90),IMOD(90)
      IF(IS1.EQ.1.OR.IS1.EQ.3)RETURN
      DO 30 ISTR=1,NSTR
      I11=IMOD(ISTR)
      IF(IR2.NE.0)GO TO 10
      IF(I11.GT.1.AND.I11.LT.7)I11=1
      GO TO 30
   10 IF(IH2.EQ.1)GO TO 20
      IF(I11.GT.2.AND.I11.LT.7)I11=0
      IF(I11.EQ.2)I11=1
      GO TO 30
   20 IF(I11.EQ.3.OR.I11.EQ.5)I11=7
      IF(I11.EQ.4.OR.I11.EQ.6)I11=8
   30 IMOD(ISTR)=I11
      RETURN
      END
C
C*************************************************************************
C
      SUBROUTINE BARN(ISTR,A2,A3,NX)
C
C     THIS ROUTINE PERFORMS A SPECIAL CLASSIFICATION TEST
C     FOR UNSTABLE WASTES BASED ON EXISTING DISPOSAL FACILITY
C     LICENSE CONDITIONS.  BOTH NON-DISTRIBUTIONAL AND DISTRI-
C     BUTIONAL WASTE STREAMS CAN BE SUBJECTED TO THIS TEST.
C
```

```
      COMMON/BAST/BAS(90,32,2)/NBAS/NSTR,NNUC,NDXS(90)
      A1=0.
      DO 10 I=19,27
   10 A1=A1+BAS(ISTR,I,1)
      A2=A1
      A1=A1-BAS(ISTR,22,1)*(1.-1./35.)
      IF(NDXS(ISTR).LT.0)GO TO 20
      IF(A1.GT.0.016)RETURN
      DO 12 I=5,6
      IF(BAS(ISTR,I,1).GT.1.0)RETURN
   12 CONTINUE
      DO 14 I=8,18
      IF(BAS(ISTR,I,1).GT.1.0)RETURN
   14 CONTINUE
      NX=1
      RETURN
   20 DO 22 I=5,18
   22 A2=A2+BAS(ISTR,I,1)
      A4=AMAX1(BAS(ISTR,5,1),BAS(ISTR,6,1))
      DO 24 I=8,18
      IF(A4.LT.BAS(ISTR,I,1))A4=BAS(ISTR,I,1)
   24 CONTINUE
      A3=A1/0.016
      IF(A4.LT.A3)A4=A3
      A3=A2/A4
      RETURN
      END
C
C**********************************************************************
C
      FUNCTION ERFS(A1,A2)
      A3=0.5*SQRT(A2/A1)
      A4=A3*(1.-A1)
      A5=A3*(1.+A1)
      IF(A4.GT.0)GO TO 10
      ERFS=2.+EXM(A4*A4)*(POLY(A5)-POLY(-A4))
      RETURN
   10 ERFS=EXM(A4*A4)*(POLY(A4)+POLY(A5))
      RETURN
      END
C
      FUNCTION POLY(X1)
      DATA A1,A2,A3,A4,A5,P/.254829592,-.284496736,1.421413741,
     *                     -1.453152027,1.061405429,.3275911/
      T1=1./(1.+P*X1)
      POLY=T1*(A1+T1*(A2+T1*(A3+T1*(A4+T1*A5))))
      RETURN
      END
C
      FUNCTION EXM(A1)
      A2=0.0
      IF(A1.LT.85.)A2=EXP(-A1)
      EXM=A2
      RETURN
      END
C
C**********************************************************************
C
      SUBROUTINE GWATER(NTYM,TYMO,THIC,ICN,NOPTW)
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32,2),ISPC(6,90,10),DCF(36,7,8),FICRP(7)
     +       /CHRC/BASN,NUC
```

```
     +       /NUCS/AL(36),FMF(36),RET(36,5)
     +    /DTNX1/IR1,ID1,IC1,IX1,IE1,IS1,IL1,IG1,IH1,IQ1,ICL1,IPO1,IIC1
     +    /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2,IQ2,ICL2,IPO2,IIC2
     +       /DTIS/FSC(6),FSA(6),PRC(6,2),GFC(6,3),TTM(6,3),TPC(6,3),
     +            RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPD(6,2),NRET(6)
     +       /IMPS/DZ(23,22,21)
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16)
      DIMENSION EMP(5),EFF(2),SEFF(2),TYMD(22),RES(22,3)
      DATA EMP/.5,.75,.5,.5,.75/
      DATA EFF/6.4,7.0/
      DATA SEFF/0.9,0.35/
      DATA NOPT/1/
C
C      THE ABOVE MATRICES AND ARRAYS ARE :
C         EMP(5)     : VOLUME EMPLACEMENT EFFICIENCIES
C         EFF(2)     : LAND USE VOLUME EFFICIENCIES
C         SEFF(2)    : LAND USE SURFACE AREA EFFICIENCIES
C         TYMD(22)   : THE 22 TIMESTEPS
C         RES(22,3)  : WILL CONTAIN RESULTS FROM SUBROUTINE RTIJ
C         IHIC(90)   : INDEX FOR INTERNMENT IN HIGH INTEGRITY CONT.
C
      IF(ICN.EQ.2) GO TO 1
      IR=IR1
      ID=ID1
      IC=IC1
      IX=IX1
      IE=IE1
      IS=IS1
      IL=IL1
      IG=IG1
      IH=IH1
      IQ=IQ1
      ICL=ICL1
      IPO=IPO1
      IIC=IIC1
      GO TO 2
    1 IR=IR1
      ID=ID2
      IC=IC2
      IX=IX2
      IE=IE2
      IS=IS2
      IL=IL2
      IG=IG2
      IH=IH2
      IQ=IQ2
      ICL=ICL2
      IPO=IPO2
      IIC=IIC2
    2 TVOL=0.0
      CINS=IPO+IIC
      NSEC=10
C
C
C      NEXT SECTION DETERMINES PERCOLATION VALUE AND LOWER
C      LIMIT FOR THE DILUTION FACTOR.
C
      PRC1=PRC(IR,1)
      PRC2=PRC(IR,2)
      IF(IG.EQ.1.OR.ID.EQ.2) GO TO 5
      IF(IE.EQ.4.OR.IE.EQ.5) PRC1=PRC(IR,1)/10.
      IF(IE.EQ.4.OR.IE.EQ.5) PRC2=PRC(IR,2)/10.
```

```
    5 CONTINUE
      IF(IC.EQ.1)PRCD=PRC1
      IF(IC.GT.1)PRCD=PRC2
      IF(IX.EQ.1)PRCD=4.0*PRC1
      IF(IC.EQ.1.AND.IX.EQ.2)PRCD=2.25*PRC1
      IF(IC.EQ.2.AND.IX.EQ.2)PRCD=4.00*PRC2
      TVOL=352000.*SQRT(PRC(IR,1)*27.8)
      IF(TVOL.LT.7700.)TVCL=7700.
C
C      LOOP 90 IS THE MAIN LOOP OF GROUNDWATER PATHWAY EQUATION
C
      DO 90 ISTR=1,NSTR
      I11=IMOD(ISTR)
      IF(I11.EQ.0)GO TO 90
      IF(I11.EQ.1.AND.ICN.NE.1) GO TO 90
      IF(I11.GT.1.AND.ICN.NE.2) GO TO 90
      IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
      I6=ISPC(NSPC,ISTR,6)
      VUR=0.9/(EMP(IE)*EFF(ID))
      I7=ISPC(NSPC,ISTR,7)
      IF(I11.GT.6)VUR=0.19
      I8=ISPC(NSPC,ISTR,8)
      IF(IS.LT.2.OR.I7.EQ.1)I6=I6-1
      IF(IHIC(ISTR).GT.0)I8=1+IHIC(ISTR)
      GDEL=0.
      IF(IHIC(ISTR).EQ.1.OR.I8.EQ.2)GDEL=THIC
      I9=ISPC(NSPC,ISTR,9)
      PERC=PRCD
      IF(I8.LT.1.OR.IS1.EQ.0.OR.IS1.EQ.2)GO TO 10
      IF(IC.EQ.1)PERC=PRC1
      IF(IC.GT.1)PERC=PRC2
   10 IF(I11.GT.6.OR.ID.EQ.2)PERC=PRC2/16.
      PERC=PERC*(1.0-0.9*IG)
      PER2=3.6*PERC+0.1*PRC1
      IF(ID.EQ.2)PER2=0.9*PERC+0.1*PRC2
      NX=0
      IF(PERC.LT.PRC1)NX=1
      A6=1.0
      IF(I6.GT.1)A6=4.**(1-I6)
      A9=1.0
      IF(I9.GT.1)A9=10.**(1-I9)
      I1=NRET(IR)
      IF(IS.LT.2.OR.I7.EQ.1)I1=I1-1
      TDUM-1.0/(PERC*VUR*A6*A9)
      IF(I1.LE.0)I1=1
      DO 80 INUC=1,NNUC
      IF(BAS(ISTR,INUC+4,2).LT.1.E-14)GO TO 80
      TDUR=TDUM/FMF(INUC)
      C1=TDUR
      IF(NX.EQ.0.OR.NOPT.EQ.0)GO TO 15
      IF(C1.LT.GINS)C1=GINS
C
   15 CALL RTIJ(TYMD,NTYM,INUC,IR,I1,C1,0.0,RES,GDEL,NOPTW)
C
C      RESULTS FROM SUBROUTINE RTIJ ARE RETURNED IN RES MATRIX
C
      B1=BAS(ISTR,3,2)*BAS(ISTR,INUC+4,2)/TDUR
      DO 30 IPTH=1,3
      B2=B1*RGF(IR,IPTH)/(GFC(IR,IPTH)*NSEC)
      IF(TVOL.GT.GFC(IR,IPTH))B2=B2*GFC(IR,IPTH)/TVOL
      I3=(IPTH-1)*7
      I2=6
```

```
      IF(IPTH.EQ.3)I2=7
      DO 25 ITYM=1,NTYM
      A3=EXM(AL(INUC)*TYMD(ITYM))
      DO 20 I=1,7
      A4=A3*RES(ITYM,IPTH)*B2*DCF(INUC,I,I2)
   20 DZ(INUC,ITYM,I3+I)=DZ(INUC,ITYM,I3+I)+A4
   25 CONTINUE
   30 CONTINUE
C
C      THE NEXT SECTION CONSIDERS (NOPT=0 CANCELS THIS CONSIDER-
C      ATION) THE SECOND SOURCE TERM OF THE 2-STEP ANALYSIS WITH
C      AN INCREASED SOURCE TERM (PER2) AFTER THE INSTITUTIONAL
C      CONTROL PERIOD.
C
      IF(NX.EQ.0.OR.NOPT.EQ.0)GO TO 60
      IF(TDUR.LE.GINS)GO TO 60
      T1=GINS
      T2=T1+PERC*(TDUR-T1)/PER2
C
      CALL RTIJ(TYMD,NTYM,INUC,IR,I1,T2,T1,RES,GDEL,NOPTW)
C
      B1=B1*PER2/PERC
      DO 50 IPTH=1,3
      B2=B1*RGF(IR,IPTH)/(QFC(IR,IPTH)*NSEC)
      IF(TVOL.GT.QFC(IR,IPTH))B2=B2*QFC(IR,IPTH)/TVOL
      I3=(IPTH-1)*7
      I2=6
      IF(IPTH.EQ.3)I2=7
      DO 45 ITYM=1,NTYM
      A3=EXM(AL(INUC)*TYMD(ITYM))
      DO 40 I=1,7
      A4=A3*RES(ITYM,IPTH)*B2*DCF(INUC,I,I2)
   40 DZ(INUC,ITYM,I3+I)=DZ(INUC,ITYM,I3+I)+A4
   45 CONTINUE
   50 CONTINUE
   60 CONTINUE
   80 CONTINUE
   90 CONTINUE
      RETURN
      END
C
C*****************************************************************************
C
      SUBROUTINE RTIJ(TYMD,NTYM,INUC,IR,I1,TDUR,TMIN,RES,GDEL,NOPTW)
C
C      SUBROUTINE RTIJ CALCULATES THE MIGRATION REDUCTION FACTORS
C
      COMMON/NUCS/AL(36),FMF(36),RET(36,5)
     *      /DTIS/FSC(6),FSA(6),PRC(6,2),QFC(6,3),TTM(6,3),TPC(6,3),
     *            RGF(6,3),PCP(6,3),DTTM(6),DTPC(6),TPD(6,2),NRET(6)
      DIMENSION TYMD(NTYM),RES(22,3),BTTM(6),BTPC(6)
      DATA BTTM/350.,66.,175.,283.,56.,116./
      DATA BTPC/700.,1900.,700.,1600.,1900.,1900./
C
C      THE ABOVE ARRAYS ARE DTTM AND DTPC ARRAYS FOR
C      THE BOUNDARY WELL CASE (NOPTW=1)
C
      CALL ZERO(RES,66)
C
      DO 30 IPTH=1,3
      A1=RET(INUC,I1)*TTM(IR,IPTH)+GDEL
      IF(NOPTW.EQ.1.AND.IPTH.EQ.1)A1=RET(INUC,I1)*BTTM(IR)+GDEL
      DO 20 ITYM=1,NTYM
```

```
      TYM=TYMD(ITYM)-THIN
      A2=TYMD(ITYM)-TDUR
      DO 10 ISEC=1,10
      B3=1.0/(A1+RET(INUC,I1)*(ISEC-1)*DTTM(IR))
      IF(TYM*1.1*B3.LT.1.0) GO TO 20
      B4=TPC(IR,IPTH)+(ISEC-1)*DTPC(IR)
      IF(NOPTW.EQ.1.AND.IPTH.EQ.1)B4=BTPC(IR)+(ISEC-1)*DTPC(IR)
      A3=0.5*ERFS(B3*TYM,B4)
      IF(A2.GT.0.0)A3=A3-0.5*ERFS(B3*A2,B4)
      IF(A3.LT.0.0)A3=0.0
   10 RES(ITYM,IPTH)=RES(ITYM,IPTH)+A3
   20 CONTINUE
   30 CONTINUE
      RETURN
      END
C
C**************************************************************************
C
      SUBROUTINE ZERO(A,N)
C
      DIMENSION A(N)
      DO 10 I=1,N
   10 A(I)=0.0
      RETURN
      END
```

OPTIONR Code

```
      PROGRAM OPTIONR
C
C***********************************************************************
C     THIS IS THE REVISED OPTIONS IMPACTS CODE.  IT FINDS THE          *
C     DISPOSAL PRACTICES FOR PROPER INTERNMENT OF WASTE STREAMS.       *
C     WASTE-VOLUME-AVERAGED INTRUDER IMPACTS, EXPOSED WASTE            *
C     IMPACTS, IMPACTS FROM SITE OPERATIONAL ACCIDENTS, POTENTIAL      *
C     TRENCH OVERFLOW AND LEACHATE TREATMENT IMPACTS, AND COSTS,       *
C     ENERGY USE, LAND USE, OCCUPATIONAL EXPOSURES, AND POPULATION*
C     EXPOSURES ASSOCIATED WITH MANAGEMENT, TRANSPORT, AND             *
C     DISPOSAL OF WASTE.                                               *
C***********************************************************************
C
      CHARACTER*10 BASN(90),NUC(36),NOTE(2),DES(9)
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8),FICRP(7),AZR(90)
     +      /CHRC/BASN,NUC
     +      /NUCS/AL(36),FMF(36),RET(36,5)/COMB/TPOP(2),DEC(36,2)
     +      /DTNX1/IRDC1(13)/DTNX2/IRDC2(13)
     +      /DTIS/FSC(6),FSA(6),PRC(6,2),GFC(6,3),TTM(6,3),TPC(6,3),
     +            RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPD(6,2),NRET(6)
     +      /VOLS/VRG1,VRG2,VLAY,VHOT,VNOT,RVOL(4,37)
     +      /IMPS/DZ(8,7,2),DZQ(4,7,2),DZA(7,7),DZS(90,7,2)
     +      /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +      /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16),NLST
     +      /CSTS/TIMP(6),COST(8),GD(8),UN(8),TCU(30)
     +      /CHYN/NXUC(36),ICH(7,6),LCH(6),ACT(7)
     +      /CHIN/BCT(7,2)
      DIMENSION IGN(90),IGR1(90),IGR2(90),IGL(90),IGH(90),
     +          DZUS(3,7,2),DZST(4,7,2),IORDD(6),NORDD(6)
C
C***********************************************************************
C     THE ABOVE MATRICES AND ARRAYS ARE BRIEFLY EXPLAINED BELOW.*
C     MORE DETAILED EXPLANATIONS CAN BE FOUND IN THE DEIS&FEIS    *
C                                                                      *
C     BASN   = NAME OF THE WASTE STREAMS                               *
C     NUC    = NAME OF THE RADIONUCLIDES CONSIDERED                    *
C     NOTE   = TITLE OF THE PROBLEM                                    *
C     DES    = DESCRIPTIONS OF PATHWAYS                                *
C     BAS    = BASIC DATA MATRIX OF VOLUMES&CONCENTRATIONS             *
C     ISPC   = WASTE SPECTRUM INFORMATION                              *
C     DCF    = PATHWAY DOSE CONVERSION FACTORS                         *
C     FICRP  = ICRP WEIGHTING FACTORS FOR ORGANS                       *
C     AZR    = VRF/VIF FOR THE FIRST SPECTRUM                          *
C     AL     = DECAY CONSTANTS OF RADIONUCLIDES                        *
C     FMF    = PARTITION RATIOS BETWEEN WASTE AND LEACHATE             *
C     RET    = RETARDATION COEFFICIENTS OF RADIONUCLIDES               *
C     TPOP   = RURAL AND URBAN X/Q WEIGHTED POPULATION FACTORS         *
C     DEC    = DECONTAMINATION FACTORS FOR INCINERATORS                *
C     IRDC1  = DISPOSAL TECHNOLOGY INDICES FOR UNSTABLE WASTES         *
C     IRDC2  = DISPOSAL TECHNOLOGY INDICES FOR STABLE WASTES           *
C     FSC    = SOIL-TO-AIR TRANSFER FACTOR - CONSTRUCTION              *
C     FSA    = SOIL-TO-AIR TRANSFER FACTOR - AGRICULTURE               *
C     GFC    = DILUTION FACTORS FOR GROUNDWATER SCENARIOS              *
C     TTM    = TRAVEL TIME(YEARS) FOR GW SCENARIOS                     *
C     TPC    = PECLET NUMBERS FOR GW SCENARIOS                         *
C     RGF    = GEOMETRIC REDUCTION FACTORS FOR GW SCENARIOS            *
C     POP    = POPULATION FACTORS FOR ACCIDENT SCENARIOS               *
C     DTTM   = TRAVEL TIME BETWEEN DISPOSAL SITE SECTORS               *
C     DTPC   = PECLET NUMBER BETWEEN DISPOSAL SITE SECTORS             *
C     TPD    = X/Q WEIGHTED POPULATION SUM-DISTRIBUTION                *
C     NRET   = RETARDATION COEFFICIENT SET FOR THE DISPOSAL SITE*
C     RVOL   = REGIONAL VOLUMES OF WASTE GENERATED                     *
C     DZ     = DUMMY DOSE MATRIX CALCULATED INTERNALLY                 *
```

```
C      DZQ     = DUMMY DOSE MATRIX CALCULATED INTERNALLY                *
C      DZA     = DUMMY DOSE MATRIX CALCULATED INTERNALLY                *
C      DZS     = DUMMY DOSE MATRIX CALCULATED INTERNALLY                *
C      NDXS    = INDEX ON STATUS OF WASTE STREAM                        *
C      IMOD    = CALCULATED DISPOSAL MODE OF WASTE STREAM               *
C      ISPEC   = CURRENT SPECTRUM FOR THE WASTE STREAM                  *
C      IHIC    = HIGH INTEGRITY CONTAINER INDEX                         *
C      CLST    = LISTS OF WASTE CLASSIFICATION CONCENTRATIONS           *
C      DIST    = ACTIVITY DISTRIBUTIONS OF CERTAIN WASTE STREAMS        *
C      IORD    = ORDER IN WHICH WASTE SPECTRUMS ARE CONSIDERED          *
C      FLST    = GENERAL LISTS OF WASTE CLAS. CONCENTRATIONS            *
C      CSTS    = IMPACTS RELATED ARRAYS                                 *
C      NXUC    = INDEX DENOTING WHETHER MEMBER OF CHAIN                 *
C      ICH     = ORDER OF THE FOUR CHAINS CONSIDERED                    *
C      LCH     = NUMBER OF MEMBERS IN FOUR CHAINS CONSIDERED            *
C      ACT     = FRACTIONAL ACTIVITIES OF CHAIN MEMBERS                 *
C      BCT     = INTERMEDIATE ARRAY USED IN CHAIN CALCULATIONS          *
C      IGN     = NUMBERS OF NOT-ACCEPTABLE WASTE STREAMS                *
C      IGR1    = NUMBERS OF UNSTABLE-REGULAR WASTE STREAMS              *
C      IGR2    = NUMBERS OF STABLE-REGULAR WASTE STREAMS                *
C      IGL     = NUMBERS OF LAYERED WASTE STREAMS                       *
C      IGH     = NUMBERS OF HOT-WASTE FACILITY WASTE STREAMS            *
C      DZUS    = INTERMEDIATE INTRUDER IMPACTS-UNSTABLE WASTES          *
C      DZST    = INTERMEDIATE INTRUDER IMPACTS-STABLE WASTES            *
C      IORDD   = BASIC ORDER FOR SPECTRUM CONSIDERATION                 *
C      NORDD   = DUMMY ORDER FOR SPECTRUM CONSIDERATION                 *
C*************************************************************************
C
      DATA DES/' INT-CONS ',' INT-AGRI ',' INT-AIR  ',
     +         ' ERO-AIR  ',' INT-WAT  ',' ERO-WAT  ',
     +         ' ACC-SNGC ',' ACC-FIRE ',' ACC-AVG  '/
      DATA RI,RJ/.1,.09/
      DATA AZR/1.,1.4,3*1.,1.4,15*1.,4*3.,2*1.92,3*1.,2.,1.3,58*1./
C
C     NEXT SECTION READS ALL THE BASIC INFORMATION
C
   10 REWIND 1
      REWIND 2
      CALL READIN
C
C     NEXT SECTION READS BASIC AND CONDITIONAL INFORMATION
C     FROM TAPES.  PROGRAM QUITS WHEN THERE ARE NO MORE CASES
C     TO BE CONSIDERED.  CONDITIONAL INFORMATION IS USED TO
C     ALTER THE BASIC INFORMATION DEPENDING ON THE CASE.
C
      READ(5,1020,END=100)NOTE
   12 READ(5,1022)NOPR,NNDX,NORD,NLST,NHIC,NBEST
      READ(5,1022)(IRDC1(I),I=1,13)
      READ(5,1022)(IRDC2(I),I=1,13)
      READ(5,1022)(IORDD(I),I=1,6)
      IF(NLST.EQ.0)READ(5,1025)((CLST(I,J),J=1,16),I=1,4)
      DO 14 I=1,NSTR
      ISPEC(I)=1
   14 NDXS(I)=1
      DO 16 I=1,3
      NDXS(I)=-1
   16 NDXS(I+4)=-1
      NDXS(37)=-1
      IF(NNDX.EQ.0)GO TO 20
      DO 18 I=1,NNDX
      READ(5,1022) IDIFF,NDXD
   18 NDXS(IDIFF)=NDXD
   20 DO 22 I=1,NSTR
```

```
   22 IHIC(I)=0
      IF(NHIC.EQ.0)GO TO 26
      DO 24 I=1,NHIC
      READ(5,1022) IDIF,NHCD
   24 IHIC(IDIF)=NHCD
   26 DO 28 I=1,NSTR
      DO 28 J=1,6
   28 IORD(J,I)=IORDD(J)
      IF(NORD.EQ.0)GO TO 34
      DO 32 I=1,NORD
      READ(5,1022) NK,(NORDD(J),J=1,6)
      DO 30 J=1,6
   30 IORD(NK,J)=NORDD(J)
   32 CONTINUE
   34 IF(NLST.EQ.0)GO TO 38
      DO 36 J=1,4
      DO 36 K=1,16
      IF(FLST(NLST,J,K).LT.1.E-7)FLST(NLST,J,K)=1.E-7
   36 CLST(J,K)=FLST(NLST,J,K)
      IRR=IRDC1(1)
   38 IF(NOPR.EQ.0)GO TO 43
      IF(IRR.GT.4)IRR=2
   40 DO 41 ISTR=1,NSTR
   41 BAS(ISTR,3)=RVOL(IRR,ISTR)
   43 IF(IRR.NE.4)GO TO 42
      DO 39 I=1,6
      DO 39 ISTR=1,NSTR
   39 ISPC(I,ISTR,5)=ISPC(I,ISTR,5)-1
C
C     THIS IS THE REAL BEGINNING OF THE CODE.
C     FIRST BASIC INFO IS PRINTED, THEN ARRAYS ARE ZEROED OUT.
C
   42 WRITE(4,1002) NOTE
      N=1
      WRITE(4,1003) N,IRDC1
      N=2
      WRITE(4,1003) N,IRDC2
      WRITE(4,1032)NOPR,NNDX,NORD,NLST,NHIC,NBEST,(IORDD(I),I=1,6)
 1032 FORMAT(/2X'NOPR='I2,2X'NNDX='I2,2X'NORD='I2,2X/
     +          2X'NLST='I2,2X'NHIC='I2,2X'NBES='I2,2X/
     +          2X'IORD 1-6 ARE: '6I2)
      CALL ZERO(DZ,1477)
      CALL ZERO(DZUS,42)
      CALL ZERO(DZST,56)
      VRG1=0.0
      VRG2=0.0
      VLAY=0.0
      VHOT=0.0
      VNOT=0.0
      NNOT=0
      NHOT=0
      NLAY=0
      NRG1=0
      NRG2=0
C
C     NEXT SECTION IS THE OPEN ENDED DO LOOP THAT DETERMINES
C     THE STATUS OF THE WASTE STREAMS.
C
      ISTR=0
   44 ISTR=ISTR+1
      IF(ISTR.GT.NSTR) GO TO 66
      IF(NDXS(ISTR).NE.0) GO TO 46
      WRITE(4,1006)BASN(ISTR)
```

OPTIONR Code (cont'd)

```
      IMOD(ISTR)=0
      GO TO 44
   46 IMOD(ISTR)=1
      IHC=IHIC(ISTR)
C
      CALL RCLAIM(ISTR,INDX,NOPR,NBEST)
C
      II=IMOD(ISTR)+1
C
C     AFTER DETERMINING THE STATUS AND IMPACTS OF THE WASTE
C     STREAMS, IMPACTS AND VOLUMES ARE STORED APPROPRIATELY.
C
      GO TO (48,50,54,54,54,58,58,62,62),II
   48 NNOT=NNOT+1
      IGN(NNOT)=ISTR
      VNOT=VNOT+BAS(ISTR,3)
      GO TO 44
   50 NRG1=NRG1+1
      IGR1(NRG1)=ISTR
      DO 52 I=1,7
      DO 52 J=1,2
      DZUS(1,I,J)=DZUS(1,I,J)+BAS(ISTR,3)*DZ(INDX,I,J)
      DZUS(2,I,J)=DZUS(2,I,J)+BAS(ISTR,3)*DZ(3,I,J)
   52 DZUS(3,I,J)=DZUS(3,I,J)+BAS(ISTR,3)*DZ(8,I,J)
      VRG1=VRG1+BAS(ISTR,3)
      GO TO 44
   54 NRG2=NRG2+1
      IGR2(NRG2)=ISTR
      DO 56 I=1,7
      DO 56 J=1,2
      DZST(1,I,J)=DZST(1,I,J)+BAS(ISTR,3)*DZ(INDX,I,J)
      DZST(2,I,J)=DZST(2,I,J)+BAS(ISTR,3)*DZ(3,I,J)
   56 DZST(3,I,J)=DZST(3,I,J)+BAS(ISTR,3)*DZ(8,I,J)
      VRG2=VRG2+BAS(ISTR,3)
      GO TO 44
   58 NLAY=NLAY+1
      IGL(NLAY)=ISTR
      DO 60 I=1,7
      DO 60 J=1,2
      DZST(4,I,J)=DZST(4,I,J)+BAS(ISTR,3)*DZ(INDX,I,J)
      DZST(2,I,J)=DZST(2,I,J)+BAS(ISTR,3)*DZ(3,I,J)
   60 DZST(3,I,J)=DZST(3,I,J)+BAS(ISTR,3)*DZ(8,I,J)
      VLAY=VLAY+BAS(ISTR,3)
      GO TO 44
   62 NHOT=NHOT+1
      IGH(NHOT)=ISTR
      DO 64 I=1,7
      DO 64 J=1,2
      DZST(1,I,J)=DZST(1,I,J)+BAS(ISTR,3)*DZ(INDX,I,J)
   64 DZST(3,I,J)=DZST(3,I,J)+BAS(ISTR,3)*DZ(8,I,J)
      VHOT=VHOT+BAS(ISTR,3)
      GO TO 44
C
C     THIS IS THE END OF THE OPEN DO LOOP TO CLASSIFY THE
C     WASTE STREAMS   NEXT SECTION CALCULATES AND PRINTS
C     WASTE VOLUMES AND VOLUME-AVERAGED INTRUDER IMPACTS.
C
   65 V1=VRG2+VNOT
      V2=VRG2+VLAY
      V3=VRG2+VLAY+VHOT
      V4=VRG1+V1
      V5=VRG1+V2
      V6=VRG1+V3
```

```
      DO 70 J=1,7
      DO 70 K=1,2
      DO 68 I=1,3
   68 DZQ(I,J,K)=DZUS(I,J,K)+DZST(I,J,K)
      IF(V1.GT.1.)DZST(1,J,K)=DZST(1,J,K)/V1
      IF(V2.GT.1.)DZST(2,J,K)=DZST(2,J,K)/V2
      IF(V3.GT.1.)DZST(3,J,K)=DZST(3,J,K)/V3
      DZQ(1,J,K)=DZQ(1,J,K)/V4
      DZQ(2,J,K)=DZQ(2,J,K)/V5
      DZQ(3,J,K)=DZQ(3,J,K)/V6
      IF(VLAY.GT.1.)DZST(1,J,K)=DZST(1,J,K)+DZST(4,J,K)/VLAY
      IF(VLAY.GT.1.)DZQ(1,J,K)=DZQ(1,J,K)+DZQ(4,J,K)/VLAY
      IF(NRG1.LT.1)GO TO 70
      DZUS(1,J,K)=DZUS(1,J,K)/VRG1
      DZUS(2,J,K)=DZUS(2,J,K)/VRG1
      DZUS(3,J,K)=DZUS(3,J,K)/VRG1
   70 CONTINUE
      WRITE(4,1026)
      WRITE(4,1027)(NUC(I),(CLST(J,I),J=1,4),I=1,14)
      WRITE(4,1028)((CLST(J,I),J=1,4),I=15,16)
      IF(NRG1.GT.0) CALL PRT(VRG1,IGR1,NRG1,1)
      IF(NRG2.GT.0) CALL PRT(VRG2,IGR2,NRG2,2)
      IF(NLAY.GT.0) CALL PRT(VLAY,IQL,NLAY,3)
      IF(NHOT.GT.0) CALL PRT(VHOT,IGH,NHOT,4)
      IF(NNOT.GT.0) CALL PRT(VNOT,IGN,NNOT,5)
      WRITE(4,1008)
      DO 76 IK=1,3
      IF(IK.EQ.1) WRITE(4,1029)
      IF(IK.EQ.2) WRITE(4,1030)
      IF(IK.EQ.3) WRITE(4,1031)
      DO 76 I=1,3
      DO 74 K=1,2
      A1=0.0
      DO 72 J=1,7
      IF(IK.EQ.1)A1=A1+DZUS(I,J,K)*FICRP(J)
      IF(IK.EQ.2)A1=A1+DZST(I,J,K)*FICRP(J)
      IF(IK.EQ.3)A1=A1+DZQ(I,J,K)*FICRP(J)
   72 CONTINUE
      IF(IK.EQ.1)WRITE(4,1009) DES(K),(DZUS(I,J,K),J=1,7),A1
      IF(IK.EQ.2)WRITE(4,1009) DES(K),(DZST(I,J,K),J=1,7),A1
      IF(IK.EQ.3)WRITE(4,1009) DES(K),(DZQ(I,J,K),J=1,7),A1
   74 CONTINUE
   76 CONTINUE
C
C     NEXT SECTION CALCULATES AND PRINTS ACCIDENT, EROSION,
C     AND INTRUDER INITIATED POPULATION EXPOSURE IMPACTS.
C
      DO 82 ICN=1,2
      CALL ACCEXP(NBEST,ICN)
      IF(ICN.EQ.1) GO TO 82
      WRITE(4,1014)
      DO 80 K=1,7
      KK=K+2
      A1=0.0
      DO 78 J=1,7
   78 A1=A1+DZA(J,K)*FICRP(J)
   80 WRITE(4,1015)DES(KK),(DZA(J,K),J=1,7),A1
   82 CONTINUE
C
C     NEXT SECTION CALCULATES AND PRINTS IN TWO STEPS (UNSTABLE
C     AND STABLE WASTES) IMPACTS RESULTING FROM MANAGEMENT,
C     TRANSPORT, AND DISPOSAL OF WASTES OTHER THAN THOSE
C     RADIOLOGICAL IMPACTS PRINTED ABOVE.
```

```
C
      CALL ZERO(TIMP,60)
      WRITE(4,1010)
      DO 88 ICN=1,2
C
      CALL TRANSP(TIMP,ICN)
C
      CALL ZERO(GD,8)
      DO 84 ISTR=1,NSTR
      IF(ICN.EQ.1.AND.IMOD(ISTR).NE.1)GO TO 84
      IF(ICN.EQ.2.AND.IMOD(ISTR).EQ.1)GO TO 84
      IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
      I1=ISPC(NSPC,ISTR,10)
      I2=I1/100
      I3=(I1/10)-I2*10
      IF(I3 EQ.0) GO TO 84
      I4=0
      IF(I3.EQ.2) I4=4
      GD(I4+1)=GD(I4+1)+BAS(ISTR,29)
      GD(I4+2)=GD(I4+2)+BAS(ISTR,30)
      GD(I4+3)=GD(I4+3)+BAS(ISTR,31)
      GD(I4+4)=GD(I4+4)+BAS(ISTR,32)
   84 CONTINUE
C
      CALL ECON(RI,RJ,COST,ICN)
C
      VT=VRG1
      IF(ICN.EQ.2) VT=VRG2+VLAY+VHOT
      CALL ZERO(UN,8)
      IF(VT.LT.0.1) GO TO 85
      UN(1)=GD(1)/VT
      UN(2)=GD(5)/VT
      UN(3)=TIMP(1)/VT
      UN(4)=COST(1)/VT
      UN(5)=COST(5)/VT
      UN(6)=COST(6)/VT
      UN(7)=COST(7)/VT
      UN(8)=COST(8)/VT
   85 COST(2)=COST(2)+TIMP(5)
      X=0.0
      TIMP(3)=TIMP(3)+TIMP(6)
      WRITE(4,1013)ICN,GD(1),GD(5),TIMP(1),COST(1),COST(5),
     +              COST(6),COST(7),COST(8),UN(1),UN(2),UN(3),
     +              UN(4),UN(5),UN(6),UN(7),UN(8),GD(4),GD(8),
     +              TIMP(4),X,GD(3),GD(7),TIMP(3),COST(2),X,X,X,
     +              COST(4),GD(2),GD(6),TIMP(2),COST(3),RI,RJ
      DO 86 I=1,22
   86 TCU(I)=TCU(I)+TIMP(I)
   89 CONTINUE
C
C     NEXT SECTIONS SUMS AND PRINTS THE TOTAL IMPACTS.
C
      VT=VRG1+VRG2+VLAY+VHOT
      TCU(23)=TCU(15)/VT
      TCU(24)=TCU(19)/VT
      TCU(25)=TCU( 1)/VT
      TCU(26)=TCU( 7)/VT
      TCU(27)=TCU(11)/VT
      TCU(28)=TCU(12)/VT
      TCU(29)=TCU(13)/VT
      TCU(30)=TCU(14)/VT
      WRITE(4,1013)ICN,TCU(15),TCU(19),TCU(1),TCU(7),TCU(11),
```

```
     +              TCU(12),TCU(13),TCU(14),TCU(23),TCU(24),TCU(25),
     +              TCU(26),TCU(27),TCU(28),TCU(29),TCU(30),TCU(18),
     +              TCU(22),TCU(4),X,TCU(17),TCU(21),TCU(3),TCU(8),
     +        X,X,X,TCU(10),TCU(16),TCU(20),TCU(2),TCU(9),RI,RJ
C
      CALL OVERFLO
C
      DO 92 K=1,2
      IF(K.EQ.1)WRITE(4,1016)
      IF(K.EQ.2)WRITE(4,1017)
      WRITE(4,1018)
      DO 92 I=1,NSTR
      A1=0.0
      DO 90 J=1,7
   90 A1=A1+DZS(I,J,K)*FICRP(J)
      WRITE(4,1009)BASN(I),(DZS(I,J,K),J=1,7),A1
   92 CONTINUE
      GO TO 10
  100 STOP
C
 1002 FORMAT(1H1/2X,2A10)
 1003 FORMAT(//,2X,'DISPOSAL TECHNOLOGY INDICES GRP',I2/2X,
     +             'IR ='I2'  ID ='I2'  IC ='I2'  IX ='I2/2X
     +             'IE ='I2'  IS ='I2'  IL ='I2'  IG ='I2/2X
     +             'IH ='I2'  IQ ='I2'  INS='I2'  IPO='I2/2X
     +             'IIC='I5)
 1006 FORMAT(/,2X'WASTE STREAM NOT INCLUDED:',2X,A10)
 1008 FORMAT(1H1/2X,'INTRUDER IMPACTS',7X,'BODY       BONE       LIVER'
     +'     THYROID     KIDNEY     LUNG     G-I TRACT    ICRP')
 1009 FORMAT(1P,12X,A10,8E10.3)
 1010 FORMAT(1H1)
 1013 FORMAT(/2X,'OTHER IMPACTS IRDC',I2/20X,
     +' WASTE PROCESSING:    TRANSP     ',
     +'DISPOSAL          POST OPERATIONAL COSTS',
     +/16X'      GENERAT  DISPOSAL'20X'  TOTAL      CLOSURE   ',
     +'OBSERVE     INSTITUT.
     +/2X'COST ($)     6X,1P,6E10.2/2X'UNIT COST ($/M3)'8E10.2,
     +/2X'POP DOSE (MREM)  '4E10.2/2X'OCC DOSE (MREM)  '4E10.2,
     +/2X'LAND USE (M2)    '4E10.2/2X'ENERGY USE (GAL)'4E10.2,
     +/2X'INTEREST RATE    'OP,1F5.3/2X'INFLATION RATE   '1F5.3)
 1014 FORMAT(/2X'EXPOSE/ACC IMPACTS')
 1015 FORMAT(1P,12X,A10,8E10.3)
 1016 FORMAT(//2X'SINGLE CONTAINER ACCIDENT - ALL STREAMS')
 1017 FORMAT(//2X'ACCIDENT BY FIRE - ALL STREAMS')
 1018 FORMAT(14X,'STREAM',5X,'BODY       BONE       LIVER     THYROID
     +'KIDNEY      LUNG     G-I TRACT    ICRP')
 1020 FORMAT(2A10)
 1022 FORMAT(11I2,2I5)
 1024 FORMAT(10X,4E10.3)
 1025 FORMAT(8E10.3)
 1026 FORMAT(//2X,'LISTS            A          B          C          HW     ')
 1027 FORMAT(2X,A10,1P,4E10.3)
 1028 FORMAT(2X'TRU'7X,1P,4E10.3/2X'PU-241'4X,1P,4E10.3)
 1029 FORMAT(/10X,'VOLUME WEIGHTED IMPACTS - UNSTABLE WASTES')
 1030 FORMAT(/10X,'VOLUME WEIGHTED IMPACTS - STABLE WASTES')
 1031 FORMAT(/10X,'VOLUME WEIGHTED IMPACTS - ALL WASTES')
      END
C
C*********************************************************************
C
      SUBROUTINE READIN
C
C     ALL THE BASIC INFORMATION CONTAINED IN TAPES 1 AND 2 ARE
```

```
C     READ IN THROUGH THIS SUBROUTINE.
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8),FICRP(7),AZR(90)
     +       /CHRC/BASN,NUC
     +       /NUCS/AL(36),FMF(36),RET(36,5)
     +       /DTIS/FSC(6),FSA(6),PRC(6,2),QFC(6,3),TTM(6,3),TPC(6,3),
     +            RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPO(6,2),NRET(6)
     +       /VOLS/VRG1,VRG2,VLAY,VHOT,VNOT,RVOL(4,37)
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16)
      READ(1,101) NSTR,NNUC,FICRP
      DO 20 I=1,NSTR
   20 READ(1,102)BASN(I),(BAS(I,J),J=2,27)
      NN=NNUC+13
      DO 40 I=1,NN
      READ(1,104)NUC(I),AL(I),FMF(I),RET(I,1),RET(I,4)
      DO 30 K=1,8
   30 READ(1,106)(DCF(I,J,K),J=1,7)
   40 CONTINUE
      DO 50 I=1,6
      READ(1,105)FSC(I),FSA(I),(PRC(I,J),J=1,2),(QFC(I,J),J=1,3),
     +           (TTM(I,J),J=1,3),(TPC(I,J),J=1,3),
     +           (RGF(I,J),J=1,3),(POP(I,J),J=1,3),NRET(I),
     +           DTTM(I),DTPC(I),(TPO(I,J),J=1,2)
   50 CONTINUE
      DO 55 I=1,4
   55 READ(1,108) (RVOL(I,J),J=1,NSTR)
      DO 60 K=1,6
      DO 60 I=1,NSTR
   60 READ(2,103) (ISPC(K,I,J),J=1,10)
      DO 70 K=1,7
   70 READ(2,107) ((DIST(I,J,K),J=1,16),I=1,3)
      DO 75 I=1,6
      DO 75 K=1,16
   75 READ(2,109) (FLST(I,J,K),J=1,4)
  101 FORMAT(2I5,7F5.2)
  102 FORMAT(A10,2E10.3/10X,6E10.3/10X,6E10.3/10X,6E10.3/10X,6E10.3)
  103 FORMAT(10X,10I5)
  104 FORMAT(A10,4E10.3)
  105 FORMAT(10X,7E10.3/10X,6E10.3/10X,6E10.3,I5/10X,4E10.3)
  106 FORMAT(10X,7E10.3)
  107 FORMAT(8E10.3)
  108 FORMAT(10X,6E10.3)
  109 FORMAT(10X,4E10.3)
      RETURN
      END
C
C*****************************************************************
C
      SUBROUTINE COMBYN(ISTR,NOPR)
C
C     THIS SUBROUTINE IS CALLED FROM SUBR. RCLAIM AND CHANGES
C     WASTE SPECTRUMS, MODIFIES ACTIVITY DISTRIBUTIONS (DIST),
C     AND CALCULATES WASTE GENERATOR IMPACTS.
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8),FICRP(7),AZR(90)
     +       /CHRC/BASN,NUC
     +       /NUCS/AL(36),FMF(36),RET(36,5)
     +  /DTNX1/IR1,ID1,IC1,IX1,IE1,IS1,IL1,IG1,IH1,IQ1,ICL1,IPO1,IIC1
     +  /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2,IQ2,ICL2,IPO2,IIC2
     +       /DTIS/FSC(6),FSA(6),PRC(6,2),QFC(6,3),TTM(6,3),TPC(6,3),
```

```
     +          RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPO(6,2),NRET(6)
     +      /VOLS/VRG1,VRG2,VLAY,VHOT,VNOT
     +      /NBAS/NSTR,NNUC,NOXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +      /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90)
     +      /COMB/TPOP(2),DEC(36,2)
      DIMENSION UPRS(7,3),USOL(5,3),USAV(3)
      DATA UPRS/335.,503.,1006.,690.,2060.,1938.,1039.,3*4.6,
     +          56.3,116.,129.,72.,3*15.,4.42,8.,6.12,5.35/
      DATA USAV/210.,.4,4./,TPOP/1.56E-8,1.56E-10/
      DATA USOL/1282.,1873.,2445.,2*450.,3*40.,2*15.,3*24.,0.,10./
      DATA DEC/.9,.75,6*2.5E-3,2*1.E-2,26*2.5E-3,.9,.25,6*2.5E-5,
     +        2*1.E-4,13*2.5E-5,13*2.5E-5/
      AA5=3.62
      IF(NOPR.GT.0)AA5=1.0
      IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
C
C     IF THIS IS CALLED FOR THE FIRST TIME (IDR=1) THEN ROUTINE
C     PROCEEDS TO STATEMENT 8 (THE MAIN SECTION), HOWEVER, IF
C     IDR > 1, THEN IT MUST FIRST UNDO THE PREVIOUS MODIFICATION.
C
      IF(IDR.EQ.1) GO TO 8
      ISP=IORD(IDR-1,ISTR)
      A1=ISPC(ISP,ISTR,2)
      A1=A1/ISPC(ISP,ISTR,3)
      BAS(ISTR,3)=BAS(ISTR,3)*A1*AA5
      DO 4 I=4,27
    4 BAS(ISTR,I)=BAS(ISTR,I)/A1
      IF(NOXS(ISTR).GE.0)GO TO 7
      IJK=BAS(ISTR,2)+0.1
      DO 6 I=1,16
      DIST(1,I,IJK)=DIST(1,I,IJK)/A1
    6 DIST(3,I,IJK)=DIST(3,I,IJK)/A1
    7 IP=ISPC(ISP,ISTR,10)/1000
      IF(IP.LT.5) GO TO 8
      J=2
      IF(IP.EQ.5) J=1
      BAS(ISTR,5)=BAS(ISTR,5)/(1.-DEC(1,J))
      BAS(ISTR,6)=BAS(ISTR,6)/(1.-DEC(2,J))
C
C     MAIN SECTION STARTS HERE.  FIRST THE WASTE GENERATOR
C     IMPACTS ARE SET EQUAL TO ZERO. THEN THE VOLUMES AND
C     CONCENTRATIONS ARE MODIFIED.
C
    8 DO 10 J=28,32
      BAS(ISTR,J)=0.0
   10 CONTINUE
      A1=ISPC(NSPC,ISTR,2)
      A1=A1/ISPC(NSPC,ISTR,3)
      A2=BAS(ISTR,3)/AA5
C
      A3=A2/A1
      BAS(ISTR,3)=A3
C
      DO 12 I=5,27
   12 BAS(ISTR,I)=BAS(ISTR,I)*A1
      IF(NOXS(ISTR).GE.0)GO TO 16
      IJK=BAS(ISTR,2)+0.1
      DO 14 I=1,16
      DIST(1,I,IJK)=DIST(1,I,IJK)*A1
   14 DIST(3,I,IJK)=DIST(3,I,IJK)*A1
   16 BAS(ISTR,28)=BAS(ISTR,3)
C
```

```
C     NEXT SECTION UNSCRAMBLES THE WASTE PROCESSING INDEX,
C     AND CALCULATES THE WASTE GENERATOR IMPACTS (IF ANY).
C
      J=ISPC(NSPC,ISTR,10)
      BAS(ISTR,4)=BAS(ISTR,4)*A1
      IP=J/1000
      IS=(J/100)-IP*10
      IL=(J/10)-IP*100-IS*10
      IH=J-IP*1000-IS*100-IL*10
      IF(IHIC(ISTR).GT.0.AND.IL.EQ.0)IL=1
      IF(IL.EQ.0)RETURN
      IF(IL.NE.2) GO TO 20
      BAS(ISTR,28)=A2
      BAS(ISTR,4)=BAS(ISTR,4)/A1
   20 A5=0.1
      IF(ISTR.LE.11.OR.ISTR.GT.37) A5=0.5
      IF(ISTR.EQ.30.OR.ISTR.EQ.31) A5=0.5
      DO 25 J=1,3
      A4=-A3*(AZR(ISTR)*A1-1.)*USAV(J)
      IF(IP.GT.0)A4=A4+A2*UPRS(IP,J)
      IF(IS.GT.0)A4=A4+A3*USOL(IS,J)
      IHC=IHIC(ISTR)
      IF(IHC.GT.0.AND.IS.LT.4)A4=A4+A3*USOL(3+IHC,J)
      IF(J.EQ.3)A4=A4*A5
   25 BAS(ISTR,28+J)=A4
C
C     NEXT SECTION IS USED TO CALCULATE POPULATION IMPACTS
C     FROM ATMOSPHERIC RELEASES IF THE WASTE IS INCINERATED.
C
      IF(IP.LT.5)RETURN
      A5=0.0
      J=2
      IF(IP.EQ.5) J=1
      IF(IH.NE.1.AND.IH.NE.2)IH=1
      DO 40 INUC=1,NNUC
      A4=BAS(ISTR,3)*BAS(ISTR,INUC+4)*DEC(INUC,J)*TPOP(IH)
   40 A5=A5+A4*DCF(INUC,1,8)
      BAS(ISTR,32)=A5
      BAS(ISTR,5)=(1.-DEC(1,J))*BAS(ISTR,5)
      BAS(ISTR,6)=(1.-DEC(2,J))*BAS(ISTR,6)
      RETURN
      END
C
C*****************************************************************
C
      SUBROUTINE RCLAIM(ISTR,INDX,NOPR,NBEST)
C
C     THIS SUBROUTINE CLASSIFIES THE WASTE STREAMS IF THEY DONT
C     HAVE A DISTRIBUTION, CLASSIFIES THE PORTION OF THE
C     DISTRIBUTION (AS APPROPRIATE), AND COMPUTES THE IMPACTS
C     RESULTING FROM THE INTRUDER-INITIATED SCENARIOS.
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8),FICRP(7),AZR(90)
     +       /CHRC/BASN,NUC
     +       /NUCS/AL(36),FMF(36),RET(36,5)
     +  /DTNX1/IR1,ID1,IC1,IX1,IE1,IS1,IL1,IG1,IH1,IQ1,ICL1,IPO1,IIC1
     +  /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2,IQ2,ICL2,IPO2,IIC2
     +       /DTIS/FSC(6),FSA(6),PRC(6,2),QFC(6,3),TTM(6,3),TPC(6,3),
     +             RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPO(6,2),NRET(6)
     +       /IMPS/DZ(8,7,2),DZQ(4,7,2)
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90)
```

```
      DIMENSION EMP(5)
      DATA EMP/.5,.75,.5,.5,.75/
      NFG=0
C
C     NEXT STATEMENT IS THE STARTING POINT AFTER EACH SPECTRUM
C     CHANGE AS WELL AS FOR THE FIRST TIME - IN EFFECT AN OPEN
C     ENDED DO-LOOP UNTIL ALL, SOME, OR NONE OF THE WASTE IS
C     CLASSIFIED.  SEE COMMENTS UNDER STATEMENT 29.
C     THE LOGIC OF THE SECTION FOLLOWS FIGURE 3 OF APPENDIX C.
C
   10 IF(NDXS(ISTR).EQ.0)GO TO 30
      IF(ISTR.LE.37)CALL COMBYN(ISTR,NOPR)
      IDR=ISPEC(ISTR)
      ISP=IORD(IDR,ISTR)
      IB=ISPC(ISP,ISTR,8)
      IF(IHIC(ISTR).GT.0)IB=1+IHIC(ISTR)
      IF(ISTR.GT.37.AND.NFG.EQ.0)GO TO 29
      CALL LISTS(ISTR,1,NX)
      IF(NX.EQ.1) GO TO 21
      IF(IB.GT.0)GO TO 16
      IF(IABS(NDXS(ISTR)).NE.2) GO TO 29
      IF(IG2.EQ.1.OR.IX2.EQ.3) GO TO 12
      IF(IH2.EQ.1) GO TO 14
      GO TO 29
   12 CALL LISTS(ISTR,2,NX)
      IF(NX.EQ.1) GO TO 23
      IF(IL2.EQ.0) GO TO 13
      CALL LISTS(ISTR,3,NX)
      IF(NX.EQ.1) GO TO 25
   13 IF(IH2.EQ.0) GO TO 29
   14 CALL LISTS(ISTR,4,NX)
      IF(NX.EQ.1) GO TO 27
      GO TO 29
   16 CALL LISTS(ISTR,2,NX)
      IF(NX.EQ.1) GO TO 24
      IF(IL2.EQ.0) GO TO 17
      CALL LISTS(ISTR,3,NX)
      IF(NX.EQ.1) GO TO 26
   17 IF(IH2.EQ.0) GO TO 29
      CALL LISTS(ISTR,4,NX)
      IF(NX.EQ.1) GO TO 28
      GO TO 29
   21 IMOD(ISTR)=1
      INDX=1
      IF(IB.EQ.0) GO TO 32
      IMOD(ISTR)=2
      INDX=2
      GO TO 32
   23 IMOD(ISTR)=3
      INDX=2
      GO TO 32
   24 IMOD(ISTR)=4
      INDX=2
      GO TO 32
   25 IMOD(ISTR)=5
      INDX=4
      GO TO 32
   26 IMOD(ISTR)=6
      INDX=5
      GO TO 32
   27 IMOD(ISTR)=7
      INDX=7
      GO TO 32
```

```
   28 IMOD(ISTR)=8
      INDX=7
      GO TO 32
   29 IF(IDR.EQ.6) GO TO 30
      NFG=1
      IDR=IDR+1
      ISPEC(ISTR)=IDR
      IF(ISTR.GT.37)CALL COMBYN(ISTR,NOPR)
      GO TO 10
C
C       THIS IS THE END OF THE OPEN ENDED DO LOOP TO CLASSIFY
C       ALL OR SOME OF THE WASTE STREAMS.  IF THE WASTE IS NOT
C       ACCEPTABLE, THEN STATEMENT 30 IS CALLED.  IF SOME OF
C       THE WASTE IS ACCEPTABLE, THE ACCEPTABLE PORTION IS LEFT
C       IN ITS ORIGINAL ORDER, AND THE REST OF THE STREAM IS
C       DESIGNATED AS NSTR+1 STREAM.  SEE SUBROUTINE LISTS.
C
   30 IMOD(ISTR)=0
      RETURN
C
C     AFTER CLASSIFICATION BASED ON THE PROPERTIES OF THE
C     WASTE STREAM, THE CLASSIFICATION STATUS MAY BE CHANGED
C     IN SUBROUTINE MODIF DEPENDING ON THE DISPOSAL TECHNOLOGY
C     INDICES.
C
   32 CALL MODIF(ISTR,INDX)
C
C     NEXT SECTION STARTS THE CALCULATION OF THE INTRUDER
C     IMPACTS FOR VARIOUS TIMES: AT IIC YEARS FOR UNSTABLE (41)
C     REGULAR-STABLE (42), LAYERED-UNSTABLE (44), LAYERED-STABLE (45)
C     AND HOT (47) WASTES; AT 500 YEARS FOR REGULAR-STABLE (43) AND
C     LAYERED (46) WASTES; AND AT 1000 YEARS FOR HOT (48) WASTES.
C
   31 I5=ISPC(ISP,ISTR,5)
      I6=ISPC(ISP,ISTR,6)
      I7=ISPC(ISP,ISTR,7)
      I9=ISPC(ISP,ISTR,9)
      IF(IMOD(ISTR).GT.1.AND.I8.EQ.0) I8=1
      A7=1.0
      IF(I6.EQ.2.OR.I6.EQ.3) A7=0.80
      IF(IMOD(ISTR).GT.1) GO TO 38
      IR=IR1
      ID=ID1
      IC=IC1
      IX=IX1
      IE=IE1
      IS=IS1
      IL=IL1
      IG=IG1
      IH=IH1
      IQ=IQ1
      ICL=ICL1
      IPO=IPO1
      IIC=IIC1
      GO TO 40
   38 IR=IR1
      ID=ID2
      IC=IC2
      IX=IX2
      IE=IE2
      IS=IS2
      IL=IL2
      IG=IG2
```

OPTIONR Code (cont'd)

```
      IH=IH2
      IQ=IQ2
      ICL=ICL2
      IPO=IPO2
      IIC=IIC2
   40 CALL ZERO(DZ,112)
      IF(I7.EQ.1.OR.IS.EQ.0) I6=I6-1
      FDES=EMP(IE)*(1.-.9*IC)
      IF(I9.EQ.3) A7=A7*10.
      A5=1.0
      IF(I5.LT.3) A5=10.**(I5-3)
      A6=1.0
      IF(I6.GT.1) A6=4.**(1-I6)
      A9=1.0
      IF(I9.GT.1) A9=10.**(1-I9)
      DO 60 I3=1,8
      GDEL=IPO+IIC
      IF(IC.EQ.3) GDEL=IPO+500.
      GO TO (41,42,43,44,45,46,47,48),I3
   41 A4C=1.0
      A4A=1.0
      ABC=A7
      ABA=A7
      GO TO 50
   42 A4C=0.012
      A4A=0.0
      ABC=0.012*A7
      ABA=0.0
      GO TO 50
   43 GDEL=IPO+500.
      A4C=1.0
      A4A=1.0
      ABC=A7
      ABA=A7
      GO TO 50
   44 A4C=0.1
      A4A=0.0
      ABC=A7/1200.
      ABA=0.0
      GO TO 50
   45 A4C=0.0012
      A4A=0.0
      ABC=0.0012*A7/1200.
      ABA=0.0
      GO TO 50
   46 GDEL=IPO+500.
      A4C=1.0
      A4A=1.0
      ABC=A7
      ABA=A7
      GO TO 50
   47 ABC=0.1*A7/1.44E6
      IF(IG.EQ.0) ABC=ABC*0.1
      A4C=0.01
      A4A=0.0
      ABA=0.0
      GO TO 50
   48 GDEL=IPO+1000.
      ABC=A7
      IF(IG.EQ.0) ABC=0.1*A7
      A4C=1.0
      A4A=1.0
      ABA=ABC
```

```
50 I11=IMOD(ISTR)
   DO 58 INUC=1,NNUC
   A1=A9*FDES*BAS(ISTR,INUC+4)
C
C      IF((I3.EQ.3.OR.I3.EQ.8).AND.(I11.EQ.5.OR.I11.EQ.6))A1=0.1*A1
C      EFFECT OF CHAIN DECAY ARE HANDLED THROUGH CHNS AND CALC.
C      CHNS CALCULATES THE FRACTION OF EACH MEMBER OF THE CHAIN
C      AT TIME GDEL, AND CALC MULTIPLIES THESE FRACTIONS WITH
C      THE DOSE CONVERSION FACTORS AND SUMS.
C
   CALL CHNS(INUC,GDEL,IEN,IBG,NCH)
   DO 56 I=1,7
   CALL CALC(INUC,I,C1,C2,C3,C4,IEN,IBG,NCH)
   A2=C1
   B5=0.25*A1*A8A*A2*0.27
   B2=A1*A8C*A2*0.057
   IF(NBEST.EQ.0) GO TO 52
   B1=A1*A4C*A5*FSC(IR)*C2
   B3=0.25*A1*A4A*A5*FSA(IR)*C3
   B4=0.5*0.25*A1*A4A*A6*C4
   GO TO 54
52 B3=0.25*A1*A4A*FSA(IR)*C3
   B4=0.5*0.25*A1*A4A*C4
   B1=A1*A4C*FSC(IR)*C2
54 DZ(I3,I,1)=DZ(I3,I,1)+B1+B2
56 DZ(I3,I,2)=DZ(I3,I,2)+B3+B4+B5
58 CONTINUE
60 CONTINUE
   RETURN
   END
C
C**********************************************************************
C
      SUBROUTINE LISTS(ISTR,NQ,NX)
C
C      THIS SUBROUTINE COMPARES THE CONCENTRATIONS OF THE ISTR WASTE
C      STREAM WITH THE CONCENTRATION FOR REGULAR (NQ=1), STABLE
C      (NQ=2), LAYERED (NQ=3), OR HOT (NQ=4) WASTE DISPOSAL, AND
C      MANIPULATES THE WASTE ACTIVITY DISTRIBUTIONS, IF NECESSARY.
C
      CHARACTER*10 BASN(90),NUC(36)
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8),FICRP(,,,AZR(90)
     +      /CHRC/BASN,NUC
     +      /NUCS/AL(36),FMF(36),RET(36,5)
     +  /DTNX1/IR1,ID1,IC1,IX1,IE1,IS1,IL1,IG1,IH1,IQ1,ICL1,IPO1,IIC1
     +  /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2,IQ2,ICL2,IPO2,IIC2
     +      /DTIS/FSC(6),FSA(6),PRC(6,2),GFC(6,3),TTM(6,3),TPC(6,3),
     +            RGF(6,3),PCP(6,3),DTTM(6),DTPC(6),TPO(6,2),NRET(6)
     +      /VOLS/VRG1,VRG2,VLAY,VHOT,VNOT
     +      /IMPS/DZ(8,7,2),DZG(4,7,2)
     +      /NBAS/NSTR,NNUC,NOXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +      /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90),FLST(6,4,16),NLST
      NX=0
      A1=0.
      INDEX=0
      IF(IR2.NE.0.OR.NQ.NE.1)GO TO 4
      IF(ISTR.GT.7.AND.ISTR.NE.32)GO TO 4
      INDEX=1
C
C      THE SECTION BETWEEN HERE AND STATEMENT 16 IS FOR WASTE
C      STREAMS WITHOUT AN ACTIVITY DISTRIBUTION.
C
    4 IDR=ISPEC(ISTR)
```

```
      ISP=IORD(IDR,ISTR)
      I9=ISPC(ISP,ISTR,9)
      A11=CLST(NQ,16)
      IF(IR2.NE.0)GO TO 6
      IF(NLST.GT.3.AND.NQ.NE.1)GO TO 6
      IJK=BAS(ISTR,2)+0.1
      IF(ISTR.LE.7.OR.ISTR.EQ.32.OR.ISTR.GT.37)A11=A11*35.
      IF(IJK.EQ.7)A11=CLST(NQ,16)
    6 IF(NDXS(ISTR).LT.0) GO TO 16
      IF(INDEX.EQ.0)GO TO 8
C
C     SUBROUTINE BARN PERFORMS A SPECIAL SUMMATION OF THE
C     ACTIVITIES AND CLASSIFICATION BASED ON THE EXISTING
C     DISPOSAL FACILITY LICENSE CONDITIONS.  ONLY UNSTABLE
C     WASTES ARE SUBJECTED TO THIS TEST, AND ONLY IF IR2=0
C
      CALL BARN(ISTR,A2,A3,NX)
C
      RETURN
    8 DO 10 I=19,27
   10 A1=A1+BAS(ISTR,I)
      A1=(A1-BAS(ISTR,22))/CLST(NQ,15)+BAS(ISTR,22)/A11
      IF(IR2.EQ.0.AND.NQ.EQ.1)GO TO 14
      DO 12 I=1,14
      A2=1.0
      IF(I9.EQ.1)GO TO 12
      IF(I.EQ.2.OR.I.EQ.4.OR.I.EQ.6.OR.I.EQ.7)A2=10.0
   12 A1=A1+BAS(ISTR,I+4)/(CLST(NQ,I)*A2)
   14 IF(A1.GT.1.0) RETURN
      NX=1
      RETURN
C
C     THIS SECTION STARTS THE TESTING AND CLASSIFICATION FOR
C     WASTE STREAMS WITH AN ACTIVITY DISTRIBUTION.  FIRST THE
C     TOTAL ACTIVITY THAT WOULD PERMIT A PORTION OF THE WASTE
C     TO BE DISPOSED AS CLASS NQ IS DETERMINED, THEN THE VOLUME
C     OF THE WASTE CORRESPONDING TO THAT ACTIVITY IS CLASSIFIED.
C
   16 IF(INDEX.EQ.0)GO TO 18
      CALL BARN(ISTR,A2,A3,NX)
      GO TO 28
   18 DO 20 I=19,27
   20 A1=A1+BAS(ISTR,I)
      A2=A1
      A1=(A1-BAS(ISTR,22))/CLST(NQ,15)+BAS(ISTR,22)/A11
      DO 22 I=1,14
   22 A2=A2+BAS(ISTR,I+4)
      IF(IR2.EQ.0.AND.NQ.EQ.1)GO TO 26
      DO 24 I=1,14
      A3=1.0
      IF(I9.EQ.1)GO TO 24
      IF(I.EQ.2.OR.I.EQ.4.OR.I.EQ.6.OR.I.EQ.7)A3=10.0
   24 A1=A1+BAS(ISTR,I+4)/(CLST(NQ,I)*A3)
   26 A3=A2/A1
C
C     AT THIS POINT A3 IS THE MAXIMUM PERMISSIBLE TOTAL ACTIVITY
C     FOR WASTE CLASS NQ.  IT IS TESTED AGAINST DIST(1,I,IJK),
C     AND THE FRACTION OF WASTE VOLUME DETERMINED
C
   28 IJK=BAS(ISTR,2)+0.1
      DO 30 I=2,16
      IF(A3.LT.DIST(1,I,IJK)) GO TO 32
   30 CONTINUE
```

```
C
C     SUCCESS OF DO LOOP 30 MEANS ALL OF THE WASTE IS ACCEPTABLE
C     UNDER THE CLASSIFICATION NQ.
C
      NX=1
      A1=1
      A5=DIST(3,16,IJK)
      GO TO 44
   32 A4=(A3-DIST(1,I-1,IJK))/(DIST(1,I,IJK)-DIST(1,I-1,IJK))
      A1=DIST(2,I-1,IJK)+A4*(DIST(2,I,IJK)-DIST(2,I-1,IJK))
      IF(A1.LT.1.E-3) RETURN
      IF(A1.GT.0.999) GO TO 42
C
C     AT THIS POINT SOME OF THE WASTE IS FOUND TO BE ACCEPTABLE
C     UNDER CLASSIFICATION NQ.  THE PORTION THAT IS FOUND UNACCEPT-
C     ABLE MUST BE DESIGNATED AS A NEW WASTE STREAM.  THUS, A NEW
C     WASTE STREAM DENOTED NSTR+1 IS CREATED, AND PROPERTIES OF THE
C     ISTR WASTE STREAM IS STORED ONTO THE PROPERTIES OF NSTR.
C
      NSTR=NSTR+1
      BASN(NSTR)=BASN(ISTR)
      BAS(NSTR,2)=BAS(ISTR,2)
      BAS(NSTR,3)=BAS(ISTR,3)*(1.-A1)
      BAS(NSTR,4)=BAS(ISTR,4)
      DO 36 J=5,27
   36 BAS(NSTR,J)=BAS(ISTR,J)
      DO 38 J=28,32
   38 BAS(NSTR,J)=BAS(ISTR,J)*(1.-A1)
      DO 40 K=1,6
      IORD(K,NSTR)=IORD(K,ISTR)
      DO 40 J=1,10
   40 ISPC(K,NSTR,J)=ISPC(K,ISTR,J)
      ISPEC(NSTR)=ISPEC(ISTR)
      NDXS(NSTR)=NDXS(ISTR)
      IHIC(NSTR)=IHIC(ISTR)
      AZR(NSTR)=AZR(ISTR)
C
C     THE FINAL STEPS IN THE CLASSIFICATION OF THE DISTRIBUTION
C     WASTE STREAM CONSIST OF ADJUSTING THE VOLUMES, TOTAL AND
C     RADIONUCLIDE ACTIVITIES, WASTE GENERATOR IMPACTS, AND
C     MODIFYING THE DIST (DISTRIBUTIONS) TO REFLECT THAT A
C     FRACTION HAS BEEN CLASSIFIED.
C
   42 A5=DIST(3,I-1,IJK)+A4*(DIST(3,I,IJK)-DIST(3,I-1,IJK))
   44 A6=A5*A1
      A7=A5/A2
      BAS(ISTR,3)=BAS(ISTR,3)*A1
      BAS(ISTR,4)=A5
      DO 46 J=5,27
   46 BAS(ISTR,J)=BAS(ISTR,J)*A7
      IF(NX.EQ.1)RETURN
      DO 48 J=28,32
   48 BAS(ISTR,J)=BAS(ISTR,J)*A1
      DO 50 J=I,16
      A7=DIST(2,J,IJK)*DIST(3,J,IJK)-A6
      A8=DIST(2,J,IJK)-A1
      DIST(2,J,IJK)=A8
   50 DIST(3,J,IJK)=A7/A8
      DO 55 J=2,I
      DIST(2,J-1,IJK)=0.
   55 DIST(3,J-1,IJK)=0.
      DIST(1,I-1,IJK)=A3
      A5=0.
```

```
      DO 65 J=1,16
   65 DIST(2,J,IJK)=DIST(2,J,IJK)/DIST(2,16,IJK)
      NX=1
      RETURN
      END
C
C*****************************************************************
C
      SUBROUTINE TRANSP(TIMP,INX)
C
C     THIS SUBROUTINE DETERMINES THE TRANSPORTATION SCHEME FOR
C     ALL THE WASTE STREAMS BASED ON THE PACKAGING INDEX OF THE
C     SPECTRUM FILES AND THE CONCENTRATIONS OF THE INDIVIDUAL
C     WASTE STREAMS.  ULTIMATE RESULT IS THE TRANSP IMPACTS (TIMP).
C
      COMMON/BAST/BAS(90,32),ISPC(6,90,10)
     +  /DTNX1/IR1,ID1,IC1,IX1,IE1
     +  /DTNX2/IR2,ID2,IC2,IX2,IE2
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +  /LSTS/CLST(4,16),DUMY(3,16,7),IORD(6,90)
      DIMENSION PCAR(6,3),PPAK(8,6),KON(18),TYM(2,18),TCST(2,3),
     +          RDZ(2,3),TDZ(2,2),PKV(5),KWT(18),DIST(6),STPS(6),
     +          CASK(6),DUM1(3),DUM2(3),DUM3(3,3),TIMP(6),TVOL(5,3)
      DATA PCAR/1.,.8,.4,.2,.1,0.,0.,.2,.5,.6,.5,.2,0.,0.,.1,.2,.4,.8/
      DATA PPAK/0.,.23,5*0.,1.,0.,.08,.025,5*0.,.69,.69,.975,.2,1.,
     +          3*0.,.15,0.,0.,.8,0.,.5,2*0.,.16,4*0.,.5,1.,0.,
     +          3.,1.,2.,4*3.,1./
      DATA KON/1103024,1104076,1236100,1370100,1411100,-1501100,
     +         2103100,2236096,-2206004,2370048,-2314051,-2306001,
     +         -2402100,-2501100,-3306051,-3301049,-3402100,-3501100/
      DATA TYM/200.,240.,74.,120.,16.,24.,6.,24.,136.,165.,1200.,1440.,
     +         300.,360.,26.,39.,250.,300.,10.,24.,86.,175.,200.,312.,
     +         600.,720.,1200.,1440.,200.,312.,600.,720.,600.,720.,
     +         1500.,1800./
      DATA TCST/1.69,1.25,1.47,1.14,1.17,1.08/
      DATA RDZ/500.,750.,1200.,1800.,2200.,2200./
      DATA TDZ/1.8E-2,2.0E-2,2.,2./
      DATA PKV/3.625,.453,.208,1.416,4.814/
      DATA KWT/16*0,2*1/
      DATA DIST/300.,400.,600.,1000.,2*400./
      DATA STPS/2*1.,2.,3.,2*1./
      DATA CASK/2.,3.,5.,8.,2*3./
C
C     ABOVE ARRAYS AND MATRICES ARE AS FOLLOWS:
C
C     PCAR  = CONTAINS 6 DISTRIBUTIONS OF 3 CARE LEVELS
C     PPAK  = CONTAINS 8 DISTRIBUTIONS OF 5 PACKAGING
C             CONTAINERS, AND A POSITIONING INDEX
C     KON   = MULTIPLE INDEX DESCRIBING THE PACKING PROPERTIES
C             FOR 3 CARE LEVELS AND 5 CONTAINERS
C     TYM   = TIME (MIN) FOR UNLOADING OF WASTE CORRESPONDING
C             TO 18 VALUES OF KON FOR RANDOM AND STACKED DISPOSAL
C     TCST  = TRANSPORTATION COST ($) PER MILE
C     RDZ   = DOSE PER HOUR OF CONTACT TIME WITH WASTE
C     TDZ   = UNIT DOSES DUE TO TRANSPORTATION
C     PKV   = VOLUME CAPACITY FOR 5 TYPES OF CONTAINERS
C     KWT   = OVERWEIGHT STATUS FOR EACH OVERPACK TYPE (KON)
C     DIST  = REGION DEPENDENT TRAVEL DISTANCE TO DISPOSAL SITE
C     STPS  = REGION DEPENDENT STOPS ALONG EACH ROUTE
C     CASK  = REGION DEPENDENT NUMBER OF CASK DAYS ON THE ROAD.
C
      CALL ZERO(TIMP,6)
      CALL ZERO(TVOL,15)
```

```
      IR=IR1
      IE=IE1
      IF(INX.EQ.1) GO TO 10
      IR=IR1
      IE=IE2
   10 CONTINUE
C
C     DO LOOP 160 DISTRIBUTES THE WASTE INTO THREE CARE LEVELS
C     AND AMONG 5 TYPES OF CONTAINERS.
C
      DO 160 IPAK=1,8
      NX=0
      CALL ZERO(DUM1,3)
C
C     DO LOOP 70 DISTRIBUTES WASTE AMONG CARE LEVELS
C
      DO 70 ISTR=1,NSTR
      IF(IMOD(ISTR).EQ.0) GO TO 70
      IF(INX.EQ.1.AND.IMOD(ISTR).NE.1) GO TO 70
      IF(INX.EQ.2.AND.IMOD(ISTR).EQ.1) GO TO 70
      IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
      I2=IABS(ISPC(NSPC,ISTR,1))
      I1=I2/10
      IF(I1.NE.IPAK) GO TO 70
      I3=I2-I1*10
      A1=BAS(ISTR,28)
      A2=BAS(ISTR,4)*100.
      IF(I3.EQ.2) A2=BAS(ISTR,4)*10.
      NX=1
      IF(I3.GT.2) GO TO 40
      I5=ALOG10(A2)
      IF(I3.EQ.2) GO TO 30
      IF(A2.LT.1.) I4=1
      IF(A2.GE.1.) I4=I5+2
      IF(I4.GT.6) I4=6
      GO TO 50
   30 IF(A2.LT.1.) I4=1
      IF(A2.GE.1.) I4=I5+2
      IF(I4.GT.4) I4=4
      GO TO 50
   40 I4=I3-2
   50 DO 60 I=1,3
   60 DUM1(I)=DUM1(I)+PCAR(I4,I)*A1
   70 CONTINUE
C
C     DUM1 CONTAINS WASTE VOLUME IN EACH OF 3 CARE LEVELS
C
      IF(NX.EQ.0) GO TO 160
      A1=DUM1(1)+DUM1(2)+DUM1(3)
      I2=PPAK(IPAK,6)+0.1
      DO 80 I=1,3
      II=I-1
   80 DUM2(I)=PPAK(IPAK,I2+II)*A1
C
C     DUM2 CONTAINS WASTE VOLUME IN EACH OF 3 CONTAINER TYPES
C
      CALL ZERO(DUM3,9)
C
C     DO LOOP 130 DETERMINES PACKAGING STRATEGY FOR THIS LOOP
C     OF IPAK, AND ACCORDINGLY DUM1 AND DUM2 ARE DISTRIBUTED
C     AND STORED INTO DUM3 · OVERALL DISTRIBUTION FOR THIS STREAM.
C
```

```
      DO 130 J=1,3
      DO 120 I=1,3
      IF(DUM1(J).LE.0.0) GO TO 130
      IF(DUM2(I).LE.0.0) GO TO 120
      IF(DUM1(J)-DUM2(I))90,100,110
   90 DUM3(I,J)=DUM1(J)
      DUM2(I)=DUM2(I)-DUM1(J)
      DUM1(J)=-1.0
      GO TO 130
  100 DUM3(I,J)=DUM1(J)
      DUM2(I)=-1.0
      DUM1(J)=-1.0
      GO TO 130
  110 DUM3(I,J)=DUM2(I)
      DUM1(J)=DUM1(J)-DUM2(I)
      DUM2(I)=-1.0
  120 CONTINUE
  130 CONTINUE
      DO 150 I=1,3
      II=I-1
      DO 150 J=1,3
  150 TVOL(I2+II,J)=TVOL(I2+II,J)+DUM3(I,J)
  160 CONTINUE
C
C     AT THIS POINT TVOL CONTAINS TOTAL UNSTABLE OR STABLE
C     WASTE DISTRIBUTED FOR 3 CARE LEVELS AND 5 CONTAINERS.
C
C     THE NEXT SECTION, DO LOOP 240, COMPUTES THE TRANSPORTATION
C     IMPACTS FOR THE TVOL, AND STORES IN TIMP, WHICH ARE:
C       TIMP(1) = DOLLAR COSTS
C       TIMP(2) = ENERGY USE
C       TIMP(3) = TRANSP OCCUPATIONAL DOSE
C       TIMP(4) = TRANSP POPULATION DOSE
C       TIMP(5) = DISPOSAL SITE UNLOADING OCCUPATIONAL DOSE
C       TIMP(6) = TRANSPORTATION LOADING OCCUPATIONAL DOSE
C
      DO 240 IKON=1,18
      II=KON(IKON)
      NX=1
      FRC=1.0
      IF(II.GT.0) GO TO 210
C
C     IF KON INDEX IS NEGATIVE, THEN RETURN TRIP IS NECESSARY
C
      II=-II
      NX=2
  210 I3=II/100000
      I2=I3/10
      I1=I3-I2*10
      I5=II-I3*100000
      I3=I5/1000
      I4=I5-I3*1000
C
C     IN ABOVE SECTION, KON INDEX IS BROKEN UP INTO:
C       I1 = PACKAGE TYPE    I3 = NO. OF PACKAGES PER SHIPMENT
C       I2 = CARE LEVEL      I4 = PCT OF WASTE IN KON MODE
C
      IF((I2.EQ.1).OR.(I2.EQ.2.AND.NX.EQ.2)) FRC=0.1
      FRS=I4/100.
      A1=TVOL(I1,I2)*FRS
      IF(A1.LT.1.E-06) GO TO 240
      KSHP=A1/(I3*PKV(I1))+1.0
      A2=KSHP*DIST(IR)
```

```
      A3=A2*NX
      TIMP(2)=TIMP(2)+A3/6.
      TIMP(4)=TIMP(4)+(A2*TDZ(1,1)+KSHP*TDZ(1,2)*STPS(IR))*FRC
      TIMP(3)=TIMP(3)+(A2*TDZ(2,1)+KSHP*TDZ(2,2)*STPS(IR))*FRC
      NC=3
      IF(DIST(IR).GT.400..AND.DIST(IR).LT.1000.) NC=2
      IF(DIST(IR).LE.400.) NC=1
      TIMP(1)=TIMP(1)+A3*TCST(NX,NC)*1.15
C
C     CASK RENTAL FEE, AND OVERWEIGHT FEE ARE ADDED IN THE
C     NEXT SECTION IF APPLICABLE.
C
      IF(NX.EQ.1) GO TO 220
      TIMP(1)=TIMP(1)+KSHP*CASK(IR)*250.
      IF(KWT(IKON).GT.0)TIMP(1)=TIMP(1)+A2*0.76+60.*STPS(IR)
  220 KPAK=A1/PKV(I1)+1.0
      NX=2
      IF(IE.EQ.1.OR.IE.EQ.4) NX=1
      FRC=1.0
      IF(IE.EQ.3) FRC=2.0
      A2=KPAK*1.E-3/60.
      TIMP(5)=TIMP(5)+A2*TYM(NX,IKON)*RDZ(NX,I2)*FRC
      TIMP(6)=TIMP(6)+A2*TYM(2,IKON)*RDZ(2,I2)
  240 CONTINUE
 3002 FORMAT(1P,'TVOL    '3E10.2)
 3003 FORMAT(1P,'TIMPS   '6E10.2)
      RETURN
      END
C
C**************************************************************************
C
      SUBROUTINE ECON(RI,RJ,COST,ICN)
C
C     THIS ROUTINE CALCULATES THE DISPOSAL IMPACTS BASED ON
C     THE WASTE VOLUMES AND THE DISPOSAL TECHNOLOGY INDICES.
C     THE RESULTS ARE PLACED IN ARRAY COST, WHERE:
C
C       COST(1) = PRE-OP AND OPERATIONAL COST
C       COST(2) = OCCUPATIONAL DOSE
C       COST(3) = ENERGY USE
C       COST(4) = LAND USE
C       COST(5) = TOTAL POST OPERATIONAL COST
C       COST(6) = COST FOR CLOSURE PERIOD
C       COST(7) = COST FOR OBSERVATION PERIOD
C       COST(8) = COST FOR INSTITUTIONAL CONTROL PERIOD
C
      COMMON/BAST/BAS(90,32),ISPC(6,90,10)
     + /DTNX1/IR1,ID1,IC1,IX1,IE1,IS1,IL1,IG1,IH1,IQ1,ICL1,IPO1,IIC1
     + /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2,IQ2,ICL2,IPO2,IIC2
     +      /VOLS/VRG1,VRG2,VL,VH,VN
     +      /NBAS/NSTR,NNUC,NOXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +      /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90)
      DIMENSION EMP(5),EFF(2),SEFF(2),AMULT(2),CONT(6),
     +          IMA(2),COST(8),XCAP(4),CAP(5)
      DATA EMP/.5,.75,.5,.5,.75/
      DATA EFF/6.4,7.0/
      DATA SEFF/0.9,0.35/
      DATA AMULT/1.43,1.30/
      DATA CONT/1114.,439.,439.,0.,183.,1114./
      DATA XCAP/2*1200.,2*750./
      DATA IMA/2,4/
      DATA ITO/20/
      DATA F/.015/
```

```
C
C     ARRAYS NEWLY INTRODUCED ABOVE ARE THE FOLLOWING:
C
C       AMULT  = CAPITAL AND OPERATIONAL COST MULTIPLIERS
C       CONT   = CONTINGENCY FOR DIFFERENT SOIL CONDITIONS
C       XCAP   = (ALSO CAP) ARE THE BASE ANNUAL CAPITAL COSTS
C                FOR SITING AND CONSTRUCTION OF A FACILITY
C
      CALL ZERO(COST,8)
    1 VSTAB=0.0
      VUNS=0.0
      VCHM=0.0
      VCON=0.0
      IF(ICN.EQ.2) GO TO 2
      IR=IR1
      ID=ID1
      IC=IC1
      IX=IX1
      IE=IE1
      IS=IS1
      IL=IL1
      IG=IG1
      IH=IH1
      IQ=IQ1
      ICL=ICL1
      IPO=IPO1
      IIC=IIC1
      GO TO 5
    2 IR=IR1
      ID=ID2
      IC=IC2
      IX=IX2
      IE=IE2
      IS=IS2
      IL=IL2
      IG=IG2
      IH=IH2
      IQ=IQ2
      ICL=ICL2
      IPO=IPO2
      IIC=IIC2
C
C     NEXT SECTION CALCULATES VARIOUS VOLUMES AND AREAS-SEE BELOW.
C
    5 DO 10 ISTR=1,NSTR
      I11=IMOD(ISTR)
      IF(I11.NE.1) GO TO 6
      IF(ICN.EQ.1.AND.IE.EQ.3) VCON=VCON+BAS(ISTR,3)
    6 IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
      I7=ISPC(NSPC,ISTR,7)
      IF(ICN.EQ.2)GO TO 7
      IF(I11.EQ.1.AND.I7.EQ.1)VCHM=VCHM+BAS(ISTR,3)
      GO TO 10
    7 IF((I11.GE.2.AND.I11.LT.7).AND.I7.EQ.1)VCHM=VCHM+BAS(ISTR,3)
   10 CONTINUE
      IF(ICN.EQ.2) GO TO 12
      VREG=VRG1
      VLAY=0.0
      VHOT=0.0
      VUNS=VRG1
      GO TO 15
   12 VREG=VRG2
```

```
      VLAY=VL
      VHOT=VH
      VSTAB=VREG+VLAY+VHOT
   15 CONTINUE
      DLAY=VLAY*1.00E-06
      DREG=(VREG+VLAY)*1.0E-6
      DHOT=VHOT*1.0E-6
      DCHM=VCHM*1.0E-6
      SV=DREG*((1.1567/EMP(IE))-1.)
      DCON=VCON*1.0E-06
      DVOL=DREG/EMP(IE)
      DAREA=DVOL/(EFF(ID)*SEFF(ID))
      GV=(1.-EMP(IE))*DVOL
      VTOT=VREG+VLAY+VHOT
      DTOT=DREG+DHOT
C
C     AT THIS POINT THE VARIOUS VARIABLES ARE AS FOLLOWS:
C
C       VREG = REGULAR WASTE VOLUME
C       VLAY = LAYERED WASTE VOLUME
C       VHOT = HOT WASTE VOLUME
C       VUNS = UNSTABLE WASTE VOLUME
C       VSTAB= STABLE WASTE VOLUME
C       VCHM = CHEMICAL WASTE VOLUME
C       VCON = DECONTAINERIZED DISPOSAL WASTE VOLUME
C
C       AFTER THE INITIAL CALCULATION, THESE ARE MULTIPLIED BY
C       1.0E-6 TO CONVERT THEM INTO MEGA UNITS   DLAY, DHOT,
C       DCHM AND DCON ARE ALL CONVERTED UNITS.   IN ADDITION :
C
C       DVOL = DISPOSAL VOLUME
C       DAREA= DISPOSAL AREA
C       VTOT = TOTAL VOLUME (IN STANDARD UNITS)
C       SV   = SAND VOLUME
C       GV   = GROUT VOLUME
C
      IF(VTOT.LT.0.1)RETURN
      VTOTT=VRG1+VRG2+VL+VH
      RATIO=VTOT/VTOTT
      COST(4)=DAREA*1.0E+06+(DHOT/1.84)*1.0E+06
C
C     IN WHAT FOLLOWS, C1, C2, AND C3 ACCUMULATE THE DOLLAR
C     COSTS, DOSE, AND ENERGY USE THROUGH VARIOUS PHASES
C     OF THE DISPOSAL FACILITY LIFE.
C
C      PRE-OPERATIONAL (CAPITAL) COSTS
C
C      ******* REFERENCE BASE CASE ********
C
      C1=3970.2*RATIO
      DEP=2120.5*RATIO
      COST(3)=212.*RATIO
C
C      ******* ADDITIVE ALTERNATIVES ******
C
   18 IF(ID.NE.2) GO TO 98
      A1=593.5
      D1=539.5
      IF(ID1.EQ.2.AND.ID2.EQ.2) A1=A1*RATIO
      IF(ID1.EQ.2.AND.ID2.EQ.2) D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
   98 IF(IS.LT.2.OR.VCHM.LT.0.1)GO TO 100
```

```
      A1=0.99
      D1=0.9
      IF(IS1.GE.2.AND.IS2.GE.2)A1=A1*RATIO
      IF(IS1.GE.2.AND.IS2.GE.2)D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  100 IF(IE.NE.2.AND.IE.NE.5) GO TO 101
      A1=225.5
      D1=205.
      IF((IE1.EQ.2.OR.IE1.EQ.5).AND.(IE2.EQ.2.OR.IE2.EQ.5))A1=A1*RATIO
      IF((IE1.EQ.2.OR.IE1.EQ.5).AND.(IE2.EQ.2.OR.IE2.EQ.5))D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  101 IF(IS.EQ.0.OR.IS.EQ.2) GO TO 102
      IF(VRG1.LT.0.1)GO TO 102
      A1=0.99
      D1=0.9
      IF((IS1.EQ.1.OR.IS1.EQ.3).AND.(IS2.EQ.1.OR.IS2.EQ.3))A1=A1*RATIO
      IF((IS1.EQ.1.OR.IS1.EQ.3).AND.(IS2.EQ.1.OR.IS2.EQ.3))D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  102 IF(IL.NE.1.OR.ICN.EQ.1) GO TO 103
      A1=132.
      D1=120.
      C1=C1+A1
      DEP=DEP+D1
  103 IF(IE.NE.3) GO TO 104
      A1=924.3
      D1=840.25
      IF(IE1.EQ.3.AND.IE2.EQ.3) A1=A1*RATIO
      IF(IE1.EQ.3.AND.IE2.EQ.3) D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  104 IF(IH.NE.1) GO TO 105
      A1=259.5
      D1=235.9
      IF(IH1.EQ.1.AND.IH2.EQ.1) A1=A1*RATIO
      IF(IH1.EQ.1.AND.IH2.EQ.1) D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  105 IF(IG.NE.1) GO TO 106
      A1=55.
      D1=50.
      IF(IG1.EQ.1.AND.IG2.EQ.1) A1=A1*RATIO
      IF(IG1.EQ.1.AND.IG2.EQ.1) D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  106 IF(IC.NE.3) GO TO 107
      A1=280.5
      D1=255.
      IF(IC1.EQ.3.AND.IC2.EQ.3) A1=A1*RATIO
      IF(IC1.EQ.3.AND.IC2.EQ.3) D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  107 IF(IX.NE.3) GO TO 108
      A1=9.9
      D1=9.
      IF(IX1.EQ.3.AND.IX2.EQ.3) A1=A1*RATIO
      IF(IX1.EQ.3.AND.IX2.EQ.3) D1=D1*RATIO
      C1=C1+A1
      DEP=DEP+D1
  108 CONTINUE
      DEP=DEP*1.3
```

```
      CAP(5)=C1*AMULT(1)
      DO 110 I=1,4
  110 CAP(I)=XCAP(I)*AMULT(1)*RATIO
C
C      OPERATIONAL COSTS
C
C      ******* REFERENCE BASE CASE *******
C
      C1=2341.*DVOL
      C2=300.*DVOL
      C3=200.*DVOL
      C1=C1+1420.*DAREA
      C2=C2+2400.*DAREA
      C3=C3+100.*DAREA
      C1=C1+78759.*RATIO
      C2=C2+1000.*RATIO
      C3=C3+200.*RATIO
C
C      ******* ADDITIVE ALTERNATIVES *****
C
      IF(ID.NE.2) GO TO 20
      C1=C1+77118.*DVOL
      C2=C2+700.*DVOL
      C3=C3+300.*DVOL
   20 IF(IE.NE.2) GO TO 24
      C1=C1+13010.*DREG
      C2=C2+100.*DREG
      C3=C3+100.*DREG
   24 IF(IE.NE.5) GO TO 25
      C1=C1+13010.*DREG
      C2=C2+100.*DREG
      C3=C3+100.*DREG
   25 IF(IS.EQ.0.OR.IS.EQ.2) GO TO 26
      IF(VRG1.LT.0.1)GO TO 26
      C1=C1+4809.9*DREG
      C2=C2+100.*DREG
      C3=C3+30.*DREG
   26 IF(IS.LT.2)GO TO 30
      C1=C1+4809.9*DCHM
      C2=C2+100.*DCHM
      C3=C3+30.*DCHM
   30 IF(IL.NE.1) GO TO 35
      C1=C1+23076.*DLAY
      C2=C2+(-100.)*DLAY
      C3=C3+30.*DLAY
   35 IF(IE.NE.3) GO TO 40
      C1=C1+57262.3*DCON
      C2=C2+400.*DCON
      C3=C3+100.*DCON
   40 IF(IH.NE.1) GO TO 45
      C1=C1+181823.*DHOT
      C2=C2+(-200.)*DHOT
      C3=C3+450.*DHOT
   45 IF(IG.NE.1) GO TO 46
      C2=C2+2250.*GV
      C3=C3+800.*GV
   46 IF(IE.LT.4) GO TO 50
      C1=C1+3270.*SV
      C3=C3+185.*SV
   50 IF(IC.NE.2) GO TO 55
      C1=C1+15555.*DAREA
      C2=C2+2400.*DAREA
```

```
      C3=C3+150.*DAREA
   55 IF(IC.NE.3) GO TO 60
      C1=C1+106447.*DAREA
      C2=C2+2400.*DAREA
      C3=C3+300.*DAREA
   60 IF(IX.EQ.1) GO TO 75
      S3=DAREA
      IXX=IX-1
      GO TO (65,70),IXX
   65 C1=C1+3496.*S3
      C2=C2+4800.*S3
      C3=C3+300.*S3
      GO TO 75
   70 C1=C1+39167.*S3
      C2=C2+4800.*S3
      C3=C3+600.*S3
   75 OP=C1*AMULT(2)
      COST(2)=COST(2)+C2
      COST(3)=COST(3)+C3
C
      CALL COSTS(CAP,DEP,OP,DTOT,DC)
C
C      POST-OPERATIONAL COSTS
C
C      ******* CLOSURE PERIOD *******
C
      C1=1063.*RATIO
      C2=500.*RATIO
      C3=15.*RATIO
      IF(IQ.NE.2) GO TO 76
      C1=3345.*RATIO
      C2=1000.*RATIO
      C3=60.*RATIO
C
C      ******* INSTITUTIONAL PERIOD ******
C
C      DOLLAR COST SECTION
C
   76 CA=RATIO*167.3
      CB=RATIO*66.5
      CC=RATIO*54.
      COM=RATIO*106.6
      IF(ICL.NE.2) GO TO 77
      CA=RATIO*384.6
      CB=RATIO*167.3
      CC=RATIO*91.5
      COM=RATIO*258.7
   77 IF(ICL.NE.3) GO TO 78
      CA=RATIO*(523.2+CONT(IR))
      CB=RATIO*384.6
      CC=RATIO*167.3
      COM=RATIO*339.3
   78 S1=0.0
      S2=0.0
      S3=0.0
      D1=1.
      D2=(1.+RJ)/(1.+RI)
      DO 80 N=1,10
      D1=D1*D2
      DO 85 N=11,25
      D1=D1*D2
   85 S2=S2+D1
```

```
      DO 90 N=26,IIC
      D1=D1*D2
   90 S3=S3+D1
      IMI=IMA(IQ)
      IM=IPO-IMI
      S4=0.0
      IF(IM.LT.1) GO TO 95
      DO 93 N=1,IM
      E=N
      D1=(1.+RJ)**E
      D2=(1.+RI)**E
   93 S4=S4+D1/D2
   95 CONTINUE
      PV80=CA*S1+CB*S2+CC*S3
      M=IPO+ITO
      M1=ITO+IMI
      EM=M
      EITO=ITO
      EIPO=IPO
      EM1=M1
      D1=(1.+RJ)**EITO
      D2=(1.+RJ)**EM
      D3=(1.+RI)**EITO
      D4=(1.+RJ)**EIPO
      D5=(1.+RJ)**EM1
      D6=(((1.+RI)**EM1)-1.)
      COST(8)=(EITO*PV80*D2*RI)/((D3-1.)*D4)
      COST(7)=EITO*COM*D5*S4*RI/D6
      COST(6)=EITO*D1*C1*(F+(RI/(D3-1.)))
      COST(1)=DC*DTOT
      COST(5)=COST(6)+COST(7)+COST(8)
C
C      ENERGY USE SECTION
C
      IICC=(IIC-26)+1
      GO TO (200,210,220),ICL
  200 C3=C3+(10*5.+15*3.+IICC*1.)*RATIO
      GO TO 225
  210 C3=C3+(10*10.+15*5.+IICC*3.)*RATIO
      GO TO 225
  220 C3=C3+(10*12.+15*10.+IICC*5.)*RATIO
  225 CONTINUE
      COST(1)=COST(1)*1000.
      COST(2)=COST(2)+C2
      COST(5)=COST(5)*1000.
      COST(3)=COST(3)+C3
      COST(3)=COST(3)*1000.
      COST(6)=COST(6)*1000.
      COST(7)=COST(7)*1000.
      COST(8)=COST(8)*1000.
      RETURN
      END
C
C*****************************************************************************
C
      SUBROUTINE ZERO(A,N)
C
      DIMENSION A(N)
      DO 10 I=1,N
   10 A(I)=0.0
      RETURN
      END
C
```

```
C**********************************************************************
C
      FUNCTION EXM(A1)
C
      A2=0.0
      IF(A1.LT.85.) A2=EXP(-A1)
      EXM=A2
      RETURN
      END
C
C**********************************************************************
C
      SUBROUTINE PRT(V,IQ,N,ID)
C
C     SUBROUTINE PRT IDENTIFIES AND PRINTS OUT WASTE VOLUMES,
C     DISPOSAL MODE, SPECTRUM, AND STREAM NUMBER IN FIVE TYPES:
C     UNSTABLE-REGULAR, STABLE-REGULAR, LAYERED, HOT, AND
C     UNACCEPTABLE.  CHEMICAL AND NON-CHEMICAL PORTION OF EACH
C     GROUP IS PRINTED SEPARATELY.
C
      CHARACTER*10 BASN(90),LAB(2)
      COMMON/BAST/BAS(90,32),ISPC(6,90,10)
     +      /CHRC/BASN
     +      /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +      /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90)
      DIMENSION IQ(90)
      DATA LAB/'N-CHEMICAL','CHEMICAL
      IF(N.EQ.0)RETURN
      GO TO (10,10,10,50,70),ID
   10 IF(ID.EQ.1)WRITE(4,410)V
      IF(ID.EQ.2)WRITE(4,420)V
      IF(ID.EQ.3)WRITE(4,425)V
      DO 40 K=1,2
      IT=0
      VTOT=0.0
      DO 20 I=1,N
      J=IQ(I)
      IDR=ISPEC(J)
      NSPC=IORD(IDR,J)
      I7=ISPC(NSPC,J,7)
      IF(K.EQ.1.AND.I7.NE.0) GO TO 20
      IF(K.EQ.2.AND.I7.NE.1) GO TO 20
      IF(IT.EQ.0)WRITE(4,430)LAB(K),BASN(J),BAS(J,3),J,IMOD(J),IDR,NSPC
      IF(IT.EQ.1)WRITE(4,440)BASN(J),BAS(J,3),J,IMOD(J),IDR,NSPC
      IT=1
      VTOT=VTOT+BAS(J,3)
   20 CONTINUE
      IF(IT.EQ.1) WRITE(4,470)VTOT
   40 CONTINUE
      RETURN
   50 WRITE(4,450)V
      DO 55 I=1,N
      J=IQ(I)
      IDR=ISPEC(J)
      NSPC=IORD(IDR,J)
   55 WRITE(4,440)BASN(J),BAS(J,3),J,IMOD(J),IDR,NSPC
      RETURN
   70 WRITE(4,460)V
      DO 75 I=1,N
      J=IQ(I)
      IDR=ISPEC(J)
      NSPC=IORD(IDR,J)
   75 WRITE(4,440)BASN(J),BAS(J,3),J,IMOD(J),IDR,NSPC
```

```
  410 FORMAT(1P,/2X'REG-UNSTABLE  :',21X,E10.3,5H M**3)
  420 FORMAT(1P,/2X'REG-STABLE    :',21X,E10.3,5H M**3)
  425 FORMAT(1P,/2X'LAYERED WASTE :',21X,E10.3,5H M**3)
  430 FORMAT(1P,7X,2A10,E10.3,4I5)
  440 FORMAT(1P,17X,A10,E10.3,4I5)
  450 FORMAT(1P,/2X'HOT WASTE     :',21X,E10.3,5H M**3)
  460 FORMAT(1P,/2X'NOT ACCEPTABLE:',21X,E10.3,5H M**3)
  470 FORMAT(1P,18X'TOTAL VOLUME  :'5X,E10.3,5H M**3)
      RETURN
      END
C
C*****************************************************************************
C
      SUBROUTINE ACCEXP(NBEST,ICN)
C
C     THIS ROUTINE CALCULATES IMPACTS FROM OPERATIONAL
C     ACCIDENTS, AND IMPACTS FROM ATMOSPHERIC AND SURFACE
C     WATER TRANSPORT OF WASTE EXPOSED THROUGH SOME MEANS,
C     I.E., THE SO CALLED EXPOSED-WASTE SCENARIOS.
C
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8)
     +       /NUCS/AL(36)
     +  /DTNX1/IR1,ID1,IC1,IX1,IE1,IS1,IL1,IG1,IH1,IO1,ICL1,IPO1,IIC1
     +  /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2,IO2,ICL2,IPO2,IIC2
     +       /DTIS/FSC(6),FSA(6),PRC(6,2),GFC(6,3),TTM(6,3),TPC(6,3),
     +              RGF(6,3),POP(6,3),DTTM(6),DTPC(6),TPO(6,2),NRET(6)
     +       /VOLS/VRG1,VRG2,VL,VH,VN
     +       /IMPS/DZ(8,7,2),DZG(4,7,2),DZA(7,7),DZS(90,7,2)
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90)
     +       /CHYN/NXUC(36),ICH(7,6),LCH(6),ACT(7)
     +       /CHIN/BCT(7,2)
      DIMENSION EMP(5),EFF(2),SEFF(2)
      DATA EMP/.5,.75,.5,.5,.75/
      DATA EFF/6.4,7.0/
      DATA SEFF/0.9,0.35/
      IF(ICN.EQ.2) GO TO 5
      IR=IR1
      ID=ID1
      IC=IC1
      IE=IE1
      IS=IS1
      IPO=IPO1
      IIC=IIC1
      VTOP=VRG1
      VTOT=VRG1
      VLAY=0.
      VHOT=0.
      GO TO 10
    5 IR=IR1
      ID=ID2
      IC=IC2
      IE=IE2
      IS=IS2
      IPO=IPO2
      IIC=IIC2
      VTOP=VRG2
      VTOT=VRG2+VL
      VHOT=VH
C
C     EXPOSED WASTE SCENARIOS ARE HANDLED FIRST.  GREC AND GERO
C     ARE THE TIMES INTRUDER-INITIATED AND EROSION-INITIATED
C     SCENARIOS ARE INITIATED.
```

OPTIONR Code (cont'd)

```
C
   10 GREC=IPO+IIC
      GERO=IPO+2000.
      IF(IC.EQ.2) GERO=IPO+3000.
      IF(IC.EQ.3) GERO=IPO+10000.
      IF(ID.EQ.2) GERO=IPO+10000.
      FRA=5.72E-5*POP(IR,1)*1.83E+3
      VUR=EMP(IE)*EFF(ID)*SEFF(ID)
      FEA=8.09E-6*POP(IR,2)*VTOT/VUR
      FRW=1.15E-4*POP(IR,3)*1.8E+3
      FEW=1.15E-4*POP(IR,3)*VTOT/VUR
C
C     FRA = FACTOR FOR INTRUDER-ATMOSPHERIC
C     FRW = FACTOR FOR INTRUDER-SURFACE WATER
C     FEA = FACTOR FOR EROSION-ATMOSPHERIC
C     FEW = FACTOR FOR EROSION-SURFACE WATER
C
      DO 40 ISTR=1,NSTR
      A1=0.25
      I11=IMOD(ISTR)
      IF(I11.EQ.0) GO TO 40
      IF(ICN.EQ.1.AND.I11.NE.1)GO TO 40
      IF(ICN.EQ.2.AND.I11.EQ.1)GO TO 40
      IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
      I5=ISPC(NSPC,ISTR,5)
      A5=1.0
      IF(I5.LT.3) A5=10.**(I5-3)
      I9=ISPC(NSPC,ISTR,9)
      A9=1.0
      IF(I9.GT.1) A9=10.**(1-I9)
      I8=ISPC(NSPC,ISTR,8)
      IF(IMOD(ISTR).GT.1) I8=1
      IF(IHIC(ISTR).GT.0) I8=1+IHIC(ISTR)
      IF(I8.GT.0.AND.IS.EQ.1) A1=0.012/9.
      IF(I8.GT.0.AND.IS.EQ.3) A1=0.012/9.
      IF(I11.EQ.5.OR.I11.EQ.6.OR.ID.EQ.2) A1=A1*0.01
      IF(I11.EQ.7.OR.I11.EQ.8) A1=1.2E-5/9.
      A2=0
      A3=0.
      A4=EMP(IE)*SEFF(ID)*BAS(ISTR,3)
      IF(VTOP.GT.0.1)A2=A4/VTOP
      IF(VTOT+VHOT.GT.0.1)A3=A4/(VTOT+VHOT)
      IF(I11.GT.4) A2=0.0
      IF(ID.EQ.2.AND.(I11.NE.5.OR.I11.NE.6)) A2=A3
      DO 30 INUC=1,NNUC
      CALL CHNS(INUC,GREC,IEN,IBC,NCH)
      DO 12 I=1,7
   12 BCT(I,1)=ACT(I)
      CALL CHNS(INUC,GERO,IEN,IBC,NCH)
      DO 14 I=1,7
   14 BCT(I,2)=ACT(I)
      A8=BAS(ISTR,INUC+4)
      IF(NBEST.EQ.0) GO TO 15
      B1=FRA*A1*A3*A9*A5*A8
      B2=FEA*A2*A8
      GO TO 20
   15 B1=FRA*A1*A3*A9*A8
      B2=FEA*A2*A8
   20 B3=FRW*A1*A3*A8*A9
      B4=FEW*A2*A8
      DO 25 IORG=1,7
      CALL CALC2(INUC,IORG,C1,C2,C3,C4,IEN,IBC,NCH)
```

```
      DZA(IORG,1)=DZA(IORG,1)+B1*C1
      DZA(IORG,2)=DZA(IORG,2)+B2*C2
      DZA(IORG,3)=DZA(IORG,3)+B3*C3
      DZA(IORG,4)=DZA(IORG,4)+B4*C4
   25 CONTINUE
   30 CONTINUE
   40 CONTINUE
      IF(ICN.EQ.2)RETURN
C
C     ACCIDENT SECTION IS EMPLOYED ONLY FOR UNSTABLE WASTES
C
      VSC=0.0
      VFR=0.0
      DO 80 ISTR=1,NSTR
      I3=IMOD(ISTR)
      IF(I3.EQ.0.OR.I3.EQ.7.OR.I3.EQ.8) GO TO 80
      IDR=ISPEC(ISTR)
      NSPC=IORD(IDR,ISTR)
      I4=ISPC(NSPC,ISTR,4)
      I5=ISPC(NSPC,ISTR,5)
      I6=ISPC(NSPC,ISTR,6)
      I9=ISPC(NSPC,ISTR,9)
      A5=BAS(ISTR,3)
      IF(I9.GT.1) GO TO 80
      IF(A5.EQ.0.0) GO TO 80
      FAF=TPO(IR,1)*0.1
      FAS=TPO(IR,2)
      A6=1.0
      IF(I5.EQ.3) A6=1.0
      IF(I5.LT.3.AND.I6.EQ.1) A6=0.1
      IF(I6.EQ.2.OR.I6.EQ.3) A6=0.01
      IF(I4.EQ.4) A6=0.001
      FAS=FAS*A6
      IF(I4.LT.3) FAF=FAF*(20.**(I4-3))
      IF(IS.EQ.1.AND.I4.NE.3) FAF=0.0
      IF(IS.EQ.3.AND.I4.NE.3) FAF=0.0
      VFR=VFR+A5
      VSC=VSC+A5
      DO 70 INUC=1,NNUC
      A1S=FAS*BAS(ISTR,INUC+4)*A5
      A1F=FAF*BAS(ISTR,INUC+4)*A5
      DO 70 IORG-1,7
      DZS(ISTR,IORG,1)=DZS(ISTR,IORG,1)+A1S*DCF(INUC,IORG,1)/A5
      DZS(ISTR,IORG,2)=DZS(ISTR,IORG,2)+A1F*DCF(INUC,IORG,1)/A5
      DZA(IORG,5)=DZA(IORG,5)+A1S*DCF(INUC,IORG,1)
   70 DZA(IORG,6)=DZA(IORG,6)+A1F*DCF(INUC,IORG,1)
   80 CONTINUE
      DO 90 IORG=1,7
      DZA(IORG,7)=(DZA(IORG,5)+DZA(IORG,6))/(VSC+VFR)
      IF(VSC.GT.0.) DZA(IORG,5)=DZA(IORG,5)/VSC
      IF(VFR.GT.0.) DZA(IORG,6)=DZA(IORG,6)/VFR
   90 CONTINUE
      RETURN
      END
C
C*************************************************************************
C
      SUBROUTINE CHNS(INUC,GDEL,IEN,IBG,NCH)
C
C     THIS ROUTINE IS IDENTICAL IN LOGIC WITH THE ACTDR
C     SUBROUTINE OF MILDOS CODE, HOWEVER, HERE FIRST THE
C     CHAIN MEMBERS ARE DETERMINED, THEN THE ACTDR CALCULATIONS
C     ARE APPLIED.  SMALL DIFFERENCES ARE DUE TO UTILIZATION
```

```
C     OF DOUBLE PRECISION TO INCREASE ACCURACY OF RESULTS.
C
      COMMON/CHYN/NXUC(36),ICH(7,6),LCH(6),ACT(7)
     *      /NUCS/AL(36),FMF(36)
      REAL*8 Y,Z,DACT(7),HLM(7),EHLM(7)
      DATA ICH/23,36,35,32,28,27, 0,18,20,15,33,29, 0, 0,
     *         19,14,34,30,26,24,0,16,34,30,26,24,0,0,
     *         22,17,13,31,27,0,0,21,17,13,31,27,0,0/
      DATA LCH/6,5,6,5,5,5/
      DATA NXUC/12*0,11*1,13*0/
      CALL ZERO(ACT,7)
      IF(NXUC(INUC).NE.0)GO TO 12
   10 ACT(1)=EXM(AL(INUC)*GDEL)
      RETURN
   12 DO 16 NCH=1,6
      IEN=LCH(NCH)
      DO 14 IBG=1,IEN
      IF(INUC.EQ.ICH(IBG,NCH))GO TO 18
   14 CONTINUE
   16 CONTINUE
      STOP
   18 IF(IBG.EQ.IEN)GO TO 10
      IEND-IEN-IBG+1
      DO 20 I=1,IEND
      J=ICH(IBG+I-1,NCH,
      HLM(I)=AL(J)
      Y=HLM(I)*GDEL
      Z=0.
      IF(Y.LT.85.)Z=DEXP(-Y)
   20 EHLM(I)=Z
      DACT(1)=EHLM(1)
      DO 60 I=2,IEND
      Y=1.0
      DO 30 J=2,I
   30 Y=Y*HLM(J)
      DACT(I)=0.
      DO 50 K=1,I
      Z=EHLM(K)
      DO 40 J=1,I
      IF(K.NE.J)Z=Z/(HLM(J)-HLM(K))
   40 CONTINUE
      DACT(I)=DACT(I)+Z
   50 CONTINUE
      DACT(I)=DACT(I)*Y
      IF(DACT(I).LT.0.)DACT(I)=0.
   60 CONTINUE
      DO 70 I=1,IEND
   70 ACT(I)=DACT(I)
      RETURN
      END
C
C*************************************************************************
C
      SUBROUTINE CALC(INUC,IP,C1,C2,C3,C4,IEN,IBG,NCH)
C
C     THIS ROUTINE OBTAINS THE C1,C2,C3,C4 COEFFICIENTS USED IN
C     THE INTRUDER IMPACT CALCULATIONS.  IF INUC IS NOT A MEMBER
C     OF A CHAIN THEN THE SECTION BEFORE STATEMENT 15 IS USED.
C     IF IT IS A CHAIN MEMBER, SECTION AFTER 15 IS USED.
C
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8)
     *      /CHYN/NXUC(36),ICH(7,6),LCH(6),ACT(7)
     *      /NUCS/AL(36),FMF(36)
```

```
      IF(NXUC(INUC).NE.0)GO TO 15
   10 A1=ACT(1)
      C1=A1*DCF(INUC,IP,5)
      C2=A1*DCF(INUC,IP,2)
      C3=A1*DCF(INUC,IP,3)
      C4=A1*DCF(INUC,IP,4)*FMF(INUC)
      RETURN
   15 IEND=IEN-IBC+1
      C1=0.
      C2=0.
      C3=0.
      C4=0.
      DO 20 I=1,IEND
      NN=ICH(IBG+I-1,NCH)
      C1=C1+ACT(I)*DCF(NN,IP,5)
      C2=C2+ACT(I)*DCF(NN,IP,2)
      C3=C3+ACT(I)*DCF(NN,IP,3)
      C4=C4+ACT(I)*DCF(NN,IP,4)*FMF(NN)
   20 CONTINUE
      RETURN
      END
C
C*************************************************************************
C
      SUBROUTINE OVERFLO
C
C     THIS ROUTINE CALCULATES AND PRINTS RADIOLOGICAL AND NON-
C     RADIOLOGICAL IMPACTS IF THE DISPOSAL CELLS ARE PERMITTED
C     TO FILL WITH WATER UNDER TWO COURSES OF ACTION: LETTING
C     THE TRENCH OVERFLOW, AND TREATING AND EVAPORATING THE
C     TRENCH LEACHATE.  IN THE OVERFLOW CASE, SURFACE WATER
C     IMPACTS TO THE MAXIMUM INDIVIDUAL ARE CALCULATED, AND IN
C     THE EVAPORATION CASE, POPULATION EXPOSURES ARE CALCULATED.
C     IN ADDITION, COSTS, AND ENERGY USE ARE ESTIMATED BASED ON
C     THE EXPERIENCE AT THE MAXEY FLATS EVAPORATOR.
C
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8),FICRP(7)
     +       /NUCS/AL(36),FMF(36)
     +       /DTNX1/IR,ID,IC,IX,IE,IS,IL,IG,IH,IQ,ICL
     +       /VOLS/VRG1,VRG2,VLAY,VHOT,VNOT
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90),ISPEC(90),IHIC(90)
     +       /LSTS/CLST(4,16),DIST(3,16,7),IORD(6,90)
     +       /COMB/TPOP(2),DEC(36,2)
      DIMENSION OINP(5),TAC(23),DZFLO(2,7)
      IF(IR.EQ.1.OR.IR.EQ.6.OR.ICL.NE.3)RETURN
      CALL ZERO(OINP,5)
      CALL ZERO(TAC,23)
      CALL ZERO(DZFLO,14)
      VL=0.
      IF(IX.EQ.3.OR.IG.EQ.1.OR.ID.EQ.2)GO TO 45
      VTOT=VRG1+VRG2+VLAY+VHOT
      DO 20 ISTR=1,NSTR
      IF(IMOD(ISTR).NE.1) GO TO 20
      IDR=ISPEC(ISTR)
      ISP=IORD(IDR,ISTR)
      I6=ISPC(ISP,ISTR,6)
      I7=ISPC(ISP,ISTR,7)
      I9=ISPC(ISP,ISTR,9)
      I10=ISPC(ISP,ISTR,10)
      IP=I10/1000
      IES=(I10/100)-IP*10
      IF(IES.EQ.4.OR.IHIC(ISTR).EQ.1)GO TO 20
      IF(I7.EQ.1.OR.IS.LT.2) I6=I6-1
```

```
      A6=1.0
      A9=1.0
      IF(I6.GT.1) A6=4.**(1-I6)
      IF(I9.GT.1) A9=10.**(1-I9)
      A1=A6*A9*BAS(ISTR,3)/VTOT
      DO 10 INUC=1,NNUC
   10 TAC(INUC)=TAC(INUC)+A1*FMF(INUC)*BAS(ISTR,INUC+4)
   20 CONTINUE
      VL=VRG1/264.17205
      DO 40 INUC=1,NNUC
      A1=VL*TAC(INUC)*DEC(INUC,2)*TPOP(2)
      A2=VL*TAC(INUC)/4.5E+6
      DO 30 I=1,7
      DZFLO(1,I)=DZFLO(1,I)+A1*DCF(INUC,I,8)
      DZFLO(2,I)=DZFLO(2,I)+A2*DCF(INUC,I,7)
      OINP(1)=OINP(1)+A1*FICRP(I)*DCF(INUC,I,8)
   30 OINP(5)=OINP(5)+A2*FICRP(I)*DCF(INUC,I,7)
   40 CONTINUE
   45 VL=VL*264.17205
      OINP(2)=0.4*VL/208.
      OINP(3)=VL*300000./1.3E+6
      OINP(4)=VL*2.4E+5/1.3E+6
      WRITE(4,100)VL,OINP(1),OINP(5),OINP(2),OINP(3),OINP(4)
      DO 50 I=1,2
   50 WRITE(4,101)(DZFLO(I,J),J=1,7)
  100 FORMAT(/2X,'TRENCH OVERFLOW IMPACTS        (',1PE10.3,' GALS )'/2X,
     +'RADIOLOGICAL     POPULATION DOSE     (PERSON-MREM) : 'E10.3/2X,
     +'                 INDIVIDUAL DOSE     (   MREM/YR   ) : 'E10.3/2X,
     +'                 OCCUPATIONAL DOSE   (    MREM     ) : 'E10.3/2X,
     +'FINANCIAL        COST                (     $/YR    ) : 'E10.3/2X,
     +'ENERGY USE       PROPANE             (   GALS/YR   ) : 'E10.3/)
  101 FORMAT(3X,1P,7E10.3)
      RETURN
      END
C
C*****************************************************************************
C
      SUBROUTINE COSTS(CAP,DEP,OP,V,DC)
C
C     THIS ROUTINE CALCULATES THE DISPOSAL COSTS ACCORDING
C     TO THE ALGORITHM PRESENTED IN APPENDIX C OF THE FEIS.
C
      DIMENSION CAP(5)
      DATA ITO/20/,EJ/.09/,EDR/.75/,TF/.48/,TS/.065/
      DATA D/.15/,EID/.10/
      EITO=ITO
      OPY=OP/EITO
      VY=V/EITO
      CRF=(D*(1.+D)**ITO)/(((1.+D)**ITO)-1.)
      TR=TS+TF*(1.-TS)
      A1=0.0
      CAPD=0.0
      TCAP=0.0
      DO 30 N=1,5
      CAPD=CAPD+CAP(N)*(1.-EDR)*((1.+EJ)**(N-5))
      TCAP=TCAP+(CAP(N)*EDR+CAP(N)*(1.-EDR)*(1.+EID))*
     +      ((1.+EJ)**(N-5))
   30 A1=A1+CAP(N)*((1.+EJ)**(N-5))/((1.+D)**N)
      XIDP=(CAPD/EITO)/EID
      A2=0.0
      A3=0.0
      II=ITO+5
      XII=II
```

```
      A6=EITO*(EITO+1.)/2.
      DO 40 N=6,II
      EN=N
      DEPY=(XII-EN+1.)*DEP/A6
      A4=(1.+D)**(-N)
      A2=A2+(CRF*TCAP+((1.-TR)*GPY*(1.+EJ)**(N-5))-TR*XIDP-TR*DEPY)*A4
   40 A3=A3+(1.-TR)*VY*A4
      DC=(A1+A2)/A3
      RETURN
      END
C
C**********************************************************************
C
      SUBROUTINE MODIF(ISTR,INDX)
C
C     THIS ROUTINE MODIFIES THE DISPOSAL STATUS OF THE WASTE
C     (WHICH WAS DETERMINED BASED ON WASTE PROPERTIES) TO TAKE
C     INTO ACCOUNT THE DISPOSAL PRACTICES.
C
      COMMON/DTNX1/IR1,ID1,IC1,IX1,IE1,IS1
     +       /DTNX2/IR2,ID2,IC2,IX2,IE2,IS2,IL2,IG2,IH2
     +       /NBAS/NSTR,NNUC,NDXS(90),IMOD(90)
      IF(IS1.EQ.1.OR.IS1.EQ.3)RETURN
      I11=IMOD(ISTR)
      IF(IR2.NE.0)GO TO 20
      IF(I11.EQ.1.OR.I11.GE.7)RETURN
      IMOD(ISTR)=1
      INDX=1
      RETURN
   20 IF(IH2.EQ.1)GO TO 30
      IF(I11.GT.2)I11=0
      IF(I11.EQ.2)I11=1
      IMOD(ISTR)=I11
      INDX=1
      RETURN
   30 IF(I11.EQ.3 OR.I11.EQ.5)I11=7
      IF(I11.EQ.4.OR.I11.EQ.6)I11=8
      IMOD(ISTR)=I11
      INDX=7
      RETURN
      END
C
C**********************************************************************
C
      SUBROUTINE BARN(ISTR,A2,A3,NX)
C
C     THIS ROUTINE PERFORMS A SPECIAL CLASSIFICATION TEST
C     FOR UNSTABLE WASTES BASED ON EXISTING DISPOSAL FACILITY
C     LICENSE CONDITIONS.  BOTH NON-DISTRIBUTIONAL AND DISTRIBU-
C     TIONAL WASTE STREAMS CAN BE SUBJECTED TO THIS TEST.
C
      COMMON/BAST/BAS(90,32)/NBAS/NSTR,NNUC,NDXS(90)
      A1=0.
      DO 10 I=19,27
   10 A1=A1+BAS(ISTR,I)
      A2=A1
      A1=A1-BAS(ISTR,22)*(1.-1./35.)
      IF(NDXS(ISTR).LT.0)GO TO 20
      IF(A1.GT.0.016)RETURN
      DO 12 I=5,6
      IF(BAS(ISTR,I).GT.1.0)RETURN
   12 CONTINUE
      DO 14 I=8,18
```

```
      IF(BAS(ISTR,I).GT.1.0)RETURN
   14 CONTINUE
      NX=1
      RETURN
   20 DO 22 I=5,18
   22 A2=A2+BAS(ISTR,I)
      A4=AMAX1(BAS(ISTR,5),BAS(ISTR,6))
      DO 24 I=8,18
      IF(A4.LT.BAS(ISTR,I))A4=BAS(ISTR,I)
   24 CONTINUE
      A3=A1/0.016
      IF(A4.LT.A3)A4=A3
      A3=A2/A4
      RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE CALC2(INUC,IP,C1,C2,C3,C4,IEN,IBG,NCH)
C
C     THIS ROUTINE PERFORMS THE SAME FUNCTION THAT SUBROUTINE
C     CALC DID FOR RCLAIM FOR ACCEXP.  CHAIN EFFECTS FOR
C     INTRUDER- AND EROSION-INITIATED EXPOSED WASTE
C     SCENARIOS ARE CALCULATED IN THIS ROUTINE.
C
      COMMON/BAST/BAS(90,32),ISPC(6,90,10),DCF(36,7,8)
     *      /CHYN/NXUC(36),ICH(7,6),LCH(6),ACT(7)
     *      /CHIN/BCT(7,2)
     *      /NUCS/AL(36),FMF(36)
      IF(NXUC(INUC).NE.0)GO TO 15
   10 C1=BCT(1,1)*DCF(INUC,IP,8)
      C2=BCT(1,2)*DCF(INUC,IP,8)
      C3=BCT(1,1)*DCF(INUC,IP,7)
      C4=BCT(1,2)*DCF(INUC,IP,7)
      RETURN
   15 IEND=IEN-IBG+1
      C1=0.
      C2=0.
      C3=0.
      C4=0.
      DO 20 I=1,IEND
      NN=ICH(IBG+I-1,NCH)
      C1=C1+BCT(I,1)*DCF(NN,IP,8)
      C2=C2+BCT(I,2)*DCF(NN,IP,8)
      C3=C3+BCT(I,1)*DCF(NN,IP,7)
      C4=C4+BCT(I,2)*DCF(NN,IP,7)
   20 CONTINUE
      RETURN
      END
```

INIFIL File

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  37   231.000 .120 .060 .030 .060 .120 .060
P-IXRESIN 1.000E+00 3.463E+04
        1 3.360E-02 2.660E-03 9.740E-05 2.340E-03 2.790E-06 4.530E-03
        1 8.610E-04 8.840E-08 1.940E-04 8.230E-07 2.440E-06 8.230E-07
        1 2.190E-02 4.710E-08 3.710E-07 9.060E-12 2.600E-05 1.820E-05
        1 7.940E-04 3.990E-08 4.154E-05 1.260E-06 9.920E-09 1.380E-05
P-CONCLIQ 2.000E+00 2.435E+05
        2 1.090E-01 3.450E-03 1.270E-04 2.270E-02 2.710E-05 4.400E-02
        2 8.360E-03 8.580E-07 2.520E-04 1.070E-06 3.160E-06 1.070E-06
        2 2.850E-02 6.150E-08 4.840E-07 1.180E-11 5.120E-05 3.310E-05
        2 1.440E-03 7.250E-08 7.132E-05 2.020E-06 1.170E-08 1.920E-05
P-FSLUDGE 3.000E+00 4.279E+03
        3 1.060E+00 2.590E-03 9.550E-05 3.100E-01 3.710E-04 6.000E-01
        3 1.140E-01 1.170E-05 1.890E-04 8.030E-07 2.370E-06 8.030E-07
        3 2.140E-02 1.460E-07 1.150E-06 2.810E-11 4.760E-05 1.550E-04
        3 6.750E-03 3.390E-07 4.581E-04 1.780E-05 3.100E-07 1.770E-04
P-FCARTRG 1.100E-01 2.177E+04
        4 1.860E+00 1.150E-03 4.250E-05 5.550E-01 6.600E-04 1.070E+00
        4 2.040E-01 2.090E-05 8.400E-05 3.580E-07 1.060E-06 3.580E-07
        4 9.540E-03 3.640E-07 2.870E-06 7.020E-11 2.510E-04 3.800E-04
        4 1.660E-02 8.340E-07 6.414E-04 1.100E-05 1.930E-07 1.100E-04
B-IXRESIN 4.000E+00 7.623E+04
        5 4.630E+00 1.920E-02 1.190E-03 9.480E-01 9.800E-04 1.590E+00
        5 2.150E-02 3.090E-05 3.640E-03 7.650E-05 2.040E-04 7.650E-05
        5 2.040E+00 5.330E-08 4.200E-07 1.020E-11 8.340E-05 5.340E-05
        5 2.600E-03 1.170E-07 9.798E-05 1.570E-06 2.700E-08 1.820E-05
B-CONCLIQ 5.000E+00 2.102E+05
        6 2.870E-01 6.240E-04 3.890E-05 7.940E-02 8.210E-05 1.330E-01
        6 1.800E-03 2.590E-06 1.180E-04 2.500E-06 6.650E-06 2.500E-06
        6 6.650E-02 3.440E-08 2.710E-07 6.610E-12 1.990E-04 9.430E-05
        6 4.600E-03 2.060E-07 2.523E-04 8.100E-06 2.590E-07 2.050E-04
B-FSLUDGE 6.000E+00 1.690E+05
        7 5.240E+00 1.260E-02 7.780E-04 1.440E+00 1.490E-03 2.410E+00
        7 3.250E-02 4.700E-05 2.370E-03 5.000E-05 1.330E-04 5.000E-05
        7 1.330E+00 3.320E-07 2.610E-06 6.380E-11 4.660E-04 2.360E-04
        7 1.150E-02 5.180E-07 4.868E-04 1.050E-05 2.970E-07 2.240E-04
P-COTRASH 2.100E-01 4.244E+05
        8 2.280E-02 3.040E-04 1.120E-05 5.970E-03 7.110E-06 1.150E-02
        8 2.190E-03 2.250E-07 2.220E-05 9.420E-08 2.780E-07 9.420E-08
        8 2.510E-03 7.890E-09 6.220E-08 1.520E-12 5.970E-06 5.530E-06
        8 2.410E-04 1.210E-08 1.089E-05 2.670E-07 2.740E-09 2.610E-06
P-NCTRASH 2.100E-01 2.178E+05
        9 5.250E-01 6.990E-03 2.570E-04 1.370E-01 1.640E-04 2.650E-01
        9 5.050E-02 5.180E-06 5.110E-04 2.170E-06 6.410E-06 2.170E-06
        9 5.780E-02 1.820E-07 1.430E-06 3.490E-11 1.380E-04 1.270E-04
        9 5.550E-03 2.790E-07 2.508E-04 6.150E-06 6.300E-08 6.000E-05
B-COTRASH 2.200E-01 2.086E+05
       10 2.350E-02 6.750E-05 4.170E-06 6.010E-03 6.210E-06 1.010E-02
       10 1.360E-04 1.960E-07 1.270E-05 2.680E-07 7.140E-07 2.680E-07
       10 7.140E-03 1.220E-09 9.600E-09 2.350E-13 2.300E-06 1.160E-06
       10 5.630E-05 2.530E-09 2.586E-06 6.520E-08 1.930E-09 1.490E-06
B-NCTRASH 2.200E-01 9.896E+04
       11 3.790E+00 1.090E-02 6.730E-04 9.690E-01 1.000E-03 1.620E+00
       11 2.190E-02 3.160E-05 2.050E-03 4.330E-05 1.150E-04 4.330E-05
       11 1.150E+00 1.970E-07 1.550E-06 3.780E-11 3.710E-04 1.860E-04
       11 9.080E-03 4.080E-07 4.172E-04 1.050E-05 3.120E-07 2.410E-04
F-COTRASH 2.110E-01 2.359E+05
       12 5.580E-06    0.        0.        0.        0.        0.
       12    0.        0.        0.        0.        0.        0.
       12    0.     1.180E-06 4.400E-06    0.        0.        0.
       12    0.        0.        0.        0.        0.        0.
F-NCTRASH 2.110E-01 4.171E+04
       13 5.330E-06    0.        0.        0.        0.        0.
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INIFIL File (cont'd)

13	0.	0.	0.	0.	0.	0.
13	0.	1.130E-06	4.200E-06	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
I-COTRASH	2.030E-01	1.407E+05				
14	1.130E-01	9.130E-02	5.260E-03	0.	0.	1.040E-02
14	0.	0.	1.450E-03	3.390E-09	0.	0.
14	4.560E-03	0.	0.	0.	0.	0.
14	0.	0.	4.820E-06	0.	0.	0.
I+COTRASH	2.030E-01	1.407E+05				
15	1.130E-01	9.130E-02	5.260E-03	0.	0.	1.040E-02
15	0.	0.	1.450E-03	3.390E-09	0.	0.
15	4.560E-03	0.	0.	0.	0.	0.
15	0.	0.	4.820E-06	0.	0.	0.
N-SSTRASH	2.060E-01	1.796E+05				
16	1.120E-05	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
16	0.	2.360E-06	8.800E-06	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
N+SSTRASH	2.060E-01	1.796E+05				
17	1.120E-05	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
17	0.	2.360E-06	8.800E-06	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
N-LOTRASH	2.070E-01	5.064E+04				
18	3.530E-02	2.850E-02	1.640E-03	0.	0.	3.250E-03
18	0.	0.	4.530E-04	1.060E-09	0.	0.
18	1.420E-03	0.	0.	0.	0.	0.
18	0.	0.	1.510E-06	0.	0.	0.
N+LOTRASH	2.070E-01	5.064E+04				
19	3.530E-02	2.850E-02	1.640E-03	0.	0.	3.250E-03
19	0.	0.	4.530E-04	1.060E-09	0.	0.
19	1.420E-03	0.	0.	0.	0.	0.
19	0.	0.	1.510E-06	0.	0.	0.
F-PROCESS	3.110E-01	7.816E+04				
20	1.080E-04	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
20	0.	2.300E-05	8.540E-05	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
U-PROCESS	3.120E-01	2.811E+04				
21	3.800E-04	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.
21	0.	1.650E-05	3.640E-04	0.	0.	0.
21	0.	0.	0.	0.	0.	0.
I-LQSCNVL	3.030E-01	4.914E+04				
22	9.600E-03	5.010E-03	2.510E-04	0.	0.	0.
22	0.	0.	4.340E-03	0.	0.	0.
22	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.
I+LQSCNVL	3.030E-01	4.914E+04				
23	9.600E-03	5.010E-03	2.510E-04	0.	0.	0.
23	0.	0.	4.340E-03	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
I-ARSLIQD	3.030E-01	5.585E+03				
24	1.990E-01	1.420E-01	8.160E-03	0.	0.	3.120E-02
24	0.	0.	4.340E-03	1.020E-08	0.	0.
24	1.370E-02	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
I+ARSLIQD	3.030E-01	5.585E+03				
25	1.990E-01	1.420E-01	8.160E-03	0.	0.	3.120E-02
25	0.	0.	4.340E-03	1.020E-08	0.	0.
25	1.370E-02	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.

I-BIOWAST		3.030E-01	1.571E+04					
	26	2.060E-01	1.750E-01	1.010E-02	0.	0.	3.990E-03	
	26	0.	0.	8.330E-03	6.510E-09	0.	0.	
	26	8.760E-03	0.	0.	0.	0.	0.	
	26	0.	0.	0.	0.	0.	0.	
I+BIOWAST		3.030E-01	1.571E+04					
	27	2.060E-01	1.750E-01	1.010E-02	0.	0.	3.990E-03	
	27	0.	0.	8.330E-03	6.510E-09	0.	0.	
	27	8.760E-03	0.	0.	0.	0.	0.	
	27	0.	0.	0.	0.	0.	0.	
N-SSWASTE		3.060E-01	6.339E+04					
	28	2.170E-04	0.	0.	0.	0.	0.	
	28	0.	0.	0.	0.	0.	0.	
	28	0.	4.600E-05	1.710E-04	0.	0.	0.	
	28	0.	0.	0.	0.	0.	0.	
N-LOWASTE		3.070E-01	6.027E+04					
	29	2.110E-02	1.630E-02	9.360E-04	0.	0.	1.470E-03	
	29	0.	0.	1.310E-03	7.760E-10	0.	0.	
	29	1.040E-03	0.	0.	0.	0.	0.	
	29	0.	0.	0.	0.	0.	0.	
L-NFRCOMP		4.300E-01	2.887E+03					
	30	4.040E+03	0.	2.590E-01	2.230E+03	1.400E+00	1.600E+03	
	30	2.090E+02	8.190E-03	0.	0.	0.	0.	
	30	0.	0.	0.	0.	0.	0.	
	30	0.	0.	0.	0.	0.	0.	
L-DECONRS		4.400E-01	3.498E+04					
	31	1.560E+02	1.080E-02	6.880E-04	4.050E+01	4.490E-02	7.280E+01	
	31	3.690E+00	1.420E-03	4.280E-02	1.200E-05	3.340E-05	1.200E-05	
	31	3.180E-01	6.840E-05	5.400E-04	1.320E-08	1.340E+00	1.770E+00	
	31	3.550E+01	3.870E-03	1.026E+00	3.590E-04	3.460E-04	3.270E-03	
N-ISOPROD		4.040E-01	5.196E+03					
	32	1.500E+01	4.200E-02	4.510E-05	0.	0.	0.	
	32	0.	0.	6.270E+00	3.270E-04	2.720E-06	3.270E-04	
	32	8.730E+00	1.020E-05	3.810E-05	5.330E-13	1.970E-04	5.550E-05	
	32	7.100E-03	9.570E-08	2.152E-04	1.250E-06	1.650E-04	2.880E-07	
N-HIGHACT		4.030E-01	2.608E+03					
	33	2.100E+02	0.	1.320E-02	1.150E+02	6.560E-02	8.480E+01	
	33	1.060E+01	4.470E-04	0.	0.	0.	0.	
	33	0.	0.	0.	0.	0.	0.	
	33	0.	0.	0.	0.	0.	0.	
N-TRITIUM		4.050E-01	3.481E+03					
	34	2.330E+03	2.330E+03	0.	0.	0.	0.	
	34	0.	0.	0.	0.	0.	0.	
	34	0.	0.	0.	0.	0.	0.	
	34	0.	0.	0.	0.	0.	0.	
N-SOURCES		4.030E-01	1.865E+02					
	35	5.760E+03	2.090E+03	3.190E-03	0.	0.	8.120E+01	
	35	1.050E+01	0.	2.870E+01	0.	0.	0.	
	35	3.540E+03	0.	0.	0.	0.	0.	
	35	0.	0.	1.600E+01	0.	0.	0.	
N-TARGETS		4.030E-01	1.340E+03					
	36	8.040E+01	8.040E+01	0.	0.	0.	0.	
	36	0.	0.	0.	0.	0.	0.	
	36	0.	0.	0.	0.	0.	0	
	36	0.	0.	0.	0.	0.	0	
F-PUDECON		7.000E+00	4.663E+03					
	37	2.345E-01	0.	0.	0.	0.	0.	
	37	0.	0.	0	0.	0.	0.	
	37	0.	0.	0.	0.	1.355E-03	1.280E-02	
	37	2.188E-01	1.893E-06	1.559E-03	0.	0.	0.	
H-3		5.630E-02	1.150E+00	1.000E+00	1.000E+00			
H-3	/ACC	1.252E+09	5.190E+07	1.252E+09	1.252E+09	1.252E+09	1.252E+09	5.190E+07
H-3	/CON	1.172E+10	5.190E+07	1.172E+10	1.172E+10	1.172E+10	1.172E+10	1.052E+10

H-3	/AGR	4.451E+10	5.190E+07	4.451E+10	4.451E+10	4.451E+10	4.451E+10	4.331E+10
H-3	/FOO	5.995E+04	0.	5.995E+04	5.995E+04	5.995E+04	5.995E+04	5.995E+04
H-3	/DGM	0.	0	0.	0.	0.	0.	0.
H-3	/WWT	2.367E+06	1.422E-01	2.367E+06	2.367E+06	2.367E+06	2.367E+06	2.367E+06
H-3	/SWT	2.368E+06	1.422E-01	2.368E+06	2.368E+06	2.368E+06	2.368E+06	2.368E+06
H-3	/AIR	4.451E+10	5.190E+07	4.451E+10	4.451E+10	4.451E+10	4.451E+10	4.331E+10
C-14		1.210E-04	5.760E-03	1.000E+01	1.000E+01			
C-14	/ACC	3.166E+09	1.405E+10	3.166E+09	3.166E+09	3.166E+09	3.166E+09	2.526E+09
C-14	/CON	6.678E+10	3.321E+11	6.678E+10	6.678E+10	6.678E+10	6.678E+10	6.614E+10
C-14	/AGR	2.660E+11	1.328E+12	2.660E+11	2.660E+11	2.660E+11	2.660E+11	2.654E+11
C-14	/FOO	3.721E+05	1.861E+06	3.721E+05	3.721E+05	3.721E+05	3.721E+05	3.721E+05
C-14	/DGM	0.	0.	0.	0.	0.	0.	0.
C-14	/WWT	1.441E+07	7.205E+07	1.441E+07	1.441E+07	1.441E+07	1.441E+07	1.441E+07
C-14	/SWT	3.761E+07	1.880E+08	3.761E+07	3.761E+07	3.761E+07	3.761E+07	3.761E+07
C-14	/AIR	2.660E+11	1.328E+12	2.660E+11	2.660E+11	2.660E+11	2.660E+11	2.654E+11
FE-55		2.670E-01	1.480E-02	6.300E+02	5.400E+03			
FE-55	/ACC	1.805E+10	1.885E+10	2.413E+10	1.613E+10	1.613E+10	2.081E+11	1.925E+10
FE-55	/CON	9.283E+09	4.816E+10	3.941E+10	5.080E+07	5.080E+07	2.095E+11	2.116E+10
FE-55	/AGR	3.219E+10	1.903E+11	1.376E+11	5.080E+07	5.080E+07	2.644E+11	7.752E+10
FE-55	/FOO	3.482E+01	2.161E+02	1.493E+02	0.	0.	8.331E+01	8.566E+01
FE-55	/DGM	0.	0.	0.	0.	0.	0.	0.
FE-55	/WWT	2.727E+06	1.244E+07	8.863E+06	8.609E+05	8.609E+05	5.326E+06	5.452E+06
FE-55	/SWT	4.450E+06	2.314E+07	1.625E+07	8.609E+05	8.609E+05	9.449E+06	9.692E+06
FE-55	/AIR	4.827E+10	2.064E+11	1.537E+11	1.613E+10	1.613E+10	2.804E+11	9.360E+10
NI-59		8.660E-06	1.480E-02	4.200E+02	3.600E+03			
NI-59	/ACC	3.698E+10	9.378E+10	5.058E+10	2.578E+10	2.578E+10	5.778E+10	2.850E+10
NI-59	/CON	3.872E+10	2.325E+11	8.130E+10	5.980E+07	5.980E+07	3.206E+10	1.441E+10
NI-59	/AGR	1.247E+11	7.476E+11	2.581E+11	5.980E+07	5.980E+07	3.206E+10	5.082E+10
NI-59	/FOO	3.693E+03	2.211E+04	7.590E+03	0.	0.	0.	1.563E+03
NI-59	/DGM	6.200E+03	6.200E+03	6.200E+03	6.200E+03	6.200E+03	6.200E+03	6.200E+03
NI-59	/WWT	8.537E+06	4.425E+07	1.609E+07	1.377E+06	1.377E+05	1.377E+06	4.408E+06
NI-59	/SWT	9.825E+06	5.196E+07	1.874E+07	1.377E+06	1.377E+06	1.377E+06	4.953E+06
NI-59	/AIR	1.505E+11	7.733E+11	2.838E+11	2.578E+10	2.578E+10	5.778E+10	7.654E+10
CO-60		1.320E-01	1.480E-02	4.200E+02	3.600E+03			
CO-60	/ACC	2.358E+12	2.336E+12	2.353E+12	2.336E+12	2.336E+12	2.634E+13	2.504E+12
CO-60	/CON	1.237E+11	2.280E+10	7.599E+10	2.280E+10	2.280E+10	2.402E+13	8.593E+11
CO-60	/AGR	3.695E+11	2.280E+10	1.874E+11	2.280E+10	2.280E+10	2.402E+13	2.953E+12
CO-60	/FOO	5.274E+03	0.	2.391E+03	0.	0.	0.	4.492E+04
CO-60	/DGM	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07
CO-60	/WWT	1.432E+08	1.238E+09	1.326E+08	1.238E+08	1.238E+08	1.239E+08	2.893E+08
CO-60	/SWT	1.458E+08	1.238E+08	1.338E+08	1.238E+08	1.238E+08	1.239E+08	3.112E+08
CO-60	/AIR	2.683E+12	2.336E+12	2.500E+12	2.336E+12	2.336E+12	2.634E+13	5.266E+12
NI-63		7.530E-03	1.480E-02	4.200E+02	3.600E+03			
NI-63	/ACC	3.056E+10	9.602E+11	6.576E+10	1.560E+08	1.560E+08	8.816E+10	7.436E+09
NI-63	/CON	1.040E+11	3.150E+12	2.176E+11	1.560E+08	1.560E+08	8.816E+10	3.911E+10
NI-63	/AGR	3.341E+11	1.001E+13	6.931E+11	1.560E+08	1.560E+08	8.816E+10	1.383E+11
NI-63	/FOO	9.878E+03	2.945E+05	2.041E+04	0.	0.	0.	4.259E+03
NI-63	/DGM	0.	0.	0.	0.	0.	0.	0.
NI-63	/WWT	1.915E+07	5.711E+09	3.958E+07	4.276E-01	4.276E-01	2.416E+02	8.258E+06
NI-63	/SWT	2.260E+07	6.738E+08	4.670E+07	4.276E-01	4.276E-01	2.416E+02	9.743E+06
NI-63	/AIR	3.341E+11	1.001E+13	6.931E+11	1.560E+08	1.560E+08	8.816E+10	1.383E+11
NB-94		3.470E-05	1.110E-02	1.000E+03	1.000E+04			
NB-94	/ACC	6.102E+11	6.114E+11	6.108E+11	6.095E+11	6.107E+11	1.330E+12	6.839E+11
NB-94	/CON	1.389E+10	1.515E+10	1.454E+10	1.320E+10	1.446E+10	7.332E+11	4.432E+11
NB-94	/AGR	1.399E+10	1.548E+10	1.472E+10	1.320E+10	1.464E+10	7.332E+11	1.557E+12
NB-94	/FOO	2.116E+00	7.078E+00	3.937E+00	0.	3.892E+00	0.	2.390E+04
NB-94	/DGM	9.630E+06	9.630E+06	9.630E+06	9.630E+06	9.630E+06	9.630E+06	9.630E+06
NB-94	/WWT	3.193E+07	3.196E+07	3.194E+07	3.192E+07	3.194E+07	3.192E+07	1.466E+08
NB-94	/SWT	3.232E+07	3.324E+07	3.266E+07	3.192E+07	3.265E+07	3.192E+07	4.496E+09
NB-94	/AIR	6.103E+11	6.118E+11	6.111E+11	6.095E+11	6.110E+11	1.330E+12	2.153E+12
SR-90		2.470E-02	9.860E-03	9.000E+00	7.300E+01			
SR-90	/ACC	2.417E+13	9.617E+13	1.668E+11	1.668E+11	1.668E+11	1.980E+11	1.892E+11
SR-90	/CON	6.394E+13	2.589E+14	1.760E+09	1.760E+09	1.760E+09	3.296E+10	4.727E+12

SR-90 /AGR	1.891E+14	7.685E+14	1.760E+09	1.760E+09	1.760E+09	3.296E+10	1.946E+13
SR-90 /FOO	6.407E+07	2.611E+08	0.	0.	0.	0.	7.543E+06
SR-90 /DGM	3.060E+04	3.060E+04	3.060E+04	3.060E+04	3.060E+04	3.060E+04	3.060E+04
SR-90 /WWT	9.564E+09	3.895E+10	8.835E+06	8.835E+06	8.835E+06	8.835E+06	1.134E+09
SR-90 /SWT	1.014E+10	4.128E+10	8.835E+06	8.835E+06	8.835E+06	8.835E+06	1.201E+09
SR-90 /AIR	1.892E+14	7.688E+14	1.668E+11	1.668E+11	1.668E+11	1.980E+11	1.962E+13
TC-99	3.270E-06	1.150E-01	2.000E+00	5.000E+00			
TC-99 /ACC	1.176E+09	9.680E+09	2.280E+09	7.600E+08	1.996E+10	7.400E+09	7.880E+09
TC-99 /CON	2.960E+09	5.411E+09	8.890E+09	7.600E+08	1.031E+11	7.962E+09	2.240E+11
TC-99 /AGR	8.548E+09	1.933E+10	2.960E+10	7.600E+08	3.636E+11	9.720E+09	9.008E+11
TC-99 /FOO	6.566E+03	1.635E+04	2.433E+04	0.	3.061E+05	2.067E+03	7.953E+05
TC-99 /DGM	0.	0.	0.	0.	0.	0.	0.
TC-99 /WWT	4.186E+05	1.042E+06	1.551E+06	2.083E+00	1.951E+07	1.318E+05	5.069E+07
TC-99 /SWT	4.240E+05	1.056E+06	1.571E+06	2.083E+00	1.976E+07	1.335E+05	5.135E+07
TC-99 /AIR	8.548E+09	1.933E+10	2.960E+10	7.600E+08	3.636E+11	9.721E+09	9.008E+11
I-129	4.080E-08	1.150E-01	2.000E+00	5.000E+00			
I-129 /ACC	9.139E+11	8.515E+11	8.515E+11	5.128E+13	8.515E+11	8.572E+11	8.521E+11
I-129 /CON	2.068E+12	7.124E+11	6.123E+11	1.624E+15	1.315E+12	6.366E+09	9.787E+10
I-129 /AGR	8.346E+12	2.942E+12	2.528E+12	6.553E+15	5.433E+12	6.366E+09	4.006E+11
I-129 /FOO	6.019E+04	2.137E+04	1.836E+04	4.725E+07	3.947E+04	0.	2.901E+03
I-129 /DGM	1.920E+04	1.920E+04	1.920E+04	1.920E+04	1.920E+04	1.920E+04	1.920E+04
I-129 /WWT	4.289E+07	1.758E+07	1.562E+07	3.081E+10	2.938E+07	3.644E+06	5.536E+06
I-129 /SWT	4.389E+07	1.793E+07	1.592E+07	3.160E+10	3.004E+07	3.644E+06	5.584E+06
I-129 /AIR	9.197E+12	3.792E+12	3.379E+12	6.554E+15	6.284E+12	8.572E+11	1.251E+12
CS-135	2.310E-07	1.620E-04	8.500E+01	7.200E+02			
CS-135/ACC	2.371E+10	9.651E+10	8.851E+10	5.080E+08	3.331E+10	1.491E+10	1.004E+09
CS-135/CON	1.566E+11	4.209E+11	3.879E+11	5.080E+08	1.466E+11	4.884E+10	8.007E+09
CS-135/AGR	5.729E+11	1.439E+12	1.326E+12	5.080E+08	5.014E+11	1.551E+11	2.994E+10
CS-135/FOO	8.836E+03	2.157E+04	1.991E+04	0.	7.531E+03	2.256E+03	4.656E+02
CS-135/DGM	0.	0.	0.	0.	0.	0.	0.
CS-135/WWT	3.318E+07	8.098E+07	7.475E+07	1.392E+00	2.828E+07	8.472E+06	1.748E+06
CS-135/SWT	1.442E+08	3.520E+08	3.250E+08	1.392E+00	1.229E+08	3.683E+07	7.600E+06
CS-135/AIR	5.729E+11	1.437E+12	1.326E+12	5.080E+08	5.014E+11	1.551E+11	2.994E+10
CS-137	2.310E-02	1.620E-04	8.500E+01	7.200E+02			
CS-137/ACC	4.499E+11	6.339E+11	7.779E+11	2.419E+11	4.259E+11	3.299E+11	2.444E+11
CS-137/CON	1.397E+12	1.719E+12	2.351E+12	1.530E+09	8.010E+11	2.941E+11	3.919E+10
CS-137/AGR	5.117E+12	5.872E+12	8.030E+12	1.530E+09	2.729E+12	9.350E+11	1.491E+11
CS-137/FOO	7.896E+04	8.814E+04	1.205E+05	0.	4.092E+04	1.360E+04	2.333E+03
CS-137/DGM	3.500E+06	3.500E+06	3.500E+06	3.500E+06	3.500E+06	3.500E+06	3.500E+06
CS-137/WWT	3.094E+08	3.438E+08	4.655E+08	1.287E+07	1.665E+08	6.394E+07	2.163E+07
CS-137/SWT	1.302E+09	1.452E+09	1.981E+09	1.287E+07	6.808E+08	2.349E+08	5.096E+07
CS-137/AIR	5.358E+12	6.112E+12	8.270E+12	2.419E+11	2.969E+12	1.175E+12	3.895E+11
U-235	9.760E-10	1.250E-04	8.400E+02	7.200E+03			
U-235 /ACC	2.062E+12	3.062E+13	2.214E+11	2.214E+11	7.262E+12	3.360E+15	5.175E+11
U-235 /CON	2.643E+12	4.361E+13	1.590E+09	1.590E+09	1.013E+13	3.360E+15	1.586E+12
U-235 /AGR	5.154E+12	8.500E+13	1.590E+09	1.590E+09	1.979E+13	3.360E+15	5.621E+12
U-235 /FOO	1.443E+04	2.378E+05	0.	0.	5.552E+04	0.	2.319E+04
U-235 /DGM	1.500E+05	1.500E+05	1.500E+05	1.500E+05	1.500E+05	1.500E+05	1.500E+05
U-235 /WWT	2.073E+08	3.235E+09	1.177E+07	1.177E+07	7.643E+08	2.098E+07	3.261E+08
U-235 /SWT	2.109E+08	3.294E+09	1.177E+07	1.177E+07	7.781E+08	2.098E+07	3.318E+08
U-235 /AIR	5.374E+12	8.522E+13	2.214E+11	2.214E+11	2.001E+13	3.360E+15	5.841E+12
U-238	1.540E-10	1.250E-04	8.400E+02	7.200E+03			
U-238 /ACC	1.695E+12	2.882E+13	1.454E+10	1.454E+10	6.575E+12	3.120E+15	2.546E+11
U-238 /CON	2.429E+12	4.145E+13	8.570E+07	8.570E+07	9.447E+12	3.120E+15	1.147E+12
U-238 /AGR	4.774E+12	8.108E+13	8.570E+07	8.570E+07	1.849E+13	3.120E+15	3.989E+12
U-238 /FOO	1.348E+04	2.277E+05	0.	0.	5.196E+04	0.	1.633E+04
U-238 /DGM	5.160E+03	5.160E+03	5.160E+03	5.160E+03	5.160E+03	5.160E+03	5.160E+03
U-238 /WWT	1.835E+08	3.087E+09	7.739E+05	7.739E+05	7.050E+08	9.325E+06	2.221E+08
U-238 /SWT	1.868E+08	3.144E+09	7.739E+05	7.739E+05	7.179E+08	9.325E+06	2.262E+08
U-238 /AIR	4.789E+12	8.109E+13	1.454E+10	1.454E+10	1.850E+13	3.120E+15	4.003E+12
NP-237	3.240E-07	4.670E-04	3.000E+02	2.500E+03			
NP-237/ACC	5.202E+14	1.200E+16	1.120E+15	1.340E+11	3.840E+15	3.602E+14	3.740E+11
NP-237/CON	5.209E+14	1.202E+16	1.122E+15	8.400E+08	3.847E+15	3.600E+14	1.550E+12

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NP-237/AGR	5.236E+14	1.209E+16	1.128E+15	8.400E+08	3.868E+15	3.600E+14	5.652E+12
NP-237/FOO	1.645E+04	4.067E+05	3.533E+04	0.	1.223E+05	0.	2.357E+04
NP-237/DGM	6.560E+04	6.560E+04	6.560E+04	6.560E+04	6.560E+04	6.560E+04	6.560E+04
NP-237/WWT	2.312E+08	5.546E+09	4.885E+08	7.126E+06	1.674E+09	8.113E+06	3.263E+08
NP-237/SWT	2.572E+08	6.189E+09	5.443E+08	7.126E+06	1.867E+09	8.113E+06	3.635E+08
NP-237/AIR	5.239E+14	1.209E+16	1.128E+15	1.340E+11	3.868E+15	3.602E+14	5.785E+12
PU-238	8.020E-03	4.670E-04	8.400E+02	7.200E+03			
PU-238/ACC	2.000E+14	4.080E+15	2.800E+15	1.924E+10	8.801E+14	4.080E+15	3.313E+11
PU-238/CON	2.003E+14	4.091E+15	2.802E+15	8.870E+07	8.812E+14	4.080E+15	1.514E+12
PU-238/AGR	2.012E+14	4.126E+15	2.807E+15	8.870E+07	8.850E+14	4.080E+15	5.277E+12
PU-238/FOO	1.137E+03	4.522E+04	6.371E+03	0.	4.868E+03	0.	4.855E+03
PU-238/DGM	1.930E+01	1.930E+01	1.930E+01	1.930E+01	1.930E+01	1.930E+01	1.930E+01
PU-238/WWT	7.019E+07	2.741E+09	3.931E+08	1.025E+06	2.972E+08	1.221E+07	2.940E+08
PU-238/SWT	7.485E+07	2.926E+09	4.192E+08	1.025E+06	3.171E+08	1.221E+07	3.139E+08
PU-238/AIR	2.012E+14	4.126E+15	2.807E+15	1.924E+10	8.850E+14	4.080E+15	5.297E+12
PU-239	2.840E-05	4.670E-04	8.400E+02	7.200E+03			
PU-239/ACC	2.240E+14	4.800E+15	3.120E+15	7.400E+09	9.601E+14	3.840E+15	3.034E+11
PU-239/CON	2.243E+14	4.813E+15	3.122E+15	5.170E+07	9.613E+14	3.840E+15	1.392E+12
PU-239/AGR	2.253E+14	4.854E+15	3.127E+15	5.170E+07	9.655E+14	3.840E+15	4.826E+12
PU-239/FOO	1.270E+03	5.234E+04	7.049E+03	0.	5.393E+03	0.	4.429E+03
PU-239/DGM	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01
PU-239/WWT	7.765E+07	3.172E+09	4.343E+08	3.934E+05	3.285E+08	1.092E+07	2.676E+08
PU-239/SWT	8.286E+07	3.386E+09	4.632E+08	3.934E+05	3.506E+08	1.092E+07	2.858E+08
PU-239/AIR	2.253E+14	4.854E+15	3.127E+15	7.400E+09	9.656E+14	3.840E+15	4.833E+12
PU-241	5.250E-02	4.670E-04	8.400E+02	7.200E+03			
PU-241/ACC	3.040E+12	7.440E+13	4.560E+13	4.780E+07	1.440E+13	6.800E+12	5.568E+09
PU-241/CON	3.046E+12	7.467E+13	4.561E+13	4.780E+07	1.443E+13	6.800E+12	2.861E+10
PU-241/AGR	3.063E+12	7.552E+13	4.566E+13	4.780E+07	1.450E+13	6.800E+12	1.008E+11
PU-241/FOO	2.208E+01	1.097E+03	5.613E+01	0.	1.017E+02	0.	9.310E+01
PU-241/DGM	3.430E-01	3.430E-01	3.430E-01	3.430E-01	3.430E-01	3.430E-01	3.430E-01
PU-241/WWT	1.341E+06	6.642E+07	3.512E+06	1.310E-01	6.179E+06	1.864E+04	5.618E+06
PU-241/SWT	1.431E+06	7.091E+07	3.742E+06	1.310E-01	6.596E+06	1.864E+04	5.999E+06
PU-241/AIR	3.063E+12	7.553E+13	4.566E+13	4.780E+07	1.450E+13	6.800E+12	1.008E+11
PU-242	2.480E-06	4.670E-04	8.400E+02	7.200E+03			
PU-242/ACC	2.160E+14	4.480E+15	3.040E+15	1.441E+10	9.601E+14	3.680E+15	2.944E+11
PU-242/CON	2.163E+14	4.492E+15	3.042E+15	6.930E+07	9.613E+14	3.680E+15	1.355E+12
PU-242/AGR	2.173E+14	4.530E+15	3.047E+15	6.930E+07	9.653E+14	3.680E+15	4.722E+12
PU-242/FOO	1.224E+03	4.848E+04	6.783E+03	0.	5.194E+03	0.	4.343E+03
PU-242/DGM	0.	0.	0.	0.	0.	0.	0.
PU-242/WWT	7.520E+07	2.938E+09	4.184E+08	7.674E+05	3.168E+08	1.085E+07	2.628E+08
PU-242/SWT	8.021E+07	3.137E+09	4.462E+08	7.674E+05	3.381E+08	1.085E+07	2.806E+08
PU-242/AIR	2.173E+14	4.530E+15	3.047E+15	1.441E+10	9.654E+14	3.680E+15	4.736E+12
AM-241	1.510E-03	4.110E-03	3.000E+02	2.500E+03			
AM-241/ACC	5.041E+14	7.120E+15	6.640E+15	7.869E+10	3.840E+15	4.241E+14	3.587E+11
AM-241/CON	5.049E+14	7.134E+15	6.645E+15	3.800E+08	3.847E+15	4.240E+14	1.508E+12
AM-241/AGR	5.077E+14	7.176E+15	6.660E+15	3.800E+08	3.868E+15	4.240E+14	5.355E+12
AM-241/FOO	3.599E+04	5.448E+05	1.916E+05	0.	2.707E+05	0.	4.936E+04
AM-241/DGM	7.710E+04	7.710E+04	7.710E+04	7.710E+04	7.710E+04	7.710E+04	7.710E+04
AM-241/WWT	2.247E+08	3.340E+09	1.189E+09	4.192E+06	1.663E+09	5.354E+06	3.047E+08
AM-241/SWT	3.721E+08	5.572E+09	1.974E+09	4.192E+06	2.772E+09	5.354E+06	5.069E+08
AM-241/AIR	5.078E+14	7.176E+15	6.660E+15	7.869E+10	3.868E+15	4.241E+14	5.434E+12
AM-243	8.720E-05	4.110E-03	3.000E+02	2.500E+03			
AM-243/ACC	4.961E+14	7.040E+15	6.480E+15	9.096E+10	3.760E+15	4.001E+14	3.630E+11
AM-243/CON	4.969E+14	7.054E+15	6.485E+15	6.090E+08	3.767E+15	4.000E+14	1.713E+12
AM-243/AGR	4.996E+14	7.096E+15	6.499E+15	6.090E+08	3.787E+15	4.000E+14	6.223E+12
AM-243/FOO	3.525E+04	5.441E+05	1.849E+05	0.	2.654E+05	0.	5.787E+04
AM-243/DGM	1.860E+05	1.860E+05	1.860E+05	1.860E+05	1.860E+05	1.860E+05	1.860E+05
AM-243/WWT	2.208E+08	3.337E+09	1.148E+09	4.837E+06	1.631E+09	5.933E+06	3.572E+08
AM-243/SWT	3.653E+08	5.566E+09	1.906E+09	4.837E+06	2.718E+09	5.933E+06	5.942E+08
AM-243/AIR	4.997E+14	7.096E+15	6.499E+15	9.096E+10	3.788E+15	4.001E+14	6.313E+12
CM-243	2.170E-02	4.670E-04	3.000E+02	2.500E+03			
CM-243/ACC	3.843E+14	6.161E+15	5.601E+15	2.444E+11	1.760E+15	4.403E+14	5.484E+11
CM-243/CON	3.846E+14	6.171E+15	5.604E+15	2.260E+09	1.763E+15	4.400E+14	1.594E+12

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CM-243/AGR	3.866E+14	6.204E+15	5.616E+15	2.260E+09	1.772E+15	4.400E+14	5.629E+12
CM-243/FOO	1.113E+04	1.897E+05	7.155E+04	0.	5.195E+04	0.	2.319E+04
CM-243/DGM	3.820E+05	3.820E+05	3.820E+05	3.820E+05	3.820E+05	3.820E+05	3.820E+05
CM-243/WWT	1.647E+08	2.598E+09	9.970E+08	1.296E+07	7.212E+08	1.417E+07	3.269E+08
CM-243/SWT	2.087E+08	3.347E+09	1.280E+09	1.296E+07	9.264E+08	1.417E+07	4.184E+08
CM-243/AIR	3.868E+14	6.204E+15	5.617E+15	2.444E+11	1.772E+15	4.403E+14	5.871E+12
CM-244	3.940E-02	4.670E-04	3.000E+02	2.500E+03			
CM-244/ACC	2.800E+14	4.400E+15	4.160E+15	1.706E+10	1.280E+15	4.400E+14	3.051E+11
CM-244/CON	2.805E+14	4.408E+15	4.163E+15	7.230E+07	1.282E+15	4.400E+14	1.533E+12
CM-244/AGR	2.820E+14	4.433E+15	4.174E+15	7.230E+07	1.289E+15	4.400E+14	5.434E+12
CM-244/FOO	8.520E+03	1.434E+05	6.145E+04	0.	3.978E+04	0.	2.241E+04
CM-244/DGM	5.640E+01	5.640E+01	5.640E+01	5.640E+01	5.640E+01	5.640E+01	5.640E+01
CM-244/WWT	1.170E+08	1.954E+09	8.443E+08	9.093E+05	5.430E+08	2.115E+06	3.044E+08
CM-244/SWT	1.507E+08	2.521E+09	1.087E+09	9.093E+05	7.001E+08	2.115E+06	3.929E+08
CM-244/AIR	2.820E+14	4.433E+15	4.174E+15	1.706E+10	1.289E+15	4.400E+14	5.451E+12
PB-210	3.398E-02	4.110E-03	8.400E+02	7.200E+03			
PB-210/ACC	8.039E+12	2.561E+14	6.564E+13	3.836E+10	2.080E+14	1.040E+14	4.716E+10
PB-210/CON	1.699E+13	5.088E+14	1.378E+14	3.510E+08	4.112E+14	1.040E+14	9.045E+11
PB-210/AGR	4.514E+13	1.300E+15	3.639E+14	3.510E+08	1.048E+15	1.040E+14	3.709E+12
PB-210/FOO	2.584E+05	7.268E+06	2.076E+06	0.000E+00	5.843E+06	0.000E+00	2.575E+04
PB-210/DGM	6.580E+05	6.580E+05	6.580E+05	6.580E+05	6.580E+05	6.580E+05	6.580E+05
PB-210/WWT	2.194E+09	6.164E+10	1.761E+10	2.035E+06	4.955E+10	2.320E+06	2.204E+08
PB-210/SWT	2.623E+09	7.372E+10	2.106E+10	2.035E+06	5.927E+10	2.320E+06	2.632E+08
PB-210/AIR	4.518E+13	1.301E+15	3.640E+14	3.836E+10	1.048E+15	1.040E+14	3.747E+12
AC-227	3.209E-02	4.110E-03	3.000E+02	2.500E+02			
AC-227/ACC	3.600E+14	5.680E+15	8.000E+14	1.004E+09	2.560E+14	2.160E+16	1.140E+10
AC-227/CON	3.618E+14	5.711E+15	8.041E+14	1.190E+08	2.573E+14	2.160E+16	1.361E+12
AC-227/AGR	3.676E+14	5.807E+15	8.169E+14	1.190E+08	2.615E+14	2.160E+16	5.593E+12
AC-227/FOO	3.296E+04	5.552E+05	7.363E+04	0.000E+00	2.375E+04	0.000E+00	2.432E+04
AC-227/DGM	1.390E+07	1.390E+07	1.390E+07	1.390E+07	1.390E+07	1.390E+07	1.390E+07
AC-227/WWT	4.477E+08	7.541E+09	1.000E+09	4.740E+04	3.227E+08	5.925E+07	3.296E+08
AC-227/SWT	4.559E+08	7.679E+09	1.019E+09	4.740E+04	3.286E+08	5.925E+07	3.357E+08
AC-227/AIR	3.676E+14	5.808E+15	8.169E+14	1.004E+09	2.615E+14	2.160E+16	5.594E+12
RA-226	4.327E-04	4.110E-03	3.000E+01	2.500E+02			
RA-226/ACC	1.520E+15	2.160E+15	8.944E+09	8.944E+09	8.944E+09	8.000E+14	1.770E+11
RA-226/CON	1.654E+15	2.527E+15	5.008E+12	5.008E+12	5.008E+12	8.000E+14	4.241E+12
RA-226/AGR	2.072E+15	3.678E+15	2.069E+13	2.069E+13	2.069E+13	8.001E+14	1.700E+13
RA-226/FOO	1.330E+07	3.658E+07	4.988E+05	4.988E+05	4.988E+05	2.926E+03	4.057E+05
RA-226/DGM	2.940E+07	2.940E+07	2.940E+07	2.940E+07	2.940E+07	2.940E+07	2.940E+07
RA-226/WWT	3.256E+10	8.952E+10	1.221E+09	1.221E+09	1.221E+09	9.828E+06	9.933E+08
RA-226/SWT	3.732E+10	1.026E+11	1.400E+09	1.400E+09	1.400E+09	1.088E+07	1.138E+09
RA-226/AIR	2.072E+15	3.678E+15	2.070E+13	2.070E+13	2.070E+13	8.002E+14	1.701E+13
TH-228	3.629E-01	4.110E-03	8.400E+02	7.200E+03			
TH-228/ACC	2.402E+13	7.121E+14	1.202E+13	1.797E+10	6.802E+13	1.440E+16	2.980E+11
TH-228/CON	2.428E+13	7.202E+14	1.214E+13	1.980E+08	6.877E+13	1.440E+16	9.583E+12
TH-228/AGR	2.515E+13	7.459E+14	1.257E+13	1.980E+08	7.119E+13	1.440E+16	3.872E+13
TH-228/FOO	8.379E+03	2.474E+05	4.190E+03	0.000E+00	2.329E+04	0.000E+00	2.808E+05
TH-228/DGM	2.220E+07	2.220E+07	2.220E+07	2.220E+07	2.220E+07	2.220E+07	2.220E+07
TH-228/WWT	6.865E+07	2.000E+09	3.480E+07	9.512E+05	1.891E+08	4.042E+07	2.267E+09
TH-228/SWT	8.053E+07	2.350E+09	4.074E+07	9.512E+05	2.222E+09	4.042E+07	2.666E+09
TH-228/AIR	2.517E+13	7.459E+14	1.259E+13	1.797E+10	7.121E+13	1.440E+16	3.874E+13
RA-228	1.035E-01	4.110E-03	3.000E+01	2.500E+02			
RA-228/ACC	6.880E+14	6.480E+14	1.140E+08	1.140E+08	1.140E+08	8.800E+15	1.874E+09
RA-228/CON	7.598E+14	8.316E+14	6.511E+12	6.678E+12	6.511E+12	8.800E+15	1.688E+12
RA-228/AGR	9.846E+14	1.407E+15	2.690E+13	2.759E+13	2.690E+13	8.800E+15	6.969E+12
RA-228/FOO	7.149E+06	1.829E+07	6.484E+05	6.651E+05	6.484E+05	4.007E+03	1.679E+05
RA-228/DGM	5.000E+06	5.000E+06	5.000E+06	5.000E+06	5.000E+06	5.000E+06	5.000E+06
RA-228/WWT	1.750E+10	4.476E+10	1.587E+09	1.628E+09	1.587E+09	3.392E+07	4.110E+08
RA-228/SWT	2.006E+10	5.130E+10	1.819E+09	1.866E+09	1.819E+09	3.536E+07	4.711E+08
RA-228/AIR	9.847E+14	1.407E+15	2.690E+13	2.759E+13	2.690E+13	8.801E+15	6.969E+12
TH-229	9.443E-05	4.110E-03	8.400E+02	7.200E+03			
TH-229/ACC	1.360E+15	2.800E+16	4.243E+14	2.548E+11	2.080E+15	2.000E+16	2.495E+12
TH-229/CON	1.366E+15	2.813E+16	4.260E+14	1.790E+09	2.090E+15	2.000E+16	1.070E+13

INIFIL File (cont'd)

TH-229/AGR	1.387E+15	2.854E+16	4.321E+14	1.790E+09	2.119E+15	2.000E+16	3.720E+13
TH-229/FOO	1.950E+05	3.980E+06	5.935E+04	0.000E+00	2.868E+05	0.000E+00	2.554E+05
TH-229/DGM	1.450E+07	1.450E+07	1.450E+07	1.450E+07	1.450E+07	1.450E+07	1.450E+07
TH-229/WWT	1.591E+09	3.222E+10	4.938E+08	1.354E+07	2.334E+09	6.836E+07	2.075E+09
TH-229/SWT	1.868E+09	3.786E+10	5.779E+08	1.354E+07	2.741E+09	6.836E+07	2.437E+09
TH-229/AIR	1.387E+15	2.855E+16	4.324E+14	2.548E+11	2.120E+15	2.000E+16	3.745E+13
TH-230	8.664E-06	4.110E-03	8.400E+02	7.200E+03			
TH-230/ACC	5.360E+14	1.760E+16	1.120E+15	1.435E+10	5.280E+15	3.520E+14	2.464E+11
TH-230/CON	5.369E+14	1.763E+16	1.122E+15	1.300E+08	5.289E+15	3.520E+14	1.227E+12
TH-230/AGR	5.399E+14	1.774E+16	1.128E+15	1.300E+08	5.319E+15	3.520E+14	4.342E+12
TH-230/FOO	2.843E+04	1.027E+06	5.835E+04	0.000E+00	2.818E+05	0.000E+00	3.003E+04
TH-230/DGM	2.130E+03	2.130E+03	2.130E+03	2.130E+03	2.130E+03	2.130E+03	2.130E+03
TH-230/WWT	2.317E+08	8.342E+09	4.749E+08	7.610E+05	2.290E+09	1.726E+06	2.431E+08
TH-230/SWT	2.720E+08	9.799E+09	5.576E+08	7.610E+05	2.689E+09	1.726E+06	2.857E+08
TH-230/AIR	5.399E+14	1.774E+16	1.128E+15	1.435E+10	5.319E+15	3.520E+14	4.357E+12
PA-231	2.133E-05	4.110E-03	8.400E+02	7.200E+03			
PA-231/ACC	5.601E+14	1.360E+16	5.441E+14	1.097E+11	3.040E+15	5.120E+15	4.217E+11
PA-231/CON	5.626E+14	1.367E+16	5.465E+14	6.590E+08	3.054E+15	5.120E+15	1.495E+12
PA-231/AGR	5.706E+14	1.388E+16	5.545E+14	6.590E+08	3.099E+15	5.120E+15	5.200E+12
PA-231/FOO	4.721E+04	1.217E+06	4.572E+04	0.000E+00	2.565E+05	0.000E+00	2.129E+04
PA-231/DGM	4.560E+05	4.560E+05	4.560E+05	4.560E+05	4.560E+05	4.560E+05	4.560E+05
PA-231/WWT	6.472E+08	1.654E+10	6.270E+08	5.836E+06	3.491E+09	1.987E+07	2.944E+08
PA-231/SWT	6.589E+08	1.684E+10	6.384E+08	5.836E+06	3.555E+09	1.987E+07	2.997E+08
PA-231/AIR	5.710E+14	1.388E+16	5.546E+14	1.097E+11	3.099E+15	5.120E+15	5.309E+12
TH-232	4.916E-11	4.110E-03	8.400E+02	7.200E+03			
TH-232/ACC	2.560E+14	7.440E+15	3.520E+14	1.384E+10	1.680E+15	4.720E+15	2.379E+11
TH-232/CON	2.585E+14	7.478E+15	3.537E+14	1.080E+08	1.686E+15	4.720E+15	1.070E+12
TH-232/AGR	2.662E+14	7.597E+15	3.598E+14	1.080E+08	1.713E+15	4.720E+15	3.720E+12
TH-232/FOO	7.481E+04	1.147E+06	4.988E+04	0.000E+00	2.404E+05	0.000E+00	2.554E+04
TH-232/DGM	4.920E+04	4.920E+04	4.920E+04	4.920E+04	4.920E+04	4.920E+04	4.920E+04
TH-232/WWT	6.053E+08	9.281E+09	4.043E+08	7.352E+05	1.946E+09	1.367E+07	2.069E+08
TH-232/SWT	7.114E+08	1.091E+10	4.750E+08	7.352E+05	2.287E+09	1.367E+07	2.431E+08
TH-232/AIR	2.663E+14	7.597E+15	3.589E+14	1.384E+10	1.713E+15	4.720E+15	3.734E+12
U-233	4.279E-06	1.250E-04	8.400E+02	7.200E+03			
J-233 /ACC	2.011E+12	3.281E+13	1.077E+10	1.077E+10	7.691E+12	3.680E+15	2.908E+11
U-233 /CON	2.871E+12	4.717E+13	5.160E+07	5.160E+07	1.103E+13	3.680E+15	1.314E+12
U-233 /AGR	5.599E+12	9.217E+13	5.160E+07	5.160E+07	2.152E+13	3.680E+15	4.554E+12
U-233 /FOO	1.568E+04	2.586E+05	0.000E+00	0.000E+00	6.027E+04	0.000E+00	1.862E+04
U-233 /DGM	4.160E+06	4.160E+06	4.160E+06	4.160E+06	4.160E+06	4.160E+06	4.160E+06
U-233 /WWT	2.131E+08	3.506E+09	5.739E+05	5.739E+05	8.175E+08	1.066E+07	2.529E+08
U-233 /SWT	2.170E+08	3.570E+09	5.739E+05	5.739E+05	8.325E+08	1.066E+07	2.575E+08
U-233 /AIR	5.610E+12	9.218E+13	1.077E+10	1.077E+10	2.153E+13	3.680E+15	4.564E+12
U-234	2.806E-06	1.250E-04	8.400E+02	7.200E+03			
U-234 /ACC	1.938E+12	3.122E+13	1.746E+10	1.746E+10	7.538E+12	3.600E+15	2.895E+11
U-234 /CON	2.773E+12	4.499E+13	1.140E+08	1.140E+08	1.080E+13	3.600E+15	1.285E+12
U-234 /AGR	5.444E+12	8.818E+13	1.140E+08	1.140E+08	2.108E+13	3.600E+15	4.457E+12
U-234 /FOO	1.535E+04	2.482E+05	0.000E+00	0.000E+00	5.908E+04	0.000E+00	1.823E+04
U-234 /DGM	3.980E+05	3.980E+05	3.980E+05	3.980E+05	3.980E+05	3.980E+05	3.980E+05
U-234 /WWT	2.090E+08	3.365E+09	9.286E+05	9.286E+05	8.018E+08	1.080E+07	2.480E+08
U-234 /SWT	2.128E+08	3.427E+09	9.286E+05	9.286E+05	8.164E+08	1.080E+07	2.525E+08
U-234 /AIR	5.461E+12	8.820E+13	1.746E+10	1.746E+10	2.110E+13	3.600E+15	4.474E+12
U-236	2.900E-08	1.250E-04	8.400E+02	7.200E+03			
U-236 /ACC	1.857E+12	3.042E+13	1.648E+10	1.648E+10	7.297E+12	3.440E+15	2.725E+11
U-236 /CON	2.658E+12	4.361E+13	9.670E+07	9.670E+07	1.043E+13	3.440E+15	1.206E+12
U-236 /AGR	5.221E+12	8.500E+13	9.670E+07	9.670E+07	2.030E+13	3.440E+15	4.182E+12
U-236 /FOO	1.473E+04	2.378E+05	0.000E+00	0.000E+00	5.671E+04	0.000E+00	1.710E+04
U-236 /DGM	5.560E+04	5.560E+04	5.560E+04	5.560E+04	5.560E+04	5.560E+04	5.560E+04
U-236 /WWT	2.005E+08	3.224E+09	8.770E+05	8.770E+05	7.695E+08	1.031E+07	2.327E+08
U-236 /SWT	2.041E+08	3.283E+09	8.770E+05	8.770E+05	7.836E+08	1.031E+07	2.369E+08
U-236 /AIR	5.237E+12	8.501E+13	1.648E+10	1.648E+10	2.032E+13	3.440E+15	4.198E+12
PU-240	1.053E-04	4.670E-04	8.400E+02	7.200E+03			
PU-240/ACC	2.240E+14	4.800E+15	3.120E+15	7.400E+09	9.601E+14	3.840E+15	3.034E+11
PU-240/CON	2.243E+14	4.813E+15	3.122E+15	5.170E+07	9.613E+14	3.840E+15	1.392E+12

PU-240/AGR	2.253E+14	4.854E+15	3.127E+15	5.170E+07	9.655E+14	3.840E+15	4.826E+12
PU-240/FOO	1.270E+03	5.234E+04	7.049E+03	0.	5.393E+03	0.	4.429E+03
PU-240/DGM	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01
PU-240/WWT	7.765E+07	3.172E+09	4.343E+08	3.934E+05	3.285E+08	1.092E+07	2.676E+08
PU-240/SWT	8.286E+07	3.386E+09	4.632E+08	3.934E+05	3.506E+08	1.092E+07	2.858E+08
PU-240/AIR	2.253E+14	4.854E+15	3.127E+15	7.400E+09	9.656E+14	3.840E+15	4.833E+12
REGION 1	9.180E-12	2.960E-11	1.970E-04	4.930E-05	7.700E+03	2.000E+05	4.500E+06
	2.000E+02	5.000E+03	1.000E+04	4.000E+02	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	1.010E-09	1.510E-09	1.120E-07	3
	4.000E+02	8.000E+02	1.830E-10	2.610E-12			
REGION 2	2.010E-11	3.180E-11	1.160E-03	3.240E-05	7.700E+03	2.000E+05	4.500E+06
	4.200E+01	4.000E+02	8.000E+02	1.300E+03	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	3.500E-10	5.250E-10	1.120E-07	3
	6.400E+01	1.600E+03	1.830E-10	3.323E-12			
REGION 3	2.510E-11	3.280E-11	9.000E-05	2.250E-05	7.770E+03	2.000E+05	4.500E+06
	1.400E+02	2.900E+03	5.800E+03	4.000E+02	1.250E+04	2.500E+04	
	1.000E+00	1.000E+00	1.000E+00	3.860E-10	5.790E-10	1.120E-07	4
	1.600E+02	8.000E+02	1.830E-10	2.550E-12			
REGION 4	2.640E-10	8.060E-11	1.300E-06	3.250E-07	7.700E+03	2.000E+05	4.500E+06
	1.500E+01	3.000E+02	6.000E+02	1.300E+03	3.000E+04	6.000E+04	
	1.000E+00	1.000E+00	1.000E+00	2.660E-11	3.990E-11	1.120E-07	2
	8.000E+00	8.000E+02	1.830E-10	1.790E-12			
REGION 5	2.010E-11	3.180E-11	1.160E-04	3.240E-06	7.700E+03	2.000E+05	4.500E+06
	3.200E+01	3.900E+02	7.900E+02	1.300E+03	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	3.500E-10	5.250E-10	1.120E-07	2
	6.400E+00	1.600E+03	1.830E-10	3.323E-12			
REGION 6	2.010E-11	3.180E-11	1.160E-02	3.240E-04	7.700E+03	2.000E+05	4.500E+06
	9.200E+01	4.500E+02	8.500E+02	1.300E+03	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	3.500E-10	5.250E-10	1.120E-07	4
	6.400E+01	1.600E+03	1.830E-10	3.323E-12			
REGION 1	6.926E+03	4.870E+04	8.559E+02	4.355E+03	2.099E+04	5.788E+04	
VOLUMES	4.654E+04	8.489E+04	4.356E+04	5.744E+04	2.724E+04	4.719E+04	
	8.341E+03	4.363E+04	4.363E+04	8.978E+04	8.978E+04	1.519E+04	
	1.519E+04	1.563E+04	0.	1.523E+04	1.523E+04	1.713E+03	
	1.731E+03	4.869E+03	4.869E+03	3.169E+04	1.808E+04	6.479E+02	
	7.346E+03	5.196E+03	8.086E+02	2.646E+03	5.782E+01	4.155E+02	
	1.316E+03						
REGION 2	1.298E+04	9.124E+04	1.604E+03	8.159E+03	2.511E+04	6.925E+04	
VLOUMES	5.568E+04	1.590E+05	8.162E+04	6.872E+04	3.260E+04	1.180E+05	
	2.085E+04	3.096E+04	3.096E+04	1.796E+04	1.796E+04	1.013E+04	
	1.103E+04	3.908E+04	0.	1.081E+04	1.081E+04	1.229E+03	
	1.229E+03	3.456E+03	3.456E+03	6.339E+03	1.205E+04	1.040E+03	
	1.224E+04	0.	5.739E+02	2.089E+02	4.103E+01	2.949E+02	
	1.726E+03						
REGION 3	6.587E+03	4.631E+04	8.140E+02	4.141E+03	2.046E+04	5.643E+04	
VOLUMES	4.537E+04	8.073E+04	4.143E+04	5.600E+04	2.656E+04	0.	
	0.	3.800E+04	3.800E+04	3.591E+04	3.591E+04	1.519E+04	
	1.519E+04	0.	1.406E+04	1.327E+04	1.327E+04	1.508E+03	
	1.508E+03	4.241E+03	4.241E+03	1.268E+04	1.808E+04	6.224E+02	
	8.045E+03	0.	7.043E+02	2.089E+02	5.036E+01	3.619E+02	
	7.450E+02						
REGION 4	8.136E+03	5.720E+04	1.005E+03	5.115E+03	9.672E+03	2.668E+04	
VOLUMES	2.145E+04	9.972E+04	5.117E+04	2.647E+04	1.256E+04	7.078E+04	
	1.251E+04	2.815E+04	2.815E+04	3.591E+04	3.591E+04	1.103E+04	
	1.103E+04	2.345E+04	1.406E+04	9.829E+03	9.829E+03	1.117E+03	
	1.117E+03	3.141E+03	3.141E+03	1.268E+04	1.205E+04	5.774E+03	
	7.346E+03	0.	5.217E+02	4.178E+02	3.730E+01	2.681E+02	
	1.366E+03						

GW2FIL File

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 37   231.000 .120 .060 .030 .060 .120 .060
P-IXRESIN 1.000E+00 3.463E+04
        1 3.360E-02 2.660E-03 9.740E-05 2.340E-03 2.790E-06 4.530E-03
        1 8.610E-04 8.840E-09 1.940E-04 8.230E-07 2.440E-06 8.230E-07
        1 2.190E-02 4.710E-08 3.710E-07 9.060E-12 2.600E-05 1.820E-05
        1 7.940E-04 3.990E-08 4.154E-05 1.260E-06 9.920E-09 1.380E-05
P-CONCLIQ 2.000E+00 2.435E+05
        2 1.090E-01 3.450E-03 1.270E-04 2.270E-02 2.710E-05 4.400E-02
        2 8.360E-03 8.580E-07 2.520E-04 1.070E-06 3.160E-06 1.070E-06
        2 2.850E-02 6.150E-08 4.840E-07 1.180E-11 5.120E-05 3.310E-05
        2 1.440E-03 7.250E-08 7.132E-05 2.020E-06 1.170E-08 1.920E-05
P-FSLUDGE 3.000E+00 4.279E+03
        3 1.060E+00 2.590E-03 9.550E-05 3.100E-01 3.710E-04 6.000E-01
        3 1.140E-01 1.170E-05 1.890E-04 8.030E-07 2.370E-06 8.030E-07
        3 2.140E-02 1.460E-07 1.150E-06 2.810E-11 4.760E-05 1.550E-04
        3 6.750E-03 3.390E-07 4.581E-04 1.780E-05 3.100E-07 1.770E-04
P-FCARTRG 1.100E-01 2.177E+04
        4 1.860E+00 1.150E-03 4.250E-05 5.550E-01 6.600E-04 1.070E+00
        4 2.040E-01 2.090E-05 8.400E-05 3.580E-07 1.060E-06 3.580E-07
        4 9.540E-03 3.640E-07 2.870E-06 7.020E-11 2.510E-04 3.800E-04
        4 1.660E-02 8.340E-07 6.414E-04 1.100E-05 1.930E-07 1.100E-04
B-IXRESIN 4.000E+00 7.623E+04
        5 4.630E+00 1.920E-02 1.190E-03 9.480E-01 9.800E-04 1.590E+00
        5 2.150E-02 3.090E-05 3.640E-03 7.650E-05 2.040E-04 7.650E-05
        5 2.040E+00 5.330E-08 4.200E-07 1.020E-11 8.340E-05 5.340E-05
        5 2.600E-03 1.170E-07 9.798E-05 1.570E-06 2.700E-08 1.820E-05
B-CONCLIQ 5.000E+00 2.102E+05
        6 2.870E-01 6.240E-04 3.890E-05 7.940E-02 8.210E-05 1.330E-01
        6 1.800E-03 2.590E-06 1.180E-04 2.500E-06 6.650E-06 2.500E-06
        6 6.650E-02 3.440E-08 2.710E-07 6.610E-12 1.990E-04 9.430E-05
        6 4.600E-03 2.060E-07 2.523E-04 8.100E-06 2.590E-07 2.050E-04
B-FSLUDGE 6.000E+00 1.690E+05
        7 5.240E+00 1.260E-02 7.780E-04 1.440E+00 1.490E-03 2.410E+00
        7 3.250E-02 4.700E-05 2.370E-03 5.000E-05 1.330E-04 5.000E-05
        7 1.330E+00 3.320E-07 2.610E-06 6.380E-11 4.660E-04 2.360E-04
        7 1.150E-02 5.180E-07 4.868E-04 1.050E-05 2.970E-07 2.240E-04
P-COTRASH 2.100E-01 4.244E+05
        8 2.280E-02 3.040E-04 1.120E-05 5.970E-03 7.110E-06 1.150E-02
        8 2.190E-03 2.250E-07 2.220E-05 9.420E-08 2.780E-07 9.420E-08
        8 2.510E-03 7.890E-09 6.220E-08 1.520E-12 5.970E-06 5.530E-06
        8 2.410E-04 1.210E-08 1.089E-05 2.670E-07 2.740E-09 2.610E-06
P-NCTRASH 2.100E-01 2.178E+05
        9 5.250E-01 6.990E-03 2.570E-04 1.370E-01 1.640E-04 2.650E-01
        9 5.050E-02 5.180E-06 5.110E-04 2.170E-06 6.410E-06 2.170E-06
        9 5.780E-02 1.820E-07 1.430E-06 3.490E-11 1.380E-04 1.270E-04
        9 5.550E-03 2.790E-07 2.508E-04 6.150E-06 6.300E-08 6.000E-05
B-COTRASH 2.200E-01 2.086E+05
       10 2.350E-02 6.750E-05 4.170E-06 6.010E-03 6.210E-06 1.010E-02
       10 1.360E-04 1.960E-07 1.270E-05 2.680E-07 7.140E-07 2.680E-07
       10 7.140E-03 1.220E-09 9.600E-09 2.350E-13 2.300E-06 1.160E-06
       10 5.630E-05 2.530E-09 2.586E-06 6.520E-08 1.930E-09 1.490E-06
B-NCTRASH 2.200E-01 9.896E+04
       11 3.790E+00 1.090E-02 6.730E-04 9.690E-01 1.000E-03 1.620E+00
       11 2.190E-02 3.160E-05 2.050E-03 4.330E-05 1.150E-04 4.330E-05
       11 1.150E+00 1.970E-07 1.550E-06 3.780E-11 3.710E-04 1.860E-04
       11 9.080E-03 4.080E-07 4.172E-04 1.050E-05 3.120E-07 2.410E-04
F-COTRASH 2.110E-01 2.359E+05
       12 5.580E-06        0.        0.        0.        0.        0.
       12        0.        0.        0.        0.        0.        0.
       12        0. 1.180E-06 4.400E-06        0.        0.        0.
       12        0.        0.        0.        0.        0.        0.
F-NCTRASH 2.110E-01 4.171E+04
       13 5.330E-06        0.        0.        0.        0.        0.
```

13	0.	0.	0.	0.	0.	0.
13	0.	1.130E-06	4.200E-06	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
I-COTRASH	2.030E-01	1.407E+05				
14	1.130E-01	9.130E-02	5.260E-03	0.	0.	1.040E-02
14	0.	0.	1.450E-03	3.390E-09	0.	0.
14	4.560E-03	0.	0.	0.	0.	0.
14	0.	0.	4.820E-06	0.	0.	0.
I+COTRASH	2.030E-01	1.407E+05				
15	1.130E-01	9.130E-02	5.260E-03	0.	0.	1.040E-02
15	0.	0.	1.450E-03	3.390E-09	0.	0.
15	4.560E-03	0.	0.	0.	0.	0.
15	0.	0.	4.820E-06	0.	0.	0.
N-SSTRASH	2.060E-01	1.796E+05				
16	1.120E-05	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
16	0.	2.360E-06	8.800E-06	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
N+SSTRASH	2.060E-01	1.796E+05				
17	1.120E-05	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
17	0.	2.360E-06	8.800E-06	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
N-LOTRASH	2.070E-01	5.064E+04				
18	3.530E-02	2.850E-02	1.640E-03	0.	0.	3.250E-03
18	0.	0.	4.530E-04	1.060E-09	0.	0.
18	1.420E-03	0.	0.	0.	0.	0.
18	0.	0.	1.510E-06	0.	0.	0.
N+LOTRASH	2.070E-01	5.064E+04				
19	3.530E-02	2.850E-02	1.640E-03	0.	0.	3.250E-03
19	0.	0.	4.530E-04	1.060E-09	0.	0.
19	1.420E-03	0.	0.	0.	0.	0.
19	0.	0.	1.510E-06	0.	0.	0.
F-PROCESS	3.110E-01	7.816E+04				
20	1.080E-04	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
20	0.	2.300E-05	8.540E-05	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
U-PROCESS	3.120E-01	2.811E+04				
21	3.800E-04	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.
21	0.	1.650E-05	3.640E-04	0.	0.	0.
21	0.	0.	0.	0.	0.	0.
I-LQSCNVL	3.030E-01	4.914E+04				
22	9.600E-03	5.010E-03	2.510E-04	0.	0.	0.
22	0.	0.	4.340E-03	0.	0.	0.
22	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.
I+LQSCNVL	3.030E-01	4.914E+04				
23	9.600E-03	5.010E-03	2.510E-04	0.	0.	0.
23	0.	0.	4.340E-03	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
I-ABSLIQD	3.030E-01	5.585E+03				
24	1.990E-01	1.420E-01	8.160E-03	0.	0.	3.120E-02
24	0.	0.	4.340E-03	1.020E-08	0.	0.
24	1.370E-02	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
I+ABSLIQD	3.030E-01	5.585E+03				
25	1.990E-01	1.420E-01	8.160E-03	0.	0.	3.120E-02
25	0.	0.	4.340E-03	1.020E-08	0.	0.
25	1.370E-02	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.

I-BIOWAST	3.030E-01	1.571E+04				
26	2.060E-01	1.750E-01	1.010E-02	0.	0.	3.990E-03
26	0.	0.	8.330E-03	6.510E-09	0.	0.
26	8.760E-03	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.
I+BIOWAST	3.030E-01	1.571E+04				
27	2.060E-01	1.750E-01	1.010E-02	0.	0.	3.990E-03
27	0.	0.	8.330E-03	6.510E-09	0.	0.
27	8.760E-03	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.
N-SSWASTE	3.060E-01	6.339E+04				
28	2.170E-04	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
28	0.	4.600E-05	1.710E-04	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
N-LOWASTE	3.070E-01	6.027E+04				
29	2.110E-02	1.630E-02	9.360E-04	0.	0.	1.470E-03
29	0.	0.	1.310E-03	7.760E-10	0.	0.
29	1.040E-03	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.
L-NFRCOMP	4.300E-01	2.887E+03				
30	4.040E+03	0.	2.590E-01	2.230E+03	1.400E+00	1.600E+03
30	2.090E+02	8.190E-03	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
L-DECONRS	4.400E-01	3.498E+04				
31	1.560E+02	1.080E-02	6.880E-04	4.050E+01	4.490E-02	7.280E+01
31	3.690E+00	1.420E-03	4.280E-02	1.200E-05	3.340E-05	1.200E-05
31	3.180E-01	6.840E-05	5.400E-04	1.320E-08	1.340E+00	1.770E+00
31	3.550E+01	3.870E-03	1.026E+00	3.590E-04	3.460E-04	3.270E-03
N-ISOPROD	4.040E-01	5.196E+03				
32	1.500E+01	4.200E-02	4.510E-05	0.	0.	0.
32	0.	0.	6.270E+00	3.270E-04	2.720E-06	3.270E-04
32	8.730E+00	1.020E-05	3.810E-05	5.330E-13	1.970E-04	5.550E-05
32	7.100E-03	9.570E-08	2.152E-04	1.250E-06	1.650E-04	2.880E-07
N-HIGHACT	4.030E-01	2.605E+03				
33	2.100E+02	0.	1.320E-02	1.150E+02	6.560E-02	8.480E+01
33	1.060E+01	4.470E-04	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
N-TRITIUM	4.050E-01	3.481E+03				
34	2.330E+03	2.330E+03	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
N-SOURCES	4.030E-01	1.865E+02				
35	5.760E+03	2.090E+03	3.190E-03	0.	0.	8.120E+01
35	1.050E+01	0.	2.870E+01	0.	0.	0.
35	3.540E+03	0.	0.	0.	0.	0.
35	0.	0.	1.600E+01	0.	0.	0.
N-TARGETS	4.030E-01	1.340E+03				
36	8.040E+01	8.040E+01	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
F-PUDECON	7.000E+00	4.663E+03				
37	2.345E-01	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	1.355E-03	1.280E-02
37	2.188E-01	1.893E-06	1.559E-03	0.	0.	0.
P-IXRESIN	1.000E+00	3.463E+04				
1	3.360E-02	1.840E-03	9.730E-05	7.300E-04	2.790E-06	2.170E-03
1	8.150E-04	8.840E-08	1.630E-04	8.230E-07	2.440E-06	8.230E-07

GW2FIL File (cont'd)

1	1.860E-02	4.710E-03	3.710E-07	9.060E-12	2.450E-05	1.820E-05
1	5.630E-04	3.990E-08	4.134E-05	1.260E-06	8.520E-09	1.060E-05
P-CONCLIQ	2.000E+00	2.435E+05				
2	1.090E-01	2.390E-03	1.270E-04	7.080E-03	2.710E-05	2.110E-02
2	7.920E-03	8.580E-07	2.120E-04	1.070E-06	3.160E-06	1.070E-06
2	2.430E-02	6.150E-08	4.840E-07	1.180E-11	4.830E-05	3.310E-05
2	1.020E-03	7.250E-08	7.102E-05	2.020E-06	1.010E-08	1.470E-05
P-FSLUDGE	3.000E+00	4.279E+03				
3	1.060E+00	1.790E-03	9.540E-05	9.670E-02	3.710E-04	2.880E-01
3	1.080E-01	1.170E-05	1.590E-04	8.030E-07	2.370E-06	8.030E-07
3	1.820E-02	1.460E-07	1.150E-06	2.810E-11	4.490E-05	1.550E-04
3	4.790E-03	3.390E-07	4.551E-04	1.780E-05	2.660E-07	1.360E-04
P-FCARTRG	1.100E-01	2.177E+04				
4	1.860E+00	7.970E-04	4.250E-05	1.730E-01	6.600E-04	5.140E-01
4	1.930E-01	2.090E-05	7.070E-05	3.580E-07	1.060E-06	3.580E-07
4	8.120E-03	3.640E-07	2.870E-06	7.020E-11	2.370E-04	3.800E-04
4	1.180E-02	8.340E-07	6.394E-04	1.100E-05	1.660E-07	8.440E-05
B-IXRESIN	4.000E+00	7.623E+04				
5	4.630E+00	1.340E-02	1.190E-03	2.990E-01	9.800E-04	7.700E-01
5	2.040E-02	3.090E-05	3.080E-03	7.650E-05	2.040E-04	7.650E-05
5	1.740E+00	5.330E-08	4.200E-07	1.020E-11	7.880E-05	5.340E-05
5	1.850E-03	1.170E-07	9.768E-05	1.570E-06	2.330E-08	1.400E-05
B-CONCLIQ	5.000E+00	2.102E+05				
6	2.870E-01	4.350E-04	3.890E-05	2.500E-02	8.210E-05	6.440E-02
6	1.710E-03	2.590E-06	9.970E-05	2.500E-06	6.650E-06	2.500E-06
6	5.670E-02	3.440E-08	2.710E-07	6.610E-12	1.880E-04	9.430E-05
6	3.280E-03	2.060E-07	2.513E-04	8.070E-06	2.230E-07	1.580E-04
B-FSLUDGE	6.000E+00	1.690E+05				
7	5.240E+00	8.780E-03	7.770E-04	4.540E-01	1.490E-03	1.170E+00
7	3.080E-02	4.700E-05	2.000E-03	5.000E-05	1.330E-04	5.000E-05
7	1.130E+00	3.320E-07	2.610E-06	6.380E-11	4.400E-04	2.360E-04
7	8.200E-03	5.180E-07	4.848E-04	1.050E-05	2.560E-07	1.720E-04
P-COTRASH	2.100E-01	4.244E+05				
8	2.280E-02	2.110E-04	1.120E-05	1.860E-03	7.110E-06	5.520E-03
8	2.070E-03	2.250E-07	1.870E-05	9.420E-08	2.780E-07	9.420E-08
8	2.140E-03	7.890E-09	6.220E-08	1.520E-12	5.640E-06	5.530E-06
8	1.710E-04	1.210E-03	1.085E-05	2.670E-07	2.350E-09	2.000E-06
P-NCTRASH	2.100E-01	2.178E+05				
9	5.250E-01	4.840E-03	2.570E-04	4.270E-02	1.640E-04	1.270E-01
9	4.780E-02	5.180E-06	4.300E-04	2.170E-06	6.410E-06	2.170E-06
9	4.920E-02	1.820E-07	1.430E-06	3.490E-11	1.300E-04	1.270E-04
9	3.930E-03	2.790E-07	2.498E-04	6.140E-06	5.410E-08	4.600E-05
B-COTRASH	2.200E-01	2.086E+05				
10	2.350E-02	4.700E-05	4.170E-06	1.890E-03	6.210E-06	4.890E-03
10	1.290E-04	1.960E-07	1.070E-05	2.680E-07	7.140E-07	2.680E-07
10	6.090E-03	1.220E-09	9.600E-09	2.350E-13	2.170E-06	1.160E-06
10	4.010E-05	2.530E-09	2.575E-06	6.510E-08	1.660E-09	1.150E-06
B-NCTRASH	2.200E-01	9.896E+04				
11	3.790E+00	7.600E-03	6.720E-04	3.050E-01	1.000E-03	7.840E-01
11	2.080E-02	3.160E-05	1.730E-03	4.330E-05	1.150E-04	4.330E-05
11	9.810E-01	1.970E-07	1.550E-06	3.780E-11	3.510E-04	1.860E-04
11	6.470E-03	4.080E-07	4.152E-04	1.050E-05	2.690E-07	1.860E-04
F-COTRASH	2.110E-01	2.359E+05				
12	5.580E-06	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
12	0.	1.180E-06	4.400E-06	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
F-NCTRASH	2.110E-01	4.171E+04				
13	5.330E-06	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
13	0.	1.130E-06	4.200E-06	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
I-COTRASH	2.030E-01	1.407E+05				

GW2FIL File (cont'd)

14	1.130E-01	5.950E-02	5.250E-03	0.	0.	4.410E-03
14	0.	0.	1.190E-03	3.390E-09	0.	0.
14	3.780E-03	0.	0.	0.	0.	0.
14	0.	0.	4.760E-06	0.	0.	0.
I+COTRASH	2.030E-01	1.407E+05				
15	1.130E-01	5.950E-02	5.250E-03	0.	0.	4.410E-03
15	0.	0.	1.190E-03	3.390E-09	0.	0.
15	3.780E-03	0.	0.	0.	0.	0.
15	0.	0.	4.760E-06	0.	0.	0.
N-SSTRASH	2.060E-01	1.796E+05				
16	1.120E-05	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
16	0.	2.360E-06	8.800E-06	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
N+SSTRASH	2.060E-01	1.796E+05				
17	1.120E-05	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
17	0.	2.360E-06	8.800E-06	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
N-LOTRASH	2.070E-01	5.064E+04				
18	3.530E-02	1.860E-02	1.640E-03	0.	0.	1.380E-03
18	0.	0.	3.710E-04	1.060E-09	0.	0.
18	1.180E-03	0.	0.	0.	0.	0.
18	0.	0.	1.490E-06	0.	0.	0.
N+LOTRASH	2.070E-01	5.064E+04				
19	3.530E-02	1.860E-02	1.640E-03	0.	0.	1.380E-03
19	0.	0.	3.710E-04	1.060E-09	0.	0.
19	1.180E-03	0.	0.	0.	0.	0.
19	0.	0.	1.490E-06	0.	0.	0.
F-PROCESS	3.110E-01	7.816E+04				
20	1.080E-04	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
20	0.	2.300E-05	8.540E-05	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
U-PROCESS	3.120E-01	2.811E+04				
21	3.800E-04	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.
21	0.	1.650E-05	3.640E-04	0.	0.	0.
21	0.	0.	0.	0.	0.	0.
I-LQSCNVL	3.030E-01	4.914E+04				
22	9.600E-03	3.270E-03	2.510E-04	0.	0.	0.
22	0.	0.	3.550E-03	0.	0.	0.
22	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.
I+LQSCNVL	3.030E-01	4.914E+04				
23	9.600E-03	3.270E-03	2.510E-04	0.	0.	0.
23	0.	0.	3.550E-03	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
I-ABSLIQD	3.030E-01	5.585E+03				
24	1.990E-01	9.260E-02	8.150E-03	0.	0.	1.320E-02
24	0.	0.	3.550E-03	1.020E-08	0.	0.
24	1.140E-02	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
I+ABSLIQD	3.030E-01	5.585E+03				
25	1.990E-01	9.260E-02	8.150E-03	0.	0.	1.320E-02
25	0.	0.	3.550E-03	1.020E-08	0.	0.
25	1.140E-02	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.
I-BIOWAST	3.030E-01	1.571E+04				
26	2.060E-01	1.140E-01	1.010E-02	0.	0.	1.690E-03
26	0.	0.	6.820E-03	6.510E-09	0.	0.
26	7.260E-03	0.	0.	0.	0.	0.

GW2FIL File (cont'd)

26		0.	0.	0.	0.	0.	0.	
I+BIOWAST		3.030E-01	1.571E+04					
27		2.060E-01	1.140E-01	1.010E-02	0.	0.	1.690E-03	
27		0.	0.	6.820E-03	6.510E-09	0.	0.	
27		7.260E-03	0.	0.	0.	0.	0.	
27		0.	0.	0.	0.	0.	0.	
N-SSWASTE		3.060E-01	6.339E+04					
28		2.170E-04	0.	0.	0.	0.	0.	
28		0.	0.	0.	0.	0.	0.	
28		0.	4.600E-05	1.710E-04	0.	0.	0.	
28		0.	0.	0.	0.	0.	0.	
N-LOWASTE		3.070E-01	6.027E+04					
29		2.110E-02	1.060E-02	9.350E-04	0.	0.	6.230E-04	
29		0.	0.	1.070E-03	7.760E-10	0.	0.	
29		8.620E-04	0.	0.	0.	0.	0.	
29		0.	0.	0.	0.	0.	0.	
L-NFRCOMP		4.300E-01	2.887E+03					
30		4.040E+03	0.	2.590E-01	6.980E+02	1.400E+00	7.700E+02	
30		1.980E+02	8.190E-03	0.	0.	0.	0.	
30		0.	0.	0.	0.	0.	0.	
30		0.	0.	0.	0.	0.	0.	
L-DECONRS		4.400E-01	3.498E+04					
31		1.560E+02	7.510E-03	6.870E-04	1.270E+01	4.490E-02	3.500E+01	
31		3.490E+00	1.420E-03	3.610E-02	1.200E-05	3.340E-05	1.200E-05	
31		2.710E-01	6.840E-05	5.400E-04	1.320E-08	1.260E+00	1.770E+00	
31		2.520E+01	3.870E-03	1.026E+00	3.590E-04	2.980E-04	2.510E-03	
N-ISOPROD		4.040E-01	5.196E+03					
32		1.500E+01	2.740E-02	4.510E-05	0.	0.	0.	
32		0.	0.	5.140E+00	3.270E-04	2.720E-06	3.270E-04	
32		7.240E+00	1.020E-05	3.810E-05	5.330E-13	1.840E-04	5.550E-05	
32		4.750E-03	9.570E-03	2.151E-04	1.250E-06	1.380E-04	2.110E-07	
N-HIGHACT		4.030E-01	2.608E+03					
33		2.100E+02	0.	1.320E-02	2.970E+01	6.560E-02	3.600E+01	
33		9.950E+00	4.470E-04	0.	0.	0.	0.	
33		0.	0.	0.	0.	0.	0.	
33		0.	0.	0.	0.	0.	0.	
N-TRITIUM		4.050E-01	3.481E+03					
34		2.330E+03	1.520E+03	0.	0.	0.	0.	
34		0.	0.	0.	0.	0.	0.	
34		0.	0.	0.	0.	0.	0.	
34		0.	0.	0.	0.	0.	0.	
N-SOURCES		4.030E-01	1.865E+02					
35		5.760E+03	5.630E+02	5.750E+01	0.	0.	7.340E+02	
35		2.160E+02	0.	9.420E+02	0.	0.	0.	
35		9.530E+02	0.	0.	0.	0.	0.	
35		0.	0.	5.690E+02	0.	0.	0.	
N-TARGETS		4.030E-01	1.340E+03					
36		8.040E+01	5.240E+01	0.	0.	0.	0.	
36		0.	0.	0.	0.	0.	0.	
36		0.	0.	0.	0.	0.	0.	
36		0.	0.	0.	0.	0.	0.	
F-PUDECON		7.000E+00	4.663E+03					
37		2.345E-01	0.	0.	0.	0.	0.	
37		0.	0.	0.	0.	0.	0.	
37		0.	0.	0.	0.	1.355E-03	1.280E-02	
37		2.188E-01	1.893E-06	1.559E-03	0.	0.	0.	
H-3		5.630E-02	1.150E+00	1.000E+00	1,000E+00			
H-3	/ACC	1.252E+09	5.190E+07	1.252E+09	1.252E+09	1.252E+09	1.252E+09	5.190E+07
H-3	/CON	1.172E+10	5.190E+07	1.172E+10	1.172E+10	1.172E+10	1.172E+10	1.052E+10
H-3	/AGR	4.451E+10	5.190E+07	4.451E+10	4.451E+10	4.451E+10	4.451E+10	4.331E+10
H-3	/FOO	5.995E+04	0.	5.995E+04	5.995E+04	5.995E+04	5.995E+04	5.995E+04
H-3	/DGM	0.	0.	0.	0.	0.	0.	0.
H-3	/WWT	2.367E+06	1.422E-01	2.367E+06	2.367E+06	2.367E+06	2.367E+06	2.367E+06

H-3	/SWT	2.368E+06	1.422E-01	2.368E+06	2.368E+06	2.368E+06	2.368E+06	2.368E+06
H-3	/AIR	4.451E+10	5.190E+07	4.451E+10	4.451E+10	4.451E+10	4.451E+10	4.331E+10
C-14		1.210E-04	5.760E-03	1.000E+01	1.000E+01			
C-14	/ACC	3.166E+09	1.405E+10	3.166E+09	3.166E+09	3.166E+09	3.166E+09	2.526E+09
C-14	/CON	6.678E+10	3.321E+11	6.678E+10	6.678E+10	6.678E+10	6.678E+10	6.614E+10
C-14	/AGR	2.660E+11	1.328E+12	2.660E+11	2.660E+11	2.660E+11	2.660E+11	2.654E+11
C-14	/FOO	3.721E+05	1.861E+06	3.721E+05	3.721E+05	3.721E+05	3.721E+05	3.721E+05
C-14	/DGM	0.	0.	0.	0.	0.	0.	0.
C-14	/WWT	1.441E+07	7.205E+07	1.441E+07	1.441E+07	1.441E+07	1.441E+07	1.441E+07
C-14	/SWT	3.761E+07	1.880E+08	3.761E+07	3.761E+07	3.761E+07	3.761E+07	3.761E+07
C-14	/AIR	2.660E+11	1.328E+12	2.660E+11	2.660E+11	2.660E+11	2.660E+11	2.654E+11
FE-55		2.670E-01	1.480E-02	6.300E+02	5.400E+03			
FE-55	/ACC	1.805E+10	1.885E+10	2.413E+10	1.613E+10	1.613E+10	2.081E+11	1.925E+10
FE-55	/CON	9.283E+09	4.816E+10	3.941E+10	5.080E+07	5.080E+07	2.095E+11	2.116E+10
FE-55	/AGR	3.219E+10	1.903E+11	1.376E+11	5.080E+07	5.080E+07	2.644E+11	7.752E+10
FE-55	/FOO	3.482E+01	2.161E+02	1.493E+02	0.	0.	8.331E+01	8.566E+01
FE-55	/DGM	0.	0.	0.	0.	0.	0.	0.
FE-55	/WWT	2.727E+06	1.244E+07	8.863E+06	8.609E+05	8.609E+05	5.326E+06	5.452E+06
FE-55	/SWT	4.450E+06	2.314E+07	1.625E+07	8.609E+05	8.609E+05	9.449E+06	9.692E+06
FE-55	/AIR	4.827E+10	2.064E+11	1.537E+11	1.613E+10	1.613E+10	2.804E+11	9.360E+10
NI-59		8.660E-06	1.480E-02	4.200E+02	3.600E+03			
NI-59	/ACC	3.698E+10	9.376E+10	5.058E+10	2.578E+10	2.578E+10	5.778E+10	2.850E+10
NI-59	/CON	3.872E+10	2.325E+11	8.130E+10	5.980E+07	5.980E+07	3.206E+10	1.441E+10
NI-59	/AGR	1.247E+11	7.476E+11	2.581E+11	5.980E+07	5.980E+07	3.206E+10	5.082E+10
NI-59	/FOO	3.693E+03	2.211E+04	7.590E+03	0.	0.	0.	1.563E+03
NI-59	/DGM	6.200E+03	6.200E+03	6.200E+03	6.200E+03	6.200E+03	6.200E+03	6.200E+03
NI-59	/WWT	8.537E+06	4.425E+07	1.609E+07	1.377E+06	1.377E+06	1.377E+06	4.408E+06
NI-59	/SWT	9.825E+06	5.196E+07	1.874E+07	1.377E+06	1.377E+06	1.377E+06	4.953E+06
NI-59	/AIR	1.505E+11	7.733E+11	2.838E+11	2.578E+10	2.578E+10	5.778E+10	7.654E+10
CO-60		1.320E-01	1.480E-02	4.200E+02	3.600E+03			
CO-60	/ACC	2.358E+12	2.336E+12	2.353E+12	2.336E+12	2.336E+12	2.634E+13	2.504E+12
CO-60	/CON	1.237E+11	2.280E+10	7.599E+10	2.280E+10	2.280E+10	2.402E+13	8.593E+11
CO-60	/AGR	3.695E+11	2.280E+10	1.874E+11	2.280E+10	2.280E+10	2.402E+13	2.953E+12
CO-60	/FOO	5.274E+03	0.	2.391E+03	0.	0.	0.	4.492E+04
CO-60	/DGM	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07	1.540E+07
CO-60	/WWT	1.432E+08	1.238E+08	1.326E+08	1.238E+08	1.238E+08	1.239E+08	2.893E+08
CO-60	/SWT	1.458E+08	1.239E+08	1.338E+08	1.238E+08	1.238E+08	1.239E+08	3.112E+08
CO-60	/AIR	2.683E+12	2.336E+12	2.500E+12	2.336E+12	2.336E+12	2.634E+13	5.266E+12
NI-63		7.530E-03	1.480E-02	4.200E+02	3.600E+03			
NI-63	/ACC	3.056E+10	9.602E+11	6.576E+10	1.560E+08	1.560E+08	8.816E+10	7.436E+09
NI-63	/CON	1.040E+11	3.150E+12	2.176E+11	1.560E+08	1.560E+08	8.816E+10	3.911E+10
NI-63	/AGR	3.341E+11	1.001E+13	6.931E+11	1.560E+08	1.560E+08	8.816E+10	1.383E+11
NI-63	/FOO	9.878E+03	2.945E+05	2.041E+04	0.	0.	0.	4.259E+03
NI-63	/DGM	0.	0.	0.	0.	0.	0.	0.
NI-63	/WWT	1.915E+07	5.711E+08	3.958E+07	4.276E-01	4.276E-01	2.416E+02	8.258E+06
NI-63	/SWT	2.260E+07	6.738E+08	4.670E+07	4.276E-01	4.276E-01	2.416E+02	9.743E+06
NI-63	/AIR	3.341E+11	1.001E+13	6.931E+11	1.560E+08	1.560E+08	8.816E+10	1.383E+11
NB-94		3.470E-05	1.110E-02	1.000E+03	1.000E+04			
NB-94	/ACC	6.102E+11	6.114E+11	6.108E+11	6.095E+11	6.107E+11	1.330E+12	6.839E+11
NB-94	/CON	1.389E+10	1.515E+10	1.454E+10	1.320E+10	1.446E+10	7.332E+11	4.432E+11
NB-94	/AGR	1.399E+10	1.548E+10	1.472E+10	1.320E+10	1.464E+10	7.332E+11	1.557E+12
NB-94	/FOO	2.116E+00	7.078E+00	3.937E+00	0.	3.892E+00	0.	2.390E+04
NB-94	/DGM	9.630E+06	9.630E+06	9.630E+06	9.630E+06	9.630E+06	9.630E+06	9.630E+06
NB-94	/WWT	3.193E+07	3.196E+07	3.194E+07	3.192E+07	3.194E+07	3.192E+07	1.466E+08
NB-94	/SWT	3.232E+07	3.324E+07	3.266E+07	3.192E+07	3.265E+07	3.192E+07	4.496E+09
NB-94	/AIR	6.103E+11	6.118E+11	6.111E+11	6.095E+11	6.110E+11	1.330E+12	2.153E+12
SR-90		2.470E-02	9.860E-03	9.000E+00	7.300E+01			
SR-90	/ACC	2.417E+13	9.617E+13	1.668E+11	1.668E+11	1.668E+11	1.980E+11	1.892E+11
SR-90	/CON	6.394E+13	2.588E+14	1.760E+09	1.760E+09	1.760E+09	3.296E+10	4.727E+12
SR-90	/AGR	1.891E+14	7.686E+14	1.760E+09	1.760E+09	1.760E+09	3.296E+10	1.946E+13
SR-90	/FOO	6.407E+07	2.611E+08	0.	0.	0.	0.	7.543E+06
SR-90	/DGM	3.060E+04	3.060E+04	3.060E+04	3.060E+04	3.060E+04	3.060E+04	3.060E+04
SR-90	/WWT	9.564E+09	3.895E+10	8.835E+06	8.835E+06	8.835E+06	8.835E+06	1.134E+09

SR-90 /SWT	1.014E+10	4.122E+10	8.835E+06	8.835E+06	8.835E+06	8.835E+06	1.201E+09
SR-90 /AIR	1.892E+14	7.688E+14	1.668E+11	1.668E+11	1.668E+11	1.980E+11	1.962E+13
TC-99	3.270E-06	1.150E-01	2.000E+00	5.000E+00			
TC-99 /ACC	1.176E+09	9.680E+08	2.280E+09	7.600E+08	1.996E+10	7.400E+09	7.880E+09
TC-99 /CON	2.960E+09	5.411E+09	8.890E+09	7.600E+08	1.031E+11	7.962E+09	2.240E+11
TC-99 /AGR	8.548E+09	1.933E+10	2.960E+10	7.600E+08	3.636E+11	9.720E+09	9.008E+11
TC-99 /FOO	6.566E+03	1.635E+04	2.433E+04	0.	3.061E+05	2.067E+03	7.953E+05
TC-99 /DGM	0.	0.	0.	0.	0.	0.	0.
TC-99 /WWT	4.186E+05	1.042E+06	1.551E+06	2.083E+00	1.951E+07	1.318E+05	5.069E+07
TC-99 /SWT	4.240E+05	1.056E+06	1.571E+06	2.083E+00	1.976E+07	1.335E+05	5.135E+07
TC-99 /AIR	8.548E+09	1.933E+10	2.960E+10	7.600E+08	3.636E+11	9.721E+09	9.008E+11
I-129	4.080E-08	1.150E-01	2.000E+00	5.000E+00			
I-129 /ACC	9.139E+11	8.515E+11	8.515E+11	5.128E+13	8.515E+11	8.572E+11	8.521E+11
I-129 /CON	2.068E+12	7.124E+11	6.123E+11	1.624E+15	1.315E+12	6.366E+09	9.787E+10
I-129 /AGR	8.346E+12	2.942E+12	2.528E+12	6.553E+15	5.433E+12	6.366E+09	4.006E+11
I-129 /FOO	6.019E+04	2.137E+04	1.836E+04	4.725E+07	3.947E+04	0.	2.901E+03
I-129 /DGM	1.920E+04	1.920E+04	1.920E+04	1.920E+04	1.920E+04	1.920E+04	1.920E+04
I-129 /WWT	4.289E+07	1.758E+07	1.562E+07	3.081E+10	2.938E+07	3.644E+06	5.536E+06
I-129 /SWT	4.389E+07	1.793E+07	1.592E+07	3.160E+10	3.004E+07	3.644E+06	5.584E+06
I-129 /AIR	9.197E+12	3.792E+12	3.379E+12	6.554E+15	6.284E+12	8.572E+11	1.251E+12
CS-135	2.310E-07	1.620E-04	8.500E+01	7.200E+02			
CS-135/ACC	2.371E+10	9.651E+10	8.851E+10	5.080E+08	3.331E+10	1.491E+10	1.004E+09
CS-135/CON	1.566E+11	4.209E+11	3.879E+11	5.080E+08	1.466E+11	4.884E+10	8.007E+09
CS-135/AGR	5.729E+11	1.438E+12	1.326E+12	5.080E+08	5.014E+11	1.551E+11	2.994E+10
CS-135/FOO	8.836E+03	2.157E+04	1.991E+04	0.	7.531E+03	2.256E+03	4.656E+02
CS-135/DGM	0.	0.	0.	0.	0.	0.	0.
CS-135/WWT	3.318E+07	8.092E+07	7.475E+07	1.392E+00	2.828E+07	8.472E+06	1.748E+06
CS-135/SWT	1.442E+08	3.520E+08	3.250E+08	1.392E+00	1.229E+08	3.683E+07	7.600E+06
CS-135/AIR	5.729E+11	1.437E+12	1.326E+12	5.080E+08	5.014E+11	1.551E+11	2.994E+10
CS-137	2.310E-02	1.620E-04	8.500E+01	7.200E+02			
CS-137/ACC	4.499E+11	6.339E+11	7.779E+11	2.419E+11	4.259E+11	3.299E+11	2.444E+11
CS-137/CON	1.397E+12	1.719E+12	2.351E+12	1.530E+09	8.010E+11	2.941E+11	3.919E+10
CS-137/AGR	5.117E+12	5.872E+12	8.030E+12	1.530E+09	2.729E+12	9.350E+11	1.491E+11
CS-137/FOO	7.896E+04	8.814E+04	1.205E+05	0.	4.092E+04	1.360E+04	2.333E+03
CS-137/DGM	3.500E+06	3.500E+06	3.500E+06	3.500E+06	3.500E+06	3.500E+06	3.500E+06
CS-137/WWT	3.094E+08	3.438E+08	4.655E+08	1.287E+07	1.665E+08	6.394E+07	2.163E+07
CS-137/SWT	1.302E+09	1.452E+09	1.981E+09	1.287E+07	6.808E+08	2.349E+08	5.096E+07
CS-137/AIR	5.358E+12	6.112E+12	8.270E+12	2.419E+11	2.969E+12	1.175E+12	3.895E+11
U-235	9.760E-10	1.250E-04	8.400E+02	7.200E+03			
U-235 /ACC	2.062E+12	3.062E+13	2.214E+11	2.214E+11	7.262E+12	3.360E+15	5.175E+11
U-235 /CON	2.643E+12	4.361E+13	1.590E+09	1.590E+09	1.013E+13	3.360E+15	1.586E+12
U-235 /AGR	5.154E+12	8.500E+13	1.590E+09	1.590E+09	1.979E+13	3.360E+15	5.621E+12
U-235 /FOO	1.443E+04	2.378E+05	0.	0.	5.552E+04	0.	2.319E+04
U-235 /DGM	1.500E+05	1.500E+05	1.500E+05	1.500E+05	1.500E+05	1.500E+05	1.500E+05
U-235 /WWT	2.073E+08	3.235E+09	1.177E+07	1.177E+07	7.643E+08	2.098E+07	3.261E+08
U-235 /SWT	2.109E+08	3.294E+09	1.177E+07	1.177E+07	7.781E+08	2.098E+07	3.318E+08
U-235 /AIR	5.374E+12	8.522E+13	2.214E+11	2.214E+11	2.001E+13	3.360E+15	5.841E+12
U-238	1.540E-10	1.250E-04	8.400E+02	7.200E+03			
U-238 /ACC	1.695E+12	2.882E+13	1.454E+10	1.454E+10	6.575E+12	3.120E+15	2.546E+11
U-238 /CON	2.429E+12	4.145E+13	8.570E+07	8.570E+07	9.447E+12	3.120E+15	1.147E+12
U-238 /AGR	4.774E+12	8.108E+13	8.570E+07	8.570E+07	1.849E+13	3.120E+15	3.989E+12
U-238 /FOO	1.348E+04	2.277E+05	0.	0.	5.196E+04	0.	1.633E+04
U-238 /DGM	5.160E+03	5.160E+03	5.160E+03	5.160E+03	5.160E+03	5.160E+03	5.160E+03
U-238 /WWT	1.835E+08	3.087E+09	7.739E+05	7.739E+05	7.050E+08	9.325E+06	2.221E+08
U-238 /SWT	1.868E+08	3.144E+09	7.739E+05	7.739E+05	7.179E+08	9.325E+06	2.262E+08
U-238 /AIR	4.789E+12	8.109E+13	1.454E+10	1.454E+10	1.850E+13	3.120E+15	4.003E+12
NP-237	3.240E-07	4.670E-04	3.000E+02	2.500E+03			
NP-237/ACC	5.202E+14	1.200E+16	1.120E+15	1.340E+11	3.840E+15	3.602E+14	3.740E+11
NP-237/CON	5.209E+14	1.202E+16	1.122E+15	8.400E+08	3.847E+15	3.600E+14	1.550E+12
NP-237/AGR	5.238E+14	1.209E+16	1.128E+15	8.400E+08	3.868E+15	3.600E+14	5.652E+12
NP-237/FOO	1.645E+04	4.067E+05	3.533E+04	0.	1.223E+05	0.	2.357E+04
NP-237/DGM	6.560E+04	6.560E+04	6.560E+04	6.560E+04	6.560E+04	6.560E+04	6.560E+04
NP-237/WWT	2.312E+08	5.546E+09	4.885E+08	7.126E+06	1.674E+09	8.113E+06	3.263E+08

GW2FIL File (cont'd)

NP-237/SWT	2.572E+08	6.169E+09	5.443E+08	7.126E+06	1.867E+09	8.113E+06	3.635E+08
NP-237/AIR	5.239E+14	1.209E+16	1.128E+15	1.340E+11	3.868E+15	3.602E+14	5.785E+12
PU-238	8.020E-03	4.670E-04	8.400E+02	7.200E+03			
PU-238/ACC	2.000E+14	4.080E+15	2.800E+15	1.924E+10	8.801E+14	4.080E+15	3.313E+11
PU-238/CON	2.003E+14	4.091E+15	2.802E+15	8.870E+07	8.812E+14	4.080E+15	1.514E+12
PU-238/AGR	2.012E+14	4.126E+15	2.807E+15	8.870E+07	8.850E+14	4.080E+15	5.277E+12
PU-238/FOO	1.137E+03	4.522E+04	6.371E+03	0.	4.868E+03	0.	4.855E+03
PU-238/DGM	1.930E+01	1.930E+01	1.930E+01	1.930E+01	1.930E+01	1.930E+01	1.930E+01
PU-238/WWT	7.019E+07	2.741E+09	3.931E+08	1.025E+06	2.972E+08	1.221E+07	2.940E+08
PU-238/SWT	7.485E+07	2.926E+09	4.192E+08	1.025E+06	3.171E+08	1.221E+07	3.139E+08
PU-238/AIR	2.012E+14	4.126E+15	2.807E+15	1.924E+10	8.850E+14	4.080E+15	5.297E+12
PU-239	2.840E-05	4.670E-04	8.400E+02	7.200E+03			
PU-239/ACC	2.240E+14	4.800E+15	3.120E+15	7.400E+09	9.601E+14	3.840E+15	3.034E+11
PU-239/CON	2.243E+14	4.813E+15	3.122E+15	5.170E+07	9.613E+14	3.840E+15	1.392E+12
PU-239/AGR	2.253E+14	4.854E+15	3.127E+15	5.170E+07	9.655E+14	3.840E+15	4.826E+12
PU-239/FOO	1.270E+03	5.234E+04	7.049E+03	0.	5.393E+03	0.	4.429E+03
PU-239/DGM	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01
PU-239/WWT	7.765E+07	3.172E+09	4.343E+08	3.934E+05	3.285E+08	1.092E+07	2.676E+08
PU-239/SWT	8.286E+07	3.386E+09	4.632E+08	3.934E+05	3.506E+08	1.092E+07	2.858E+08
PU-239/AIR	2.253E+14	4.854E+15	3.127E+15	7.400E+09	9.656E+14	3.840E+15	4.833E+12
PU-241	5.250E-02	4.670E-04	8.400E+02	7.200E+03			
PU-241/ACC	3.040E+12	7.440E+13	4.560E+13	4.780E+07	1.440E+13	6.800E+12	5.568E+09
PU-241/CON	3.046E+12	7.467E+13	4.561E+13	4.780E+07	1.443E+13	6.800E+12	2.861E+10
PU-241/AGR	3.063E+12	7.552E+13	4.566E+13	4.780E+07	1.450E+13	6.800E+12	1.008E+11
PU-241/FOO	2.208E+01	1.097E+03	5.613E+01	0.	1.017E+02	0.	9.310E+01
PU-241/DGM	3.430E-01	3.430E-01	3.430E-01	3.430E-01	3.430E-01	3.430E-01	3.430E-01
PU-241/WWT	1.341E+06	6.642E+07	3.512E+06	1.310E-01	6.179E+06	1.864E+04	5.618E+06
PU-241/SWT	1.431E+06	7.091E+07	3.742E+06	1.310E-01	6.596E+06	1.864E+04	5.999E+06
PU-241/AIR	3.063E+12	7.553E+13	4.566E+13	4.780E+07	1.450E+13	6.800E+12	1.008E+11
PU-242	2.480E-06	4.670E-04	8.400E+02	7.200E+03			
PU-242/ACC	2.160E+14	4.480E+15	3.040E+15	1.441E+10	9.601E+14	3.680E+15	2.944E+11
PU-242/CON	2.163E+14	4.492E+15	3.042E+15	6.930E+07	9.613E+14	3.680E+15	1.355E+12
PU-242/AGR	2.173E+14	4.530E+15	3.047E+15	6.930E+07	9.653E+14	3.680E+15	4.722E+12
PU-242/FOO	1.224E+03	4.848E+04	6.783E+03	0.	5.194E+03	0.	4.343E+03
PU-242/DGM	0.	0.	0.	0.	0.	0.	0.
PU-242/WWT	7.520E+07	2.939E+09	4.184E+08	7.674E+05	3.168E+08	1.085E+07	2.628E+08
PU-242/SWT	8.021E+07	3.137E+09	4.462E+08	7.674E+05	3.381E+08	1.085E+07	2.806E+08
PU-242/AIR	2.173E+14	4.530E+15	3.047E+15	1.441E+10	9.654E+14	3.680E+15	4.736E+12
AM-241	1.510E-03	4.110E-03	3.000E+02	2.500E+03			
AM-241/ACC	5.041E+14	7.120E+15	6.640E+15	7.869E+10	3.840E+15	4.241E+14	3.587E+11
AM-241/CON	5.049E+14	7.134E+15	6.645E+15	3.800E+08	3.847E+15	4.240E+14	1.508E+12
AM-241/AGR	5.077E+14	7.176E+15	6.660E+15	3.800E+08	3.868E+15	4.240E+14	5.355E+12
AM-241/FOO	3.599E+04	5.448E+05	1.916E+05	0.	2.707E+05	0.	4.936E+04
AM-241/DGM	7.710E+04	7.710E+04	7.710E+04	7.710E+04	7.710E+04	7.710E+04	7.710E+04
AM-241/WWT	2.247E+08	3.340E+09	1.189E+09	4.192E+06	1.663E+09	5.354E+06	3.047E+08
AM-241/SWT	3.721E+08	5.572E+09	1.974E+09	4.192E+06	2.772E+09	5.354E+06	5.069E+08
AM-241/AIR	5.078E+14	7.176E+15	6.660E+15	7.869E+10	3.868E+15	4.241E+14	5.434E+12
AM-243	8.720E-05	4.110E-03	3.000E+02	2.500E+03			
AM-243/ACC	4.961E+14	7.040E+15	6.480E+15	9.096E+10	3.760E+15	4.001E+14	3.630E+11
AM-243/CON	4.969E+14	7.054E+15	6.485E+15	6.090E+08	3.767E+15	4.000E+14	1.713E+12
AM-243/AGR	4.996E+14	7.096E+15	6.499E+15	6.090E+08	3.787E+15	4.000E+14	6.223E+12
AM-243/FOO	3.525E+04	5.441E+05	1.849E+05	0.	2.654E+05	0.	5.787E+04
AM-243/DGM	1.860E+05	1.860E+05	1.860E+05	1.860E+05	1.860E+05	1.860E+05	1.860E+05
AM-243/WWT	2.208E+08	3.337E+09	1.148E+09	4.837E+06	1.631E+09	5.933E+06	3.572E+08
AM-243/SWT	3.653E+08	5.566E+09	1.906E+09	4.837E+06	2.718E+09	5.933E+06	5.942E+08
AM-243/AIR	4.997E+14	7.096E+15	6.499E+15	9.096E+10	3.788E+15	4.001E+14	6.313E+12
CM-243	2.170E-02	4.670E-04	3.000E+02	2.500E+03			
CM-243/ACC	3.843E+14	6.161E+15	5.601E+15	2.444E+11	1.760E+15	4.403E+14	5.484E+11
CM-243/CON	3.846E+14	6.171E+15	5.604E+15	2.260E+09	1.763E+15	4.400E+14	1.594E+12
CM-243/AGR	3.866E+14	6.204E+15	5.616E+15	2.260E+09	1.772E+15	4.400E+14	5.629E+12
CM-243/FOO	1.113E+04	1.897E+05	7.155E+04	0.	5.195E+04	0.	2.319E+04
CM-243/DGM	3.820E+05	3.820E+05	3.820E+05	3.820E+05	3.820E+05	3.820E+05	3.820E+05
CM-243/WWT	1.647E+08	2.598E+09	9.970E+08	1.296E+07	7.212E+08	1.417E+07	3.269E+08

GW2FIL File (cont'd)

CM-243/SWT	2.087E+08	3.347E+09	1.280E+09	1.296E+07	9.264E+08	1.417E+07	4.184E+08
CM-243/AIR	3.868E+14	6.204E+15	5.617E+15	2.444E+11	1.772E+15	4.403E+14	5.871E+12
CM-244	3.940E-02	4.670E-04	3.000E+02	2.500E+03			
CM-244/ACC	2.800E+14	4.400E+15	4.160E+15	1.706E+10	1.280E+15	4.400E+14	3.051E+11
CM-244/CON	2.805E+14	4.408E+15	4.163E+15	7.230E+07	1.282E+15	4.400E+14	1.533E+12
CM-244/AGR	2.820E+14	4.433E+15	4.174E+15	7.230E+07	1.289E+15	4.400E+14	5.434E+12
CM-244/FOO	8.520E+03	1.434E+05	6.145E+04	0.	3.978E+04	0.	2.241E+04
CM-244/DGM	5.640E+01	5.640E+01	5.640E+01	5.640E+01	5.640E+01	5.640E+01	5.640E+01
CM-244/WWT	1.170E+08	1.954E+09	8.443E+08	9.093E+05	5.430E+08	2.115E+06	3.044E+08
CM-244/SWT	1.507E+08	2.521E+09	1.087E+09	9.093E+05	7.001E+08	2.115E+06	3.929E+08
CM-244/AIR	2.820E+14	4.433E+15	4.174E+15	1.706E+10	1.289E+15	4.400E+14	5.451E+12
PB-210	3.398E-02	4.110E-03	8.400E+02	7.200E+03			
PB-210/ACC	8.039E+12	2.561E+14	6.564E+13	3.836E+10	2.080E+14	1.040E+14	4.716E+10
PB-210/CON	1.699E+13	5.088E+14	1.378E+14	3.510E+08	4.112E+14	1.040E+14	9.045E+11
PB-210/AGR	4.514E+13	1.300E+15	3.639E+14	3.510E+08	1.048E+15	1.040E+14	3.709E+12
PB-210/FOO	2.584E+05	7.268E+06	2.076E+06	0.000E+00	5.843E+06	0.000E+00	2.575E+04
PB-210/DGM	6.580E+05	6.580E+05	6.580E+05	6.590E+05	6.580E+05	6.580E+05	6.580E+05
PB-210/WWT	2.194E+09	6.164E+10	1.761E+10	2.035E+06	4.955E+10	2.320E+06	2.204E+08
PB-210/SWT	2.623E+09	7.372E+10	2.106E+10	2.035E+06	5.927E+10	2.320E+06	2.632E+08
PB-210/AIR	4.518E+13	1.301E+15	3.640E+14	3.836E+10	1.048E+15	1.040E+14	3.747E+12
AC-227	3.209E-02	4.110E-03	3.000E+02	2.500E+02			
AC-227/ACC	3.600E+14	5.680E+15	8.000E+14	1.004E+09	2.560E+14	2.160E+16	1.140E+10
AC-227/CON	3.618E+14	5.711E+15	8.041E+14	1.190E+08	2.573E+14	2.160E+16	1.361E+12
AC-227/AGR	3.676E+14	5.807E+15	8.169E+14	1.190E+08	2.615E+14	2.160E+16	5.593E+12
AC-227/FOO	3.296E+04	5.552E+05	7.363E+04	0.000E+00	2.375E+04	0.000E+00	2.432E+04
AC-227/DGM	1.390E+07	1.390E+07	1.390E+07	1.390E+07	1.390E+07	1.390E+07	1.390E+07
AC-227/WWT	4.477E+08	7.541E+09	1.000E+09	4.740E+04	3.227E+08	5.925E+07	3.296E+08
AC-227/SWT	4.559E+08	7.679E+09	1.019E+09	4.740E+04	3.286E+08	5.925E+07	3.357E+08
AC-227/AIR	3.676E+14	5.808E+15	8.169E+14	1.004E+09	2.615E+14	2.160E+16	5.594E+12
RA-226	4.327E-04	4.110E-03	3.000E+01	2.500E+02			
RA-226/ACC	1.520E+15	2.160E+15	8.944E+09	8.944E+09	8.944E+09	8.000E+14	1.770E+11
RA-226/CON	1.654E+15	2.527E+15	5.008E+12	5.008E+12	5.008E+12	8.000E+14	4.241E+12
RA-226/AGR	2.072E+15	3.678E+15	2.069E+13	2.069E+13	2.069E+13	8.001E+14	1.700E+13
RA-226/FOO	1.330E+07	3.658E+07	4.988E+05	4.988E+05	4.988E+05	2.926E+03	4.057E+05
RA-226/DGM	2.940E+07	2.940E+07	2.940E+07	2.940E+07	2.940E+07	2.940E+07	2.940E+07
RA-226/WWT	3.256E+10	8.952E+10	1.221E+09	1.221E+09	1.221E+09	9.828E+06	9.933E+08
RA-226/SWT	3.732E+10	1.026E+11	1.400E+09	1.400E+09	1.400E+09	1.088E+07	1.138E+09
RA-226/AIR	2.072E+15	3.678E+15	2.070E+13	2.070E+13	2.070E+13	8.002E+14	1.701E+13
TH-228	3.629E-01	4.110E-03	8.400E+02	7.200E+03			
TH-228/ACC	2.402E+13	7.121E+14	1.202E+13	1.797E+10	6.802E+13	1.440E+16	2.980E+11
TH-228/CON	2.428E+13	7.202E+14	1.214E+13	1.980E+08	6.877E+13	1.440E+16	9.583E+12
TH-228/AGR	2.515E+13	7.459E+14	1.257E+13	1.980E+08	7.119E+13	1.440E+16	3.872E+13
TH-228/FOO	8.379E+03	2.474E+05	4.190E+03	0.000E+00	2.329E+04	0.000E+00	2.808E+05
TH-228/DGM	2.220E+07	2.220E+07	2.220E+07	2.220E+07	2.220E+07	2.220E+07	2.220E+07
TH-228/WWT	6.865E+07	2.000E+09	3.480E+07	9.512E+05	1.891E+08	4.042E+07	2.267E+09
TH-228/SWT	8.053E+07	2.350E+09	4.074E+07	9.512E+05	2.222E+08	4.042E+07	2.666E+09
TH-228/AIR	2.517E+13	7.459E+14	1.259E+13	1.797E+10	7.121E+13	1.440E+16	3.874E+13
RA-228	1.035E-01	4.110E-03	3.000E+01	2.500E+02			
RA-228/ACC	6.880E+14	6.480E+14	1.140E+08	1.140E+08	1.140E+08	8.800E+15	1.874E+09
RA-228/CON	7.598E+14	8.316E+14	6.511E+12	6.678E+12	6.511E+12	8.800E+15	1.688E+12
RA-228/AGR	9.846E+14	1.407E+15	2.690E+13	2.759E+13	2.690E+13	8.800E+15	6.969E+12
RA-228/FOO	7.149E+06	1.829E+07	6.484E+05	6.651E+05	6.484E+05	4.007E+03	1.679E+05
RA-228/DGM	5.000E+06	5.000E+06	5.000E+06	5.000E+06	5.000E+06	5.000E+06	5.000E+06
RA-228/WWT	1.7505+10	4.476E+10	1.587E+09	1.628E+09	1.587E+09	3.392E+07	4.110E+08
RA-228/SWT	2.006E+10	5.130E+10	1.819E+09	1.866E+09	1.819E+09	3.536E+07	4.711E+08
RA-228/AIR	9.847E+14	1.407E+15	2.690E+13	2.759E+13	2.690E+13	8.801E+15	6.969E+12
TH-229	9.443E-05	4.110E-03	8.400E+02	7.200E+03			
TH-229/ACC	1.360E+15	2.800E+16	4.243E+14	2.548E+11	2.080E+15	2.000E+16	2.495E+12
TH-229/CON	1.366E+15	2.813E+16	4.260E+14	1.790E+09	2.090E+15	2.000E+16	1.070E+13
TH-229/AGR	1.387E+15	2.854E+16	4.321E+14	1.790E+09	2.119E+15	2.000E+16	3.720E+13
TH-229/FOO	1.950E+05	3.980E+06	5.935E+04	0.000E+00	2.868E+05	0.000E+00	2.554E+05
TH-229/DGM	1.450E+07	1.450E+07	1.450E+07	1.450E+07	1.450E+07	1.450E+07	1.450E+07
TH-229/WWT	1.591E+09	3.222E+10	4.938E+08	1.354E+07	2.334E+09	6.836E+07	2.075E+09

TH-229/SWT	1.868E+09	3.786E+10	5.779E+08	1.354E+07	2.741E+09	6.836E+07	2.437E+09
TH-229/AIR	1.387E+15	2.855E+16	4.324E+14	2.548E+11	2.120E+15	2.000E+16	3.745E+13
TH-230	8.664E-06	4.110E-03	8.400E+02	7.200E+03			
TH-230/ACC	5.360E+14	1.760E+16	1.120E+15	1.435E+10	5.280E+15	3.520E+14	2.464E+11
TH-230/CON	5.369E+14	1.763E+16	1.122E+15	1.300E+08	5.289E+15	3.520E+14	1.227E+12
TH-230/AGR	5.399E+14	1.774E+16	1.128E+15	1.300E+08	5.319E+15	3.520E+14	4.342E+12
TH-230/FDD	2.843E+04	1.027E+06	5.835E+04	0.000E+00	2.818E+05	0.000E+00	3.003E+04
TH-230/DGM	2.130E+03	2.130E+03	2.130E+03	2.130E+03	2.130E+03	2.130E+03	2.130E+03
TH-230/WWT	2.317E+08	8.342E+09	4.749E+08	7.610E+05	2.290E+09	1.726E+06	2.431E+08
TH-230/SWT	2.720E+08	9.799E+09	5.576E+08	7.610E+05	2.689E+09	1.726E+06	2.857E+08
TH-230/AIR	5.399E+14	1.774E+16	1.128E+15	1.435E+10	5.319E+15	3.520E+14	4.357E+12
PA-231	2.133E-05	4.110E-03	8.400E+02	7.200E+03			
PA-231/ACC	5.601E+14	1.360E+16	5.441E+14	1.097E+11	3.040E+15	5.120E+15	4.217E+11
PA-231/CON	5.626E+14	1.367E+16	5.465E+14	6.590E+08	3.054E+15	5.120E+15	1.495E+12
PA-231/AGR	5.708E+14	1.388E+16	5.545E+14	6.590E+08	3.099E+15	5.120E+15	5.200E+12
PA-231/FDD	4.721E+04	1.217E+06	4.572E+04	0.000E+00	2.565E+05	0.000E+00	2.129E+04
PA-231/DGM	4.560E+05	4.560E+05	4.560E+05	4.560E+05	4.560E+05	4.560E+05	4.560E+05
PA-231/WWT	6.472E+08	1.654E+10	6.270E+08	5.836E+06	3.491E+09	1.987E+07	2.944E+08
PA-231/SWT	6.589E+08	1.684E+10	6.384E+08	5.836E+06	3.555E+09	1.987E+07	2.997E+08
PA-231/AIR	5.710E+14	1.388E+16	5.546E+14	1.097E+11	3.099E+15	5.120E+15	5.309E+12
TH-232	4.916E-11	4.110E-03	8.400E+02	7.200E+03			
TH-232/ACC	2.560E+14	7.440E+15	3.520E+14	1.384E+10	1.680E+15	4.720E+15	2.379E+11
TH-232/CON	2.585E+14	7.478E+15	3.537E+14	1.080E+08	1.688E+15	4.720E+15	1.070E+12
TH-232/AGR	2.662E+14	7.597E+15	3.588E+14	1.080E+08	1.713E+15	4.720E+15	3.720E+12
TH-232/FDD	7.481E+04	1.147E+06	4.988E+04	0.000E+00	2.404E+05	0.000E+00	2.554E+04
TH-232/DGM	4.920E+04	4.920E+04	4.920E+04	4.920E+04	4.920E+04	4.920E+04	4.920E+04
TH-232/WWT	6.053E+08	9.281E+09	4.043E+08	7.352E+05	1.946E+09	1.367E+07	2.069E+08
TH-232/SWT	7.114E+08	1.091E+10	4.750E+08	7.352E+05	2.287E+09	1.367E+07	2.431E+08
TH-232/AIR	2.663E+14	7.597E+15	3.589E+14	1.384E+10	1.713E+15	4.720E+15	3.734E+12
U-233	4.279E-06	1.250E-04	8.400E+02	7.200E+03			
U-233 /ACC	2.011E+12	3.281E+13	1.077E+10	1.077E+10	7.691E+12	3.680E+15	2.908E+11
U-233 /CON	2.871E+12	4.717E+13	5.160E+07	5.160E+07	1.103E+13	3.680E+15	1.314E+12
U-233 /AGR	5.599E+12	9.217E+13	5.160E+07	5.160E+07	2.152E+13	3.680E+15	4.554E+12
U-233 /FDD	1.568E+04	2.586E+05	0.000E+00	0.000E+00	6.027E+04	0.000E+00	1.862E+04
U-233 /DGM	4.160E+06	4.160E+06	4.160E+06	4.160E+06	4.160E+06	4.160E+06	4.160E+06
U-233 /WWT	2.131E+08	3.506E+09	5.739E+05	5.739E+05	8.175E+08	1.066E+07	2.529E+08
U-233 /SWT	2.170E+08	3.570E+09	5.739E+05	5.739E+05	8.325E+08	1.066E+07	2.575E+08
U-233 /AIR	5.610E+12	9.218E+13	1.077E+10	1.077E+10	2.153E+13	3.680E+15	4.564E+12
U-234	2.806E-06	1.250E-04	8.400E+02	7.200E+03			
U-234 /ACC	1.938E+12	3.122E+13	1.746E+10	1.746E+10	7.538E+12	3.600E+15	2.895E+11
U-234 /CON	2.773E+12	4.499E+13	1.140E+08	1.140E+08	1.080E+13	3.600E+15	1.285E+12
U-234 /AGR	5.444E+12	8.818E+13	1.140E+08	1.140E+08	2.108E+13	3.600E+15	4.457E+12
U-234 /FDD	1.535E+04	2.482E+05	0.000E+00	0.000E+00	5.908E+04	0.000E+00	1.823E+04
U-234 /DGM	3.980E+05	3.980E+05	3.980E+05	3.980E+05	3.980E+05	3.980E+05	3.980E+05
U-234 /WWT	2.090E+08	3.365E+09	9.286E+05	9.286E+05	8.018E+08	1.080E+07	2.480E+08
U-234 /SWT	2.128E+08	3.427E+09	9.286E+05	9.286E+05	8.164E+08	1.080E+07	2.525E+08
U-234 /AIR	5.461E+12	8.820E+13	1.746E+10	1.746E+10	2.110E+13	3.600E+15	4.474E+12
U-236	2.900E-08	1.250E-04	8.400E+02	7.200E+03			
U-236 /ACC	1.857E+12	3.042E+13	1.648E+10	1.648E+10	7.297E+12	3.440E+15	2.725E+11
U-236 /CON	2.658E+12	4.361E+13	9.670E+07	9.670E+07	1.043E+13	3.440E+15	1.206E+12
U-236 /AGR	5.221E+12	8.500E+13	9.670E+07	9.670E+07	2.030E+13	3.440E+15	4.182E+12
U-236 /FDD	1.473E+04	2.378E+05	0.000E+00	0.000E+00	5.671E+04	0.000E+00	1.710E+04
U-236 /DGM	5.560E+04	5.560E+04	5.560E+04	5.560E+04	5.560E+04	5.560E+04	5.560E+04
U-236 /WWT	2.005E+08	3.224E+09	8.770E+05	8.770E+05	7.695E+08	1.031E+07	2.327E+08
U-236 /SWT	2.041E+08	3.283E+09	8.770E+05	8.770E+05	7.836E+08	1.031E+07	2.369E+08
U-236 /AIR	5.237E+12	8.501E+13	1.648E+10	1.648E+10	2.032E+13	3.440E+15	4.198E+12
PU-240	1.053E-04	4.670E-04	8.400E+02	7.200E+03			
PU-240/ACC	2.240E+14	4.800E+15	3.120E+15	7.400E+09	9.601E+14	3.840E+15	3.034E+11
PU-240/CON	2.243E+14	4.813E+15	3.122E+15	5.170E+07	9.613E+14	3.840E+15	1.392E+12
PU-240/AGR	2.253E+14	4.854E+15	3.127E+15	5.170E+07	9.655E+14	3.840E+15	4.826E+12
PU-240/FDD	1.270E+03	5.234E+04	7.049E+03	0.	5.393E+03	0.	4.429E+03
PU-240/DGM	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01	9.390E+01
PU-240/WWT	7.765E+07	3.172E+09	4.343E+08	3.934E+05	3.285E+08	1.092E+07	2.676E+08

PU-240/SWT	8.286E+07	3.386E+09	4.632E+08	3.934E+05	3.506E+08	1.092E+07	2.858E+08
PU-240/AIR	2.253E+14	4.854E+15	3.127E+15	7.400E+09	9.656E+14	3.840E+15	4.833E+12
REGION 1	9.180E-12	2.960E-11	1.970E-04	4.930E-05	7.700E+03	2.000E+05	4.500E+06
	2.000E+02	5.000E+03	1.000E+04	4.000E+02	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	1.010E-09	1.510E-09	1.120E-07	3
	4.000E+02	8.000E+02	1.830E-10	2.610E-12			
REGION 2	2.010E-11	3.180E-11	1.160E-03	3.240E-05	7.700E+03	2.000E+05	4.500E+06
	4.200E+01	4.000E+02	8.000E+02	1.300E+03	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	3.500E-10	5.250E-10	1.120E-07	3
	6.400E+01	1.600E+03	1.830E-10	3.323E-12			
REGION 3	2.510E-11	3.280E-11	9.000E-05	2.250E-05	7.770E+03	2.000E+05	4.500E+06
	1.400E+02	2.900E+03	5.800E+03	4.000E+02	1.250E+04	2.500E+04	
	1.000E+00	1.000E+00	1.000E+00	3.860E-10	5.790E-10	1.120E-07	4
	1.600E+02	8.000E+02	1.830E-10	2.550E-12			
REGION 4	2.640E-10	8.060E-11	1.300E-06	3.250E-07	7.700E+03	2.000E+05	4.500E+06
	1.500E+01	3.000E+02	6.000E+02	1.300E+03	3.000E+04	6.000E+04	
	1.000E+00	1.000E+00	1.000E+00	2.660E-11	3.990E-11	1.120E-07	2
	8.000E+00	8.000E+02	1.830E-10	1.790E-12			
REGION 5	2.010E-11	3.180E-11	1.160E-04	3.240E-06	7.700E+03	2.000E+05	4.500E+06
	3.200E+01	3.900E+02	7.900E+02	1.300E+03	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	3.500E-10	5.250E-10	1.120E-07	2
	6.400E+00	1.600E+03	1.830E-10	3.323E-12			
REGION 6	2.010E-11	3.180E-11	1.160E-02	3.240E-04	7.700E+03	2.000E+05	4.500E+06
	9.200E+01	4.500E+02	8.500E+02	1.300E+03	1.000E+04	2.000E+04	
	1.000E+00	1.000E+00	1.000E+00	3.500E-10	5.250E-10	1.120E-07	4
	6.400E+01	1.600E+03	1.830E-10	3.323E-12			
REGION 1	6.926E+03	4.870E+04	8.559E+02	4.355E+03	2.099E+04	5.788E+04	
VOLUMES	4.654E+04	8.489E+04	4.356E+04	5.744E+04	2.724E+04	4.719E+04	
	8.341E+03	4.363E+04	4.363E+04	8.978E+04	8.978E+04	1.519E+04	
	1.519E+04	1.563E+04	0.	1.523E+04	1.523E+04	1.713E+03	
	1.731E+03	4.869E+03	4.869E+03	3.169E+04	1.808E+04	6.479E+02	
	7.346E+03	5.196E+03	8.086E+02	2.646E+03	5.782E+01	4.155E+02	
	1.316E+03						
REGION 2	1.298E+04	9.124E+04	1.604E+03	8.159E+03	2.511E+04	6.925E+04	
VLOUMES	5.568E+04	1.590E+05	8.162E+04	6.872E+04	3.260E+04	1.180E+05	
	2.085E+04	3.096E+04	3.096E+04	1.796E+04	1.796E+04	1.013E+04	
	1.103E+04	3.908E+04	0.	1.081E+04	1.081E+04	1.229E+03	
	1.229E+03	3.456E+03	3.456E+03	6.339E+03	1.205E+04	1.040E+03	
	1.224E+04	0.	5.739E+02	2.089E+02	4.103E+01	2.949E+02	
	1.726E+03						
REGION 3	6.587E+03	4.631E+04	8.140E+02	4.141E+03	2.046E+04	5.643E+04	
VOLUMES	4.537E+04	8.073E+04	4.143E+04	5.600E+04	2.656E+04	0.	
	0.	3.800E+04	3.800E+04	3.591E+04	3.591E+04	1.519E+04	
	1.519E+04	0.	1.406E+04	1.327E+04	1.327E+04	1.508E+03	
	1.508E+03	4.241E+03	4.241E+03	1.268E+04	1.808E+04	6.224E+02	
	8.045E+03	0.	7.043E+02	2.089E+02	5.036E+01	3.619E+02	
	7.450E+02						
REGION 4	8.136E+03	5.720E+04	1.005E+03	5.115E+03	9.672E+03	2.668E+04	
VOLUMES	2.145E+04	9.972E+04	5.117E+04	2.647E+04	1.256E+04	7.078E+04	
	1.251E+04	2.815E+04	2.815E+04	3.591E+04	3.591E+04	1.103E+04	
	1.103E+04	2.345E+04	1.406E+04	9.829E+03	9.829E+03	1.117E+03	
	1.117E+03	3.141E+03	3.141E+03	1.268E+04	1.205E+04	5.774E+03	
	7.346E+03	0.	5.217E+02	4.178E+02	3.730E+01	2.681E+02	
	1.366E+03						

IN2FIL File

P-IXRESIN	11	100	100	2	1	1	0	0	1	0010
P-CONCLIQ	11	100	140	1	1	2	0	1	1	0110
P-FSLUDGE	11	100	100	1	3	1	0	0	1	0010
P-FCARTRG	11	100	100	2	2	1	0	0	1	0110
B-IXRESIN	11	100	100	2	1	1	0	0	1	0010
B-CONCLIQ	11	100	140	1	1	2	0	1	1	0110
B-FSLUDGE	11	100	100	1	3	1	0	0	1	0010
P-COTRASH	21	100	100	3	2	1	0	0	1	0000
P-NCTRASH	51	100	100	0	0	1	0	0	2	0000
B-COTRASH	21	100	100	3	2	1	0	0	1	0000
B-NCTRASH	51	100	100	0	0	1	0	0	2	0000
F-COTRASH	22	100	100	3	2	1	0	0	1	0000
F-NCTRASH	22	100	100	0	0	1	0	0	2	0000
I-COTRASH	23	100	100	3	2	1	0	0	1	0000
I+COTRASH	23	100	100	3	2	1	0	0	1	0000
N-SSTRASH	22	100	100	2	2	1	0	0	1	0000
N+SSTRASH	22	100	100	2	2	1	0	0	1	0000
N-LOTRASH	22	100	100	3	2	1	0	0	1	0000
N+LOTRASH	22	100	100	3	2	1	0	0	1	0000
F-PROCESS	52	100	100	0	3	1	0	1	1	0000
U-PROCESS	52	100	100	0	3	1	0	1	1	0000
I-LQSCNVL	33	100	300	3	3	1	1	0	1	0010
I+LQSCNVL	33	100	300	3	3	1	1	0	1	0010
I-ABSLIQD	33	100	300	3	3	1	1	1	1	0010
I+ABSLIQD	33	100	300	3	3	1	1	1	1	0010
I-BIOWAST	33	100	192	2	3	1	1	0	1	0010
I+BIOWAST	33	100	192	2	3	1	1	0	1	0010
N-SSWASTE	31	100	100	0	3	1	0	1	1	0000
N-LOWASTE	31	100	100	3	3	1	1	0	1	0000
L-NFRCOMP	51	100	100	0	0	1	0	0	2	0000
L-DECONRS	51	100	200	2	0	4	1	1	1	0310
N-ISOPROD	51	100	130	1	1	3	1	0	1	0210
N-HIGHACT	52	100	100	0	0	1	0	0	3	0000
N-TRITIUM	52	100	100	3	3	1	1	1	1	0000
N-SOURCES	52	100	100	0	0	1	0	1	2	0000
N-TARGETS	52	100	100	0	0	1	0	1	1	0000
F-PUDECON	11	100	100	2	2	1	1	0	1	0000

P-IXRESIN	11	100	165	1	1	3	0	1	1	0210
P-CONCLIQ	11	600	182	1	1	3	0	1	1	4210
P-FSLUDGE	11	100	165	1	1	3	0	1	1	0210
P-FCARTRG	11	100	100	1	1	3	0	1	1	0210
B-IXRESIN	11	100	165	1	1	3	0	1	1	0210
B-CONCLIQ	11	240	156	1	1	3	0	1	1	4210
B-FSLUDGE	11	100	165	1	1	3	0	1	1	0210
P-COTRASH	21	200	100	3	2	1	0	0	1	1010
P-NCTRASH	51	100	100	0	0	1	0	3	2	0510
B-COTRASH	21	200	100	3	2	1	0	0	1	1010
B-NCTRASH	51	100	100	0	0	1	0	1	2	0510
F-COTRASH	22	150	100	3	2	1	0	0	1	1010
F-NCTRASH	22	100	100	0	0	1	0	0	2	0000
I-COTRASH	23	200	100	3	2	1	0	0	1	1010
I+COTRASH	23	400	100	3	2	1	0	0	1	2020
N-SSTRASH	22	150	100	2	2	1	0	0	1	1010
N+SSTRASH	22	300	100	2	2	1	0	0	1	2020
N-LOTRASH	22	200	100	3	2	1	0	0	1	1010
N+LOTRASH	22	400	100	3	2	1	0	0	1	2020
F-PROCESS	52	100	100	0	3	1	0	1	1	0000
U-PROCESS	52	100	100	0	3	1	0	1	1	0000
I-LQSCNVL	33	128	300	3	3	1	1	1	1	1010
I+LQSCNVL	33	100	300	3	3	1	1	0	1	0010
I-ABSLIQD	33	100	165	3	1	3	1	1	1	0210
I+ABSLIQD	33	100	300	3	3	1	1	1	1	0010
I-BIOWAST	33	100	192	2	3	1	1	0	1	0010

IN2FIL File (cont'd)

I+BIOWAST	33	100	192	2	3	1	1	0	1	0010
N-SSWASTE	31	100	100	0	3	1	0	1	1	0000
N-LCWASTE	31	100	100	3	3	1	1	0	1	0000
L-NFRCOMP	51	100	100	0	0	1	0	3	2	0510
L-DECONRS	51	100	200	2	0	4	1	1	1	0310
N-ISOPROD	51	100	200	1	0	4	1	1	1	0310
N-HIGHACT	52	100	100	0	0	1	0	3	3	0510
N-TRITIUM	52	100	100	3	3	1	1	1	1	0000
N-SOURCES	52	100	100	0	0	1	0	1	2	0000
N-TARGETS	52	100	100	0	0	1	0	1	1	0000
F-PUDECON	11	100	100	2	2	1	1	2	1	0410
P-IXRESIN	11	100	200	2	0	4	0	1	1	0310
P-CONCLIQ	11	600	200	2	0	4	0	1	1	4310
P-FSLUDGE	11	100	200	2	0	4	0	1	1	0310
P-FCARTRG	11	100	100	2	0	4	0	1	1	0310
B-IXRESIN	11	100	200	2	0	4	0	1	1	0310
B-CONCLIQ	11	240	200	2	0	4	0	1	1	4310
B-FSLUDGE	11	100	200	2	0	4	0	1	1	0310
P-COTRASH	61	8000	200	1	0	4	0	1	1	6312
P-NCTRASH	51	100	100	0	0	1	0	3	2	0510
B-COTRASH	61	8000	200	1	0	4	0	1	1	6312
B-NCTRASH	51	100	100	0	0	1	0	3	2	0510
F-COTRASH	62	4000	200	1	0	4	0	1	1	6311
F-NCTRASH	22	100	100	0	0	1	0	0	2	0000
I-COTRASH	23	2000	200	1	0	4	0	1	1	5311
I+COTRASH	23	8000	200	1	0	4	0	1	1	7322
N-SSTRASH	22	1000	200	1	0	4	0	1	1	5311
N+SSTRASH	22	4000	200	1	0	4	0	1	1	7322
N-LOTRASH	22	2000	200	1	0	4	0	1	1	5311
N+LOTRASH	22	8000	200	1	0	4	0	1	1	7322
F-PROCESS	52	100	100	0	3	1	0	1	1	0000
U-PROCESS	52	100	100	0	3	1	0	1	1	0000
I-LQSCNVL	33	452	200	1	0	4	0	1	1	5311
I+LQSCNVL	33	100	300	3	3	1	1	0	1	0010
I-ABSLIQD	33	100	200	1	0	4	1	1	1	0310
I+ABSLIQD	33	100	300	3	3	1	1	1	1	0010
I-BIOWAST	33	1500	200	1	0	4	0	1	1	5311
I+BIOWAST	33	100	192	2	3	1	1	0	1	0010
N-SSWASTE	31	100	100	0	3	1	0	1	1	0000
N-LCWASTE	31	100	100	3	3	1	1	0	1	0000
L-NFRCOMP	51	100	100	0	0	1	0	3	2	0510
L-DECONRS	51	1800	200	1	0	4	0	1	1	6312
N-ISOPROD	51	100	200	1	0	4	1	1	1	0310
N-HIGHACT	52	100	100	0	0	1	0	3	3	0510
N-TRITIUM	52	100	100	3	3	1	1	1	1	0000
N-SOURCES	52	100	100	0	0	1	0	1	2	0000
N-TARGETS	52	100	100	0	0	1	0	1	1	0000
F-PUDECON	11	100	100	2	2	1	1	2	1	0410
P-IXRESIN	71	1800	200	1	0	4	0	1	1	6312
P-CONCLIQ	71	800	200	1	0	4	0	1	1	6312
P-FSLUDGE	71	500	200	1	0	4	0	1	1	6312
P-FCARTRG	71	100	100	2	0	4	0	1	1	0310
B-IXRESIN	71	1800	200	1	0	4	0	1	1	6312
B-CONCLIQ	71	640	200	1	0	4	0	1	1	6312
B-FSLUDGE	71	500	200	1	0	4	0	1	1	6312
P-COTRASH	71	8000	200	1	0	4	0	1	1	6312
P-NCTRASH	51	600	100	0	0	1	0	1	2	3010
B-COTRASH	71	8000	200	1	0	4	0	1	1	6312
B-NCTRASH	51	600	100	0	0	1	0	1	2	3010
F-COTRASH	72	4000	200	1	0	4	0	1	1	6311
F-NCTRASH	52	600	100	0	0	1	0	0	2	3020
I-COTRASH	63	2000	200	1	0	4	0	1	1	5311
I+COTRASH	73	8000	200	1	0	4	0	1	1	7322

N-SSTRASH	62	1000	200	1	0	4	0	1	1	5311
N+SSTRASH	72	4000	200	1	0	4	0	1	1	7322
N-LDTRASH	62	2000	200	1	0	4	0	1	1	5311
N+LDTRASH	72	8000	200	1	0	4	0	1	1	7322
F-PROCESS	52	100	100	0	3	1	0	1	1	0000
U-PROCESS	52	100	100	0	3	1	0	1	1	0000
I-LQSCNVL	63	452	200	1	0	4	0	1	1	5311
I+LQSCNVL	33	100	300	3	3	1	1	0	1	0010
I-ABSLIQD	63	10000	200	1	0	4	1	1	1	5311
I+ABSLIQD	33	100	300	3	3	1	1	1	1	0010
I-BIOWAST	63	1500	200	1	0	4	0	1	1	5311
I+BIOWAST	73	100	192	2	3	1	1	0	1	0010
N-SSWASTE	31	100	100	0	3	1	0	1	1	0000
N-LDWASTE	31	100	100	3	3	1	1	0	1	0000
L-NFRCOMP	51	100	100	0	0	1	0	3	2	0510
L-DECONRS	71	1800	200	1	0	4	0	1	1	6312
N-ISOPROD	51	100	200	1	0	4	1	1	1	0310
N-HICHACT	52	100	100	0	0	1	0	3	3	0510
N-TRITIUM	52	100	100	3	3	1	1	1	1	0000
N-SOURCES	52	100	100	0	0	1	0	1	2	0000
N-TARGETS	52	100	100	0	0	1	0	1	1	0000
F-PUDECON	71	100	100	2	2	1	1	2	1	0410
P-IXRESIN	11	100	100	2	1	1	0	2	1	0410
P-CONCLIQ	11	100	140	1	1	2	0	1	1	0110
P-FSLUDGE	11	100	100	1	3	1	0	2	1	0410
P-FCARTRG	11	100	100	2	2	1	0	2	1	0410
B-IXRESIN	11	100	100	2	1	1	0	2	1	0410
B-CONCLIQ	11	100	140	1	1	2	0	1	1	0110
B-FSLUDGE	11	100	100	1	3	1	0	2	1	0410
P-COTRASH	21	200	100	3	2	1	0	2	1	1410
P-NCTRASH	51	100	100	0	0	1	0	3	2	0510
B-COTRASH	21	200	100	3	2	1	0	2	1	1410
B-NCTRASH	51	100	100	0	0	1	0	3	2	0510
F-COTRASH	22	150	100	3	2	1	0	2	1	1410
F-NCTRASH	22	100	100	0	0	1	0	3	2	0510
I-COTRASH	23	200	100	3	2	1	0	2	1	1410
I+COTRASH	23	400	100	3	2	1	0	2	1	2420
N-SSTRASH	22	150	100	2	2	1	0	2	1	1410
N+SSTRASH	22	300	100	2	2	1	0	2	1	2420
N-LDTRASH	22	200	100	3	2	1	0	2	1	1410
N+LDTRASH	22	400	100	3	2	1	0	2	1	2420
F-PROCESS	52	100	100	0	3	1	0	1	1	0000
U-PROCESS	52	100	100	0	3	1	0	1	1	0000
I-LIQSCVL	33	128	300	3	3	1	1	2	1	1410
I+LIQSCVL	33	100	300	3	3	1	1	2	1	0420
I-ABSLIQD	33	100	165	3	3	1	1	1	1	0010
I+ABSLIQD	33	100	300	3	3	1	1	1	1	0010
I-BIOWAST	33	100	192	2	3	1	1	2	1	0410
I+BIOWAST	33	100	192	2	3	1	1	2	1	0420
N-SSWASTE	31	100	100	0	3	1	0	1	1	0000
N-LDWASTE	31	100	100	3	3	1	1	2	1	0410
L-NFRCOMP	51	100	100	0	0	1	0	3	2	0510
L-DECONRS	51	100	200	2	0	4	1	1	1	0310
N-ISOPROD	51	100	200	1	1	3	1	2	1	0410
N-HICHACT	52	100	100	0	0	1	0	3	3	0510
N-TRITIUM	52	100	100	3	3	1	1	2	1	0410
N-SOURCES	52	100	100	0	0	1	0	1	2	0000
N-TARGETS	52	100	100	0	0	1	0	2	1	0410
F-PUDECON	11	100	100	2	2	1	1	2	1	0410
P-IXRESIN	11	100	100	2	1	1	0	0	1	0010
P-CONCLIQ	11	600	182	1	1	3	0	1	1	4210
P-FSLUDGE	11	100	100	1	3	1	0	0	1	0010
P-FCARTRG	11	100	100	2	2	1	0	0	1	0110

IN2FIL File (cont'd)

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B-IXRESIN   11  100  100   2    1    1    0    0    1 0010
B-CONCLIQ   11  240  156   1    1    3    0    1    1 4210
B-FSLUDGE   11  100  100   1    3    1    0    0    1 0010
P-COTRASH   21  200  100   3    2    1    0    0    1 1010
P-NCTRASH   51  100  100   0    0    1    0    0    2 0000
B-COTRASH   21  200  100   3    2    1    0    0    1 1010
B-NCTRASH   51  100  100   0    0    1    0    0    2 0000
F-COTRASH   22  150  100   3    2    1    0    0    1 1010
F-NCTRASH   22  100  100   0    0    1    0    0    2 0000
I-COTRASH   23  200  100   3    2    1    0    0    1 1010
I+COTRASH   23  400  100   3    2    1    0    0    1 2020
N-SSTRASH   22  150  100   2    2    1    0    0    1 1010
N+SSTRASH   22  300  100   2    2    1    0    0    1 2020
N-LOTRASH   22  200  100   3    2    1    0    0    1 1010
N+LOTRASH   22  400  100   3    2    1    0    0    1 2020
F-PROCESS   52  100  100   0    3    1    0    1    1 0000
U-PROCESS   52  100  100   0    3    1    0    1    1 0000
I-LQSCNVL   33  128  300   3    3    1    1    1    1 1010
I+LQSCNVL   33  100  300   3    3    1    1    0    1 0010
I-ABSLIQD   33  100  165   3    1    3    1    1    1 0210
I+ABSLIQD   33  100  300   3    3    1    1    1    1 0010
I-BIOWAST   33  100  192   2    3    1    1    0    1 0010
I+BIOWAST   33  100  192   2    3    1    1    0    1 0010
N-SSWASTE   31  100  100   0    3    1    0    1    1 0000
N-LOWASTE   31  100  100   3    3    1    1    0    1 0000
L-NFRCOMP   51  100  100   0    0    1    0    0    2 0000
L-DECONRS   51  100  200   2    0    4    1    1    1 0310
N-ISOPROD   51  100  130   1    1    3    1    0    1 0210
N-HIGHACT   52  100  100   0    0    1    0    0    3 0000
N-TRITIUM   52  100  100   3    3    1    1    1    1 0000
N-SOURCES   52  100  100   0    0    1    0    1    2 0000
N-TARGETS   52  100  100   0    0    1    0    1    1 0000
F-PUDECON   11  100  100   2    2    1    1    0    1 0000
0.000E+00 0.000E+00 3.531E-04 1.766E-03 3.531E-03 1.766E-02 3.531E-02 1.766E-01
3.531E-01 1.766E+00 3.531E+00 1.766E+01 3.531E+01 1.766E+02 3.531E+02 5.297E+02
0.000E+00 0.000E+00 0.000E+00 7.000E-03 5.500E-02 1.330E-01 1.940E-01 3.870E-01
4.700E-01 6.910E-01 7.760E-01 9.190E-01 9.580E-01 9.900E-01 9.980E-01 1.000E+00
0.000E+00 0.000E+00 0.000E+00 1.100E-03 2.147E-03 6.049E-03 1.201E-02 4.991E-02
8.701E-02 3.310E-01 5.807E-01 1.653E+00 2.604E+00 4.888E+00 6.936E+00 7.713E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.531E-04 1.766E-03 3.531E-03 1.766E-02
3.531E-02 1.766E-01 3.531E-01 1.766E+00 3.531E+00 1.766E+01 3.531E+01 1.766E+02
3.531E+02 5.297E+02 0.000E+00 0.000E+00 0.000E+00 4.000E-03 1.000E-02 5.300E-02
1.440E-01 4.300E-01 6.340E-01 9.380E-01 9.700E-01 9.960E-01 9.970E-01 1.000E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.700E-03 2.120E-03 1.374E-03
1.567E-02 7.109E-02 1.351E-01 3.636E-01 4.297E-01 5.660E-01 5.835E-01 8.414E-01
0.000E+00 0.000E+00 3.531E-04 1.766E-03 3.531E-03 1.766E-02 3.531E-02 1.766E-01
3.531E-01 1.766E+00 3.531E+00 1.766E+01 3.531E+01 1.766E+02 3.531E+02 5.297E+02
0.000E+00 0.000E+00 0.000E+00 7.000E-03 5.500E-02 1.330E-01 1.940E-01 3.870E-01
4.700E-01 6.910E-01 7.760E-01 9.190E-01 9.580E-01 9.900E-01 9.980E-01 1.000E+00
0.000E+00 0.000E+00 0.000E+00 1.100E-03 2.147E-03 6.049E-03 1.201E-02 4.991E-02
8.701E-02 3.310E-01 5.807E-01 1.653E+00 2.604E+00 4.888E+00 6.936E+00 7.713E+00
0.000E+00 0.000E+00 3.531E-04 1.766E-03 3.531E-03 1.766E-02 3.531E-02 1.766E-01
3.531E-01 1.766E+00 3.531E+00 1.766E+01 3.531E+01 1.766E+02 3.531E+02 5.297E+02
0.000E+00 0.000E+00 1.000E-03 1.000E-03 5.000E-03 4.200E-02 7.100E-02 1.850E-01
2.570E-01 5.630E-01 6.810E-01 9.380E-01 9.740E-01 9.980E-01 9.990E-01 1.000E+00
0.000E+00 0.000E+00 2.500E-04 2.500E-04 1.730E-03 8.663E-03 1.534E-02 6.751E-02
1.214E-01 5.229E-01 8.914E-01 2.669E+00 3.519E+00 4.893E+00 5.141E+00 5.598E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
3.531E-03 1.766E-02 3.531E-02 1.766E-01 3.531E-01 1.766E+00 3.531E+00 1.766E+01
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00 7.500E-02 7.500E-02 5.320E-01 7.550E-01 8.430E-01 9.040E-01 1.000E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00 9.500E-03 9.500E-03 8.724E-02 1.383E-01 2.240E-01 3.864E-01 8.654E-01
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0.000E+00 0.000E+00 3.531E-04 1.766E-03 3.531E-03 1.766E-02 3.531E-02 1.766E-01
3.531E-01 1.766E+00 3.531E+00 1.766E+01 3.531E+01 1.766E+02 3.531E+02 5.297E+02
0.000E+00 0.000E+00 1.000E-03 1.000E-03 5.000E-03 4.200E-02 7.100E-02 1.850E-01
2.570E-01 5.630E-01 6.810E-01 9.380E-01 9.740E-01 9.980E-01 9.990E-01 1.000E+00
0.000E+00 0.000E+00 2.500E-04 2.500E-04 1.730E-03 8.663E-03 1.534E-02 6.751E-02
1.214E-01 5.229E-01 8.914E-01 2.669E+00 3.519E+00 4.893E+00 5.141E+00 5.598E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.000E-02 1.000E-01 5.000E-01
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 5.000E-03 1.730E-02 2.345E-01
H-3 SET1    1.00E+09  1.00E+09  1.00E+09  1.00E+09
C-14        1.00E+09  1.00E+09  1.00E+09  1.00E+09
FE-55       1.00E+09  1.00E+09  1.00E+09  1.00E+09
NI-59       1.00E+09  1.00E+09  1.00E+09  1.00E+09
CO-60       1.00E+09  1.00E+09  1.00E+09  1.00E+09
NI-63       1.00E+09  1.00E+09  1.00E+09  1.00E+09
NB-94       1.00E+09  1.00E+09  1.00E+09  1.00E+09
SR-90       1.00E+09  1.00E+09  1.00E+09  1.00E+09
TC-99       1.00E+09  1.00E+09  1.00E+09  1.00E+09
I-129       1.00E+09  1.00E+09  1.00E+09  1.00E+09
CS-135      1.00E+09  1.00E+09  1.00E+09  1.00E+09
CS-137      1.00E+09  1.00E+09  1.00E+09  1.00E+09
U-235       1.00E+09  1.00E+09  1.00E+09  1.00E+09
U-238       1.00E+09  1.00E+09  1.00E+09  1.00E+09
TRU         1.00E+09  1.00E+09  1.00E+09  1.00E+09
PU-241      1.00E+09  1.00E+09  1.00E+09  1.00E+09
H-3 SET2    1.00E+09  1.00E+09  1.00E+09  1.00E+09
C-14        1.00E+09  1.00E+09  1.00E+09  1.00E+09
FE-55       1.00E+09  1.00E+09  1.00E+09  1.00E+09
NI-59       1.00E+09  1.00E+09  1.00E+09  1.00E+09
CO-60       1.00E+09  1.00E+09  1.00E+09  1.00E+09
NI-63       1.00E+09  1.00E+09  1.00E+09  1.00E+09
NB-94       1.00E+09  1.00E+09  1.00E+09  1.00E+09
SR-90       1.00E+09  1.00E+09  1.00E+09  1.00E+09
TC-99       1.00E+09  1.00E+09  1.00E+09  1.00E+09
I-129       1.00E+09  1.00E+09  1.00E+09  1.00E+09
CS-135      1.00E+09  1.00E+09  1.00E+09  1.00E+09
CS-137      1.00E+09  1.00E+09  1.00E+09  1.00E+09
U-235       1.00E+09  1.00E+09  1.00E+09  1.00E+09
U-238       1.00E+09  1.00E+09  1.00E+09  1.00E+09
TRU         1.60E-02  1.60E-02  1.60E-02  1.60E-02
PU-241      1.60E-02  1.60E-02  1.60E-02  1.60E-02
H-3 SET3    1.00E+00  1.00E+09  1.00E+09  1.00E+09
C-14        1.00E+00  1.00E+09  1.00E+09  1.00E+09
FE-55       1.00E+09  1.00E+09  1.00E+09  1.00E+09
NI-59       1.00E+00  1.00E+09  1.00E+09  1.00E+09
CO-60       1.00E+00  1.00E+09  1.00E+09  1.00E+09
NI-63       1.00E+00  1.00E+09  1.00E+09  1.00E+09
NB-94       1.00E+00  1.00E+09  1.00E+09  1.00E+09
SR-90       1.00E+00  1.00E+09  1.00E+09  1.00E+09
TC-99       1.00E+00  1.00E+09  1.00E+09  1.00E+09
I-129       1.00E+00  1.00E+09  1.00E+09  1.00E+09
CS-135      1.00E+00  1.00E+09  1.00E+09  1.00E+09
CS-137      1.00E+00  1.00E+09  1.00E+09  1.00E+09
U-235       1.00E+00  1.00E+09  1.00E+09  1.00E+09
U-238       1.00E+00  1.00E+09  1.00E+09  1.00E+09
TRU         1.60E-02  1.60E-02  1.60E-02  1.60E-02
PU-241      1.60E-02  1.60E-02  1.60E-02  1.60E-02
H-3 SET4    4.00E+01  1.00E+08  1.00E+09  1.00E+09
C-14        8.00E-01  8.00E-01  8.00E-01  8.00E+00
FE-55       7.00E+02  7.00E+04  1.00E+09  1.00E+09
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IN2FIL File (cont'd)

NI-59	2.20E+00	2.20E+00	2.20E+00	2.20E+01
CO-60	7.00E+02	7.00E+04	1.00E+09	1.00E+09
NI-63	3.50E+00	7.00E+01	7.00E+01	7.00E+02
NB-94	2.00E-03	2.00E-03	2.00E-03	2.00E-02
SR-90	4.00E-02	1.50E+02	7.00E+02	7.00E+03
TC-99	3.00E-01	3.00E-01	3.00E-01	3.00E+00
I-129	8.00E-03	8.00E-03	8.00E-03	8.00E-02
CS-135	8.40E+01	8.40E+01	8.40E+01	8.40E+02
CS-137	1.00E+00	4.40E+01	4.60E+03	4.60E+04
U-235	4.00E-02	4.00E-02	4.00E-02	4.00E-01
U-238	5.00E-02	5.00E-02	5.00E-02	5.00E-01
TRU	1.60E-02	1.60E-02	1.60E-02	1.60E-01
PU-241	5.60E-01	5.60E-01	5.60E-01	5.60E+00
H-3 SET5	4.00E+01	1.00E+09	1.00E+09	1.00E+09
C-14	8.00E-01	8.00E-01	8.00E+00	8.00E+01
FE-55	7.00E+02	1.00E+09	1.00E+09	1.00E+09
NI-59	2.20E+00	2.20E+00	2.20E+01	2.20E+02
CO-60	7.00E+02	1.00E+09	1.00E+09	1.00E+09
NI-63	3.50E+00	7.00E+01	7.00E+02	7.00E+03
NB-94	2.00E-03	2.00E-03	2.00E-02	2.00E-01
SR-90	4.00E-02	1.50E+02	7.00E+03	7.00E+04
TC-99	3.00E-01	3.00E-01	3.00E+00	3.00E+01
I-129	8.00E-03	8.00E-03	8.00E-02	8.00E-01
CS-135	8.40E+01	8.40E+01	8.40E+02	8.40E+03
CS-137	1.00E+00	4.40E+01	4.60E+03	4.60E+04
U-235	4.00E-02	4.00E-02	4.00E-01	4.00E+00
U-238	5.00E-02	5.00E-02	5.00E-01	5.00E+00
TRU	1.60E-02	1.60E-02	1.60E-01	1.60E+00
PU-241	5.60E-01	5.60E-01	5.60E+00	5.60E+01
H-3 SET6	0.00	1.00E+09	1.00E+09	1.00E+09
C-14	0.00	8.00E-01	8.00E+00	8.00E+01
FE-55	0.00	1.00E+09	1.00E+09	1.00E+09
NI-59	0.00	2.20E+00	2.20E+01	2.20E+02
CO-60	0.00	1.00E+09	1.00E+09	1.00E+09
NI-63	0.00	7.00E+01	7.00E+02	7.00E+03
NB-94	0.00	2.00E-03	2.00E-02	2.00E-01
SR-90	0.00	1.50E+02	7.00E+03	7.00E+04
TC-99	0.00	3.00E-01	3.00E+00	3.00E+01
I-129	0.00	8.00E-03	8.00E-02	8.00E-01
CS-135	0.00	8.40E+01	8.40E+02	8.40E+03
CS-137	0.00	4.40E+01	4.60E+03	4.60E+04
U-235	0.00	4.00E-02	4.00E-01	4.00E+00
U-238	0.00	5.00E-02	5.00E-01	5.00E+00
TRU	0.00	1.60E-02	1.60E-01	1.60E+00
PU-241	0.00	5.60E-01	5.60E+00	5.60E+01

APPENDIX E

ERRATA FOR THE DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR 10 CFR PART 61

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Location in DEIS	Errata
Volume 1, page 3, last paragraph	The reference to 40 CFR 501.7 should read 40 CFR 1501.7
Volume 2, page 20, second and last paragraphs	Insert after the words "site owner" the phrase (State or Federal government).
Volume 1, page 20, second paragraph	"Maximum annual thyroid doses are in the range of 850 mrem at the intruder and population wells...." should read "Maximum annual thyroid doses are in the range of 850 mrem at the intruder and boundary wells...."
Volume 1, page 23, third paragraph	The word "quickly" should be removed from the phrase, "Due to radioactive decay, however, the potential hazard quickly drops...."
Volume 2, page xi, first line	"Chapter 10" should read "Chapter 9"
Volume 2, page 4-8, second paragraph	"Over the next 1500 years, however, potential exposures are reasonably constant and are still at about 800 mrem of 2000 years" should read "Over the next 1500 years, however, potential exposures are reasonably constant and are still at about 800 mrem at 2000 years."

Location in DEIS	Errata
Volume 2, page 5-57, second paragraph	Under Case 10A, the sentence "Waste spectrum 2 is assumed" should read "Waste spectrum 1 is assumed"
Volume 2, page 6-3	The numbers in the table at the top of the page are in units of millirem per year or mrem/yr
Volume 2, page 6-11, last paragraph	In the fifth line of this paragraph, the number ".033" should be changed to ".33"
Volume 2, page 7-8, fourth paragraph	"For shorter-lived radionuclides such as C-137...." should read "For shorter-lived radionuclides such as Cs-137...."
Volume 2, page 7-22	The next-to-last line under Mixtures of Radioistopes should have a closing parenthesis after the word "...cm^3..."
Volume 2, page 9-6	Since the draft environmental impact statement on 10 CFR 61 was written, the state of Washington has increased its perpetual care and maintenance funding. The following revisions should be noted: a. The Perpetual Care and Maintenance (PC&M) Fund contribution by US Ecology, currently at $0.275 per cubic foot, will increase to $1.75 per cubic foot. This renegotiated contribution will provide

Location in DEIS	Errata
	a total fund of approximately $6 million by July 1, 1985. The total accumulation will be determined by the actual volume of waste disposal.
	b. In addition, US Ecology will contribute $0.25 per cubic foot of waste disposed to a newly established Contingency Closure Fund. A contribution at this rate will yield a fund of $800,000 by July 1985, assuring that the State of Washington will be able to adequately close the radioactive waste disposal operations conducted at the site if and when needed.
	c. On January 15, 1982, the company will post a surety bond in the amount of $500,000 for a period of one year to protect the state if the company should leave the site without meeting closure conditions as stated in the license.
Volume 3, Appendix E, page E-21	Concentrations listed in Table E.2 should be in micrograms per cubic meter ($\mu g/m^3$), not milligrams per cubic meter (mg/m^3). Also, the EPA standard for SO_2 should be 80 $\mu g/m^3$ as opposed to 60 $\mu g/m^3$ which is shown in the table.

Location in DEIS	Errata
Volume 3, Appendix E, page E-47, third paragraph	The first two sentences in the third paragraph should be deleted and the following sentences inserted as a new paragraph: "Waste is emplaced in the trench, and backfilled with dirt removed during trench excavation. Typically, waste packages are emplaced with the aid of construction equipment such as cranes and forklifts, using a combination of stacked and random disposal. Waste packages such as wooden boxes or steel bins having rectangular dimensions are generally stacked in place while low activity drummed waste is generally emplaced in a more random manner. Special care is taken during emplacement of higher activity waste such as high activity ion exchange liners to ensure operational safety. This combination of random and stacked disposal is termed "random disposal" in this EIS (to distinguish it from a placement alternative of fully stacked disposal: see Appendix F) and results in a trench volume efficiency of about 50%."
Volume 3, Appendix E, page E-50, first paragraph	The next-to-last sentence should be modified to read as follows: "If through a site accident, a worker may receive an open wound and the wound is suspected of having become contaminated, a radiation survey is also performed. The survey is performed for beta and gamma contamination, and also for alpha contamination if alpha emitting isotopes are suspected."

Location in DEIS	Errata
Volume 3, Appendix E, page E-48	The last sentence in Section 5.2.3 should be modified to read as follows: The results of the survey are recorded.
Volume 4, Appendix J, third paragraph	For the last sentence change "underlain" to "overlain."
Volume 4, Appendix K, page K-50, last paragraph	See the changes listed earlier in this appendix under Volume 2, page 9-6.
Volume 4, Appendix N, page N-19, last paragraph	The phrase "National Primary Drinking Water Regulations" should be replaced with "Interim National Primary Drinking Water Regulations."
Volume 4, Appendix Q, page Q-44	The last term in the equation contains two typographical errors. It should read as follows:

$$\frac{IT_o \; PV_{80} \; (1+j)^m \quad i}{V_w \; [(1+i)^{IT_o}-1] \; (1+i)^{IT_c}}$$

APPENDIX F

FINAL RULE AND SUPPLEMENTARY INFORMATION

[7590-01]

NUCLEAR REGULATORY COMMISSION

10 CFR PARTS 2, 19, 20, 21, 30, 40, 51, 61, 70, 73 and 170

Licensing Requirements for Land Disposal of Radioactive Waste

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is amending its regulations to provide specific requirements for licensing the land disposal of low level radioactive wastes containing source, special nuclear, or byproduct material. The amendments provide licensing procedures, performance objectives, and technical criteria for licensing facilities for the land disposal of radioactive waste. Specifically, the regulations establish performance objectives for land disposal of waste; technical requirements for the siting, design, operations, and closure activities for a near-surface disposal facility; technical requirements concerning the waste form that waste generators must meet for the land disposal of waste; classification of waste; institutional requirements; and administrative and procedural requirements for licensing a disposal facility. Amendments to other parts are established to govern the certification and use of shipping manifests to track waste shipments and clarify, but not substantially modify, the requirements of existing regulations. Provisions for consultation and participation in license reviews by State governments and Indian tribes are also included. Specific requirements for licensing facilities for the disposal of radioactive wastes other than high level waste by alternative land disposal methods will be proposed

in subsequent rulemakings. Disposal of radioactive wastes by an individual licensee will continue to be governed by 10 CFR Part 20.

EFFECTIVE DATE: 10 CFR 20.311 of Part 20 effective date is 365 days after publication in the Federal Register, 10 CFR Part 61 and all other changes effective 30 days after publication in the Federal Register.

FOR FURTHER INFORMATION CONTACT: Paul H. Lohaus, Low-Level Waste Licensing Branch, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, telephone (301)427-4500.

SUPPLEMENTARY INFORMATION:

Background

On October 25, 1978, the Commission published an Advance Notice of Proposed Rulemaking (43 FR 49811) regarding the development of specific regulations for the disposal of low-level radioactive wastes (LLW). The development of these regulations was in response to needs and requests expressed by the public, the Congress, industry, the States, the Commission, and other Federal agencies for codification of regulations for the disposal of LLW. The respondents to the advance notice strongly supported the Commission's development of specific criteria and standards for the disposal of low-level waste. The comments received by the Commission on the advance notice were used by the Commission in scoping the form and content of the draft Environmental Impact Statement (EIS) (NUREG-0782) and the regulation.

On February 28, 1980, the Commission also published a Notice of Availability of a preliminary draft regulation, dated November 5, 1979, announcing availability of the draft for public review and comment (45 FR 13104). This was done to help ensure wide distribution and early public review and comment on the development of the rule. Copies of this draft regulation were distributed to all of the States.

During the summer and fall of 1980, the Commission also sponsored four regional workshops to provide an opportunity for open dialogue among representatives of the States, public interest groups, industry, and others on the issues to be addressed in the Part 61 rulemaking. These workshops were particularly useful in formulating our positions on the more judgemental aspects of the rule and underlying assumptions (such as the length of time we should assume that active governmental controls could reasonably be relied on).

Proposed 10 CFR Part 61 and conforming amendments were published on July 24, 1981 (46 FR 38081). The original comment period was due to expire October 22, 1981, but was extended to January 14, 1982 to coincide with the 90-day comment period for the supporting draft EIS (NUREG-0782). The availability of the draft EIS was announced on October 22, 1981 (46 FR 51776). The proposed rule was sent to all Commission licensees and copies were provided to Agreement State officials to distribute to their licensees.

Public comments were received on both the rule and draft EIS and may be examined at the Commission's Public Document Room (PDR) located at 1717 H Street NW., Washington, D.C. Comments on the rule are available at the PDR Docket No. PR-2 et al (46 FR 38081). Comments on the draft EIS are available at the PDR referencing Docket No. PR-61 (46 FR 51776).

A total of 42 persons commented on the draft EIS. These commenters represented a variety of interests. Comments were received from 21 States, 8 industry/utilities, 8 Federal agencies/laboratories, 3 individuals and 2 broker/disposal firms. The comments generally raised or echoed the same issues raised concerning the rule except that some questions on the methodologies and presentation of results were raised. A detailed analysis of the comments on the draft EIS will be included as an appendix to the final EIS (NUREG-0945) which is being prepared.*

OVERVIEW OF COMMENTS ON 10 CFR PART 61

A total of 107 different persons submitted comments on the proposed 10 CFR Part 61. The commenters represented a variety of interests. Comments were received from: 19 industrial groups, 17 state groups, 15 individuals, 13 utilities, 9 federal agencies or laboratories, 6 universities, 4 medical groups, 4 engineering firms, 4 public interest groups, 4 professional organizations, 3 broker/disposal firms, 2 legal groups, 2 surety groups, and 5 others. Commenters offered from one to over 20 comments each. The topics addressed a wide range of issues and all parts of the rule.

The general response was quite favorable. Almost half (47) expressed explicit support of the rule or overall approach. Many of these commenters expressed some concern about one or a few specific provisions and most offered suggestions for improvements. Many expressed the view that the rule provides a needed and adequate framework for establishing additional

*Copies of this report may be obtained by written request to the Division of Technical Information and Document Control, Washington, D.C. 20555. Copies will also be made available for inspection or copying for a fee at the NRC Public Document Room, 1717 H Street NW., Washington, D.C.

low-level waste disposal capacity. The importance, reasonableness, and clarity of the rule were noted. Support was expressed by almost every sector.

Only 15 commenters expressed any outright opposition to the rule or some significant portion of the role. Most were individuals. No state group or current disposal site operator expressed opposition. The opposition expressed appeared to stem from objections to nuclear power and use of radioactive materials, opposition to shallow land burial as a disposal method in general and for TRU wastes in particular, opposition to perceived increase in costs to waste generators, the regulatory burden of the licensing process, and the technical requirements in Subpart D of the proposed rule. Several of the commenters that expressed opposition offered suggestions for improving the rule, however.

Most of the remaining commenters (45) offered constructive comments without taking a general position on the rule, or offered support with reservations about one or more aspect of the rule.

All concerns expressed by all commenters are discussed in detail in a staff analysis of comments which is available in the PDR. Because the volume of comments and analysis in detail occupy several hundred pages, the following discussion summarizes and responds to all comments of major and generic significance. For example, comments on Part 61 standard provisions that are common to all Commission regulations are not discussed in this summary, but are covered in the document available in the PDR.

SUMMARY OF COMMENTS FOR PROPOSED PART 61

Subpart A: General Provisions

A variety of comments were received that related to the scope of the rule. Two clarifying changes were made to make it clearer that uranium

and thorium tailings as defined in Section 11e(2) of the Atomic Energy Act of 1954, as amended, are not subject to the requirements of Part 61, but are disposed of according to requirements in 10 CFR Part 40. In addition, clarifying changes were made to state that the requirements of Part 61 do not apply to persons who are licensed by an Agreement State pursuant to authority relinquished to that State by the Commission in accordance with Section 274 of the Atomic Energy Act of 1954, as amended.

Some commenters felt that provisions should be made for an individual to dispose of his or her own waste. Private waste disposal may be licensed under current provisions of 10 CFR Part 20. The Commission feels that these provisions are adequate and that no change to Part 61 to accommodate private disposal is warranted.

At least two State commenters asked about Agreement State requirements being compatible with Part 61. The Commission is preparing guidance for States that will consider Section 61.2, Definitions; Subpart C, Performance Objectives; Subpart D, Technical Requirements for Land Disposal Facilities; those portions of Subpart B that are necessary to implement the provisions of Subparts C and D; and Section 20.311, Transfer for disposal and manifests; and that portion of Subpart E requiring closure funding arrangements as a matter of compatibility for the Agreement States. Guidance will identify those aspects where uniformity is desirable and those aspects where States would have flexibility in establishing their own requirements.

It was suggested that construction of a disposal facility should be permitted to begin before a license is issued. The Commission believes that to do so would have a detrimental effect on the decision making process and therefore no change is being made to this provision.

In the proposed rule, near surface disposal was defined in § 61.2 and discussed in § 61.7 as disposal in the upper 15-20 meters of the earth's surface. Based on comments received, the wording could be misinterpreted to mean that disposal was allowed only between 15 and 20 meters or that deeper disposal was prohibited. The wording was clarified to make it consistent with the waste classification requirements. (Class A and B wastes have no minimum depth requirement and Class C wastes have a 5 meter depth requirement when relying on depth alone.) Disposal at a depth greater than 5 meters would also be acceptable.

Subpart B: Licenses

Comments received on Subpart B covered a wide range of issues. Many were concerned with clarification and intent. There were, however, several issues that were more substantive and addressed by a large group of commenters.

Several commenters were concerned that the language in several places required the applicant to demonstrate in the application that certain objectives were met. Their concerns were over what would constitute a demonstration, and the impossibility of meeting an objective with complete certainty as implied by the language in the rule. The Commission agrees with these commenters and changes have been made in appropriate places to indicate that what the Commission wants is information or analyses that will provide reasonable assurance that the objective or requirement will be met. Other minor changes were made for purposes of clarification.

An advisory statement in §61.13 that the ground water pathway was generally the most significant for near surface disposal, in terms of releases of radioactivity, was deleted. This section requires an analyses

of all potential pathways and two commentators objected to singling out ground water.

Several commenters expressed concern over the length of time that the licensing process might take and suggested limits be established in the regulations. The Commission does not believe that this is practicable, considering the uncertainties in predicting the quality of future applications, the availability of staff resources at critical times, and the potential for hearings. The licensing process must be in accordance with the Commission's mission to protect public health and safety but the Commission does agree that the licensing process must be carried out in the minimum amount of time consistent with this mission. Some changes in the procedural aspects of the rule are being made with this in mind (see comments, Subpart F). The Commission staff is developing technical positions to assist applicants in preparing their applications and is developing performance assessment capabilities that will enable the staff to perform timely reviews.

Nine commenters addressed the language in §61.25 that prevents the licensee from making any changes in the facility or procedures described in the application except as provided for in specific license conditions. The commenters felt that this was unnecessarily restrictive, in that there may be aspects of the facility or procedures that were described in the application, but which are not important to public health and safety and the licensee should be free to change them. The Commission agrees, since it was not intended that all changes be subject to Commission review or approval, only those important to public health and safety. Section 61.25 is changed accordingly.

Over a dozen commenters raised objections to the requirement that the license be renewed on the usual five year interval with a concomitant public notice on the opportunity to request a public hearing. The dominant reason for these objections is the burden that is perceived if public hearings were held every five years at the time of license renewal. The Commission believes that a periodic reassessment by the licensee and the Commission staff is necessary. This reassessment should factor in the past operating experiences of the disposal facility, the results of monitoring data, changing economic conditions that might affect financial assurances, advances in technology, etc. While there are alternatives to license renewal in order to ensure these periodic reappraisals, the Commission has found through its experience that periodic license renewal is the most effective method. As for the public notice of the renewal and the notice of opportunity to request a public hearing, the Commission agrees that this is not necessary and it has been deleted. Deleting this requirement will not have an adverse effect on the public's interest and rights. According to revised §61.25, any changes to the license conditions from a license renewal process would be subject to notice and opportunity to request hearings if the conditions were in the highest category specified in that section (paragraph 61.25(a)(1)).

Two commenters suggested not subjecting the licensee to an opportunity for hearings at the time of site closure. The Commission believes that this is an important and worthwhile time to provide for public participation. No changes were made.

While none of the commenters took exception with the need for a period of post-closure observation and maintenance by the licensee, a number did object to the open-endedness of the requirements that this period be

for "a minimum of five years." This provision has been changed to state that the period will normally be five years, but that shorter or longer periods may be approved by the Commission in connection with the approval of the site closure plan for a specific site.

Several commenters, including Chem-Nuclear Systems, Inc., and U.S. Ecology, the operators of the existing disposal facilities, were concerned about possible delays in transfer of the license to the site owner at the end of the post-closure observation period. They foresee the possibility of more stringent requirements being imposed at this time, thereby delaying the transfer with an adverse effect on the ability of the licensee to affect proper closure due to changes beyond the financial requirements initially established. The Commission recognizes this possibility, but it is beyond the Commission's authority to control or regulate the site owner and force the transfer to take place. Any requirements for transfer that are outside the public health and safety considerations prescribed by Part 61 become a matter of contract or agreement between the site owner and the site operator. With the Low Level Radioactive Waste Policy Act laying the responsibility for disposal of low level waste on the States, it is obvious that the States will play an increasingly important role. State authorities, who in all likelihood will be the site owners, should become active participants in the disposal activities from the earliest stages of development through site closure and stabilization so that at the time of site transfer to them for institutional control, there are no unforeseen obstacles to the orderly and timely transfer. Part 61 provides for this participation in the licensing process, and as landlord, there are other avenues of participation.

Subpart C: Performance Objectives

A dozen commenters addressed the approach taken in Part 61 to establish performance objectives supplemented by some minimum technical requirements. All commenters except three supported the approach of addressing disposal from an overall systems standpoint, i.e., establishing overall performance objectives and minimum technical requirements and leaving considerable flexibility on how an applicant or licensee would design and operate a site. Of the three who disagreed, one felt that the concern for public health and safety is so great that the rule should be based on prescriptive requirements; one felt that there should be no technical requirements in the rule, only performance objectives; and the third felt that the rule is restrictive by establishing both performance objectives and technical requirements. The comments were judged overall to be sufficiently supportive, that no changes have been made in this regard.

One commenter challenged the performance objectives in Part 61 as being premature in advance of relevant EPA standards and beyond the agency's authority to the extent that they are not already embodied in 10 CFR Part 20 and that they are unduly stringent and unsupported. With respect to this comment, EPA, under its ambient environmental standards setting authority assigned by Reorganization Plan No. 3 of 1970 has the authority to prepare a standard that will set limits for releases of radioactivity to the general environment from disposal facilities. Presently there is no such EPA standard. In the absence of such a standard, the Commission examined a range of limits which bound that expected for the EPA standard and selected a proposed performance objective that

establishes a release limit for the site boundary, a regulatory action within the limits of NRC authority. In a rulemaking action, the Commission is not solely limited to existing standards in Part 20 and the Commission does not intend to withdraw any portion of the rule that may be related to the performance objectives.

With regard to the specific performance objective for releases to the environment, the Environmental Protection Agency commented that the establishment of an individual exposure limit at the site boundary for releases as proposed in §61.41 is appropriate. They stated that the range of 1 to 25 mrem/yr analyzed by the Commission was a reasonable range that should encompass any standard which EPA might derive for low level waste disposal facilities. Based on the Commission's analysis, NRC does not anticipate any need to change the technical requirements of Part 61 to meet a future EPA standard. In their comments, EPA stated their opinion that it was inappropriate to apply the EPA drinking water standard as proposed in §61.41. Accordingly, this part of the performance objective has been deleted. However, this does not diminish the Commission's concern over protecting sources of drinking water. The Commission will assess the potential impact on drinking water supplies as part of its licensing review.

Reaction to the proposed performance objective to protect potential inadvertent intruders was mixed. There were some who felt the proposed 500 mrem whole body dose to the intruder was too high, some felt that it was the right value for a standard, and others felt that higher values were in order. Those that felt that the standard should be higher suggested values of 5 rem or 25 rem (the Department of Energy) to correspond to limits for occupational exposure or one-time exposures to workers

from potential accidents. A number of commenters, in their comments about considering the probability that intrusion will occur, expressed concern about weighting too heavily the protection against inadvertent intrusion in determining disposal requirements for waste. Based on these comments, the Commission believes that the primary concern of those who feel that the intruder protection objective is too restrictive is the effect that this has on the concentrations of certain nuclides that are acceptable for disposal in a near surface facility and the need to meet additional requirements such as stability for some wastes. With this in mind, and in response to other comments, the Commission has reevaluated the calculations that establish the waste classification concentration limits to eliminate unnecessarily conservative assumptions with the result that the analysis is more realistic and the limits for several important isotopes have been raised. With this action, the Commission believes that most of the concerns of those who encouraged higher exposure limits or less emphasis on protection of intruders will have been met.

With respect to those who suggested that lower limits would be appropriate, there were no compelling arguments or technical demonstrations presented that persuaded the Commission to lower the dose limit for intruders.

The EPA recommended that the 500 mrem dose limit be deleted from the performance objective, since the licensee would not be able to monitor or demonstrate compliance with a specific dose limit that applies to an event that might occur hundreds of years from now. They did recommend use of the 500 mrem whole body dose limit coupled with ALARA as the basis for determining the concentration limits in Table 1 of Part 61.

The 500 mrem dose limit has been deleted from the performance objective but retained as the basis of the waste classification limits.

Comments were offered that more emphasis should be placed on requirements, such as the use of durable monuments to warn potential intruders. This concept is incorporated in the regulation.

Acts of terrorism and sabotage were identified as possible intrusion problems and suggestions were made for protecting against such acts. The Commission does not feel that the likelihood of such events or the magnitude of the effects of such acts are sufficient to warrant requirements in this regard.

EPA asked for a clarification of the intent of the performance objective in §61.43 as it pertains to effluents from the site. This performance objective states that operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20. Part 20 contains standards for concentrations of radioisotopes in air and water released from a licensed facility. Section 61.41 sets forth limits on concentrations of radioisotopes released from a land disposal facility which are lower than those in Part 20. It is the Commission's intent that the provisions of Part 20 will apply to all aspects of radiation protection during operation except for releases of radioactivity from the site which will be governed by the more stringent requirements of §61.41. The rule has been modified to clarify this point.

Commenters pointed out a need to be clearer in the rule on how the principle of maintaining radiation exposures to a level that is as low as reasonably achievable (ALARA) will be handled. The Commission intends that the ALARA principle apply to the performance objectives for long-term environmental release and protection of individuals during site operations.

It cannot apply to the intruder performance objective, since Part 61 sets out the requirements for protection and intrusion which is beyond the disposal facility licensee's control. Appropriate changes have been made in §§66.41 and 61.43 to reflect the ALARA principle.

Subpart D: § 61.50, Disposal Site Suitability for Near-Surface Disposal

Approximately two dozen commenters offered comments on various aspects of § 61.50, addressing disposal site suitability requirements. These comments address eight subject areas which are discussed below.

Eight comments were received on the requirement that the disposal site shall be capable of being characterized, modeled, analyzed, and monitored. The comments were directed to the perceived vagueness of the requirement, i.e., what does it mean to be capable of being characterized, modeled, analyzed, and monitored? Some commenters offered suggested rewording or examples. The Commission has issued a staff technical position (NUREG-0902) that provides interpretation and explanation of the meaning and intent of this requirement. In the technical position, it is explained that the site characteristics must be such that limited site characterization can adequately define the site characteristics spatially across the disposal site and that site characteristics should vary with a sufficiently narrow range so that the input to modeling is representative of the hydrogeologic units and the assumptions underlying the modeling are valid. Further, natural processes affecting the disposal site should be occurring at a consistent and definable rate such that the modeling of the site will represent both present and anticipatable

site conditions after closure. Finally, site characteristics must be such that a reasonable number of monitoring points can adequately describe the extent to which radionuclides have migrated from the waste disposal units. In addition, the Commission's staff is developing an in-house modeling capability and will share that capability through pre-qualification of prospective computer codes. The Commission believes that a concise statement in the rule along with guidance on these subjects provided by technical position papers and Regulatory Guides is appropriate.

Several aspects related to ground water were addressed in the comments. Three commenters (Ontario Hydro, the Department of Interior, and the Department of Energy) endorsed the provision in § 61.50(a)(7) that permits disposal below the water table where diffusion dominated the ground water flow system.

The Department of Interior recommended using the term, "molecular diffusion" and both they and Ontario Hydro suggested specifying a limit for soil hydraulic conductivity of less than 10^{-6} cm/sec, as appropriate. There were several commenters who disagreed with this provision and recommended total containment or some minimum depth to the water table.

The Commission envisions a site that would satisfy the exception in section 61.50(a)(7) as one with an inactive flow system so that the water which would contact the wastes would move on the order of less than one foot per year. Given the low hydraulic conductivity and effective porosity of the soils, very little water would actually contact the waste or flow from the disposal units. The travel time will result in sufficient reduction of concentration of the small amounts released and fine-grained soils will typically provide significant attenuation for most radionuclides. No change has been made to this provision of the rule.

Several commenters suggested requirements on retardation properties for soils, both impervious and porous. One suggested a leachate collection and treatment system for the impervious soils. The Commission does not consider it appropriate to set forth specific values for characteristics which promote attenuation of radionuclides. Whereas attenuation is advantageous for some radionuclides, others such as H-3, C-14, and I-129 may not be significantly attenuated. The Commission believes that reliance should be placed on siting requirements which will keep water away from wastes, result in low volumes of contaminated water being released, and provide a long travel time for decay. The Commission takes exception to any design which relies on a leachate collection and treatment system to reduce migration. Such a design is expected to result in a requirement for continued active site maintenance, therefore violating the performance objective in § 61.44.

Several comments recommended that the natural resources considered under § 61.50(a)(4) specifically include ground water and aquifers underlying the site and that the resources of significance were not limited to "economic" significance. Another suggested that the resources be "known" resources so that the applicant would not have to engage in an extensive exploration program to assure that there were no significant natural resources. The Commission considers ground water and aquifers to be natural resources in the context of this requirement. The Commission also agrees that it should not be necessary to conduct extensive exploration studies to prove that no resources exist. Several changes have been made in the sections relating to ground water to reflect these comments.

Commenters raised four questions on the siting requirements related to surface water drainage. These can be summarized as (1) definition of certain terms such as upstream drainage areas, coastal high-hazard area and wetland; (2) the adequacy of the exclusion of waste disposal based on the 100-year floodplain; (3) whether engineering drainage modifications can be made in order to meet the requirements; and (4) the vagueness of some terms.

With respect to the terms "coastal high-hazard area" and "wetland," these are defined in Executive Order 11988, Floodplain Management Guidelines which is noted in the rule. The term "upstream drainage area" can be defined in conventional hydrologic terms as all the land surface which drains, either by channel flow or sheetwash, across the disposal facility.

The 100-year floodplain is that land which would be inundated by a flood having a 1 in 100 chance of occurring in any particular year. The Commission feels the major hazard due to flooding is associated with the period of site operations when disposal units are open. Because of other provisions of the rule, the disposal units will be open a comparatively short time. Once closed, the covers and site drainage system will provide protection against the effects of flooding. The Commission considers 300 or 500-year floodplains to be unnecessarily restrictive; and questions whether an adequate data base or standard methods of determining such floodplains exist.

The question on engineering modifications will be addressed more fully in staff technical positions related to site suitability, selection and characterization and to site design and operations. Engineering features may be used to improve site drainage and protect against flooding during operations.

With respect to the vagueness, or non-prescriptive, nature of the requirements, the Commission considers the siting requirements as site screening tools which will be met in most cases and which, if not met fully, would require a site-specific evaluation to determine whether an exemption is warranted. The Commission finds this preferable to treating more prescriptive siting requirements as exclusionary.

Minor changes of a clarifying nature have been made to the requirements related to flooding.

Several commenters suggested that radioactive waste disposal facilities could be colocated with hazardous waste disposal facilities. The Commission does not object to this as long as the facilities are separated from one another and the wastes are not comingled. The provisions of § 61.50 pertaining to nearby facilities not adversely impacting the ability of the site to meet the performance objectives or significantly masking the environmental monitoring program would have to be met.

Several commenters raised the question of relevance of seismic or volcanic hazards to low level waste disposal, given the orders of magnitude difference between the time frames for those geologic phenomena and the hazard of the low-level wastes. Concern was also expressed that certain areas, such as California, would have all potential sites eliminated by the requirement to avoid seismic areas.

The requirement, as written, provides the Commission a mechanism for site specific evaluation of such factors as recurrence intervals, probabilities, liquefaction potential, and ground accelerations to compare against a long-term (500-year) radiological hazard and the disposal requirements of Part 61. This minimum technical requirement would not arbitrarily eliminate potential sites so much as it would provide a site screening

test which will be met in most cases and will mandate a thorough evaluation of site performance in areas of known tectonic hazards.

Several persons commented on the reliability of long term projections of population growth. The Commission recognizes such projections have a degree of uncertainty. Part of the staff review of any projection focuses on this uncertainty and how it has been handled by the applicant. Previous experience with commercial low-level disposal sites illustrate that suitable sites can reasonably be found in areas of low population density and minimal population growth potential.

Two commenters suggested a siting requirement based on accessibility to major transportation routes. This issue becomes a consideration in site selection and the evaluation of alternatives required under NEPA and is not necessary in the rule.

Individual comments were received suggesting siting requirements related to mechanical and physical properties of soils to make them suitable for compaction and supporting construction equipment, and requirements to avoid areas of high natural radioactivity. Changes to the rule were not deemed necessary. The mechanical and physical characteristics of soils are factors to be addressed in the site design and operations in order to meet stabilization requirements and objectives. With respect to areas of high natural radioactivity, these areas would be excluded if they could be shown to violate the ability to carry out a monitoring program. Otherwise, the Commission sees no valid reason for excluding these areas.

Several commenters raised the general question of the length of time the various siting or design requirements have to be satisfied. Others requested that the design basis natural events or phenomena be identified

and that the length of time for consideration associated with these be stated.

The siting, design, and waste form requirements relate to both stability of the disposal site and control of releases within acceptable limits. Reliance must be placed for a longer time on the site since the waste form and design features will decrease in effectiveness over time. Therefore, each of the siting requirements should be considered applicable over the indefinite future and should be evaluated for at least a 500 year time frame. A 500-year time frame for design basis natural events or phenomena should also be applied.

Subpart D: § 61.51, Disposal Site Design for Land Disposal

Five commenters objected to the absoluteness of the requirements in § 61.51 relative to preventing infiltration and eliminating the contact of water with waste. Comments were also expressed requesting preferential consideration be given to progressive slope design for burial and concern was expressed that the rule does not provide specific guidance for engineered features. Commenters also expressed concern that site areas used for disposal of Class A waste will require more maintenance.

The requirements referred to are expressed as design objectives. Given that these are design objectives, the actual achievement will be to minimize, rather than absolutely prevent or eliminate. The achievement level should be as near the design objectives as is practicable. The wording of these paragraphs has been changed to reflect this. With respect to progressive slope design for burial, the regulation does not specify the type of disposal unit. The site designer should give particular attention to the design of that portion of the facility used for

the disposal of Class A wastes so that the inherently unstable Class A wastes will not interfere with the long-term stability of the site.

Four commenters recommended that warning signs or permanent identification monuments be employed as a deterrent to inadvertent intrusion. Several suggested a design lifetime of 500 years for such markers.

Although there are few "signs" in the traditional sense that have design lives approaching 500 years, the Commission would consider such things as granite monuments near the survey marker control points as an appropriate adjunct to the physical intruder barriers employed in the disposal of the waste. A change to the rule has been made to require such monuments at the time the license is terminated.

Subpart D: § 61.52, Land Disposal Facility Operation and Disposal Site Closure

There were several issues related to facility operation and site closure identified by about thirty commenters. A half dozen commenters raised questions with respect to the requirement that Class A waste be segregated from other classes of waste. Questions also addressed the need for segregation during transportation, the meaning and intent of the term "interaction," and the need for segregation in arid sites.

The intent of the rule is not to prohibit waste from more than one class from being shipped on the same transport vehicle. Consistent with appropriate transportation regulations, the Commission has no objection to commingling different classes of waste in transport.

In identifying the need to clarify the term "interaction," the commenters noted that it was vague and unenforceable, could include migration, and could be physical or chemical interaction.

The intent of the rule is to protect Class B and C wastes. Class A wastes could interact with other wastes directly through the release of absorbed liquids, solvents, or other mobile components that might be present in Class A waste. Indirect interaction could result from degradation of Class A waste and its lack of stability. Consolidation of Class A wastes would provide a less stable support which could contribute to failure of the disposal unit cover leading to increased precipitation infiltration and surface water intrusion. The degree to which these interactions could occur depends to a large extent on site specific characteristics and the Commission does not believe that it is appropriate to set a prescriptive requirement in this area in the rule. The wording of this requirement has been changed to define the purpose for the segregation and minimization of interaction between the segregated wastes. The rule also permits Class A that meets the stability requirements to be placed with Class B and C wastes.

The State of Washington regulates the disposal site located in an arid region near Richland, Washington. The state noted that without the likelihood of ground water or surface water being factors at arid sites, segregation of Class A wastes seems to be unnecessary. They also noted that commingling Class A and B wastes would dilute the Class B wastes and have potential benefit.

The State's observations may have merit for arid sites but are difficult to adopt in a rule that must address sites located in all parts of the country. The Commission anticipated the need to consider alternative disposal requirements and included §61.54, "Alternative requirements for design and operations" to provide for consideration of such alternatives.

A number of commenters noted that factors other than waste form play a role in assuring the stability of the site. In the area of site operations, these factors are identified as the way in which waste is emplaced and the filling of voids in between waste packages after emplacement. Several pointed out the stability problems (slumping, etc.,) that could still be associated with disposal units containing the segregated and unstable Class A waste. A number of commenters objected to the requirement that wastes must be emplaced in an orderly manner because of perceived increased exposures. The requirement that was proposed in paragraph (4) of § 61.52(a) was intended to assure that the placement of packages into a disposal unit did not destroy the integrity of the package in order to minimize the possibility of releases of contamination, and also to minimize the void spaces between packages so that this would not be a contributor to site instability. It has been a common practice at waste disposal facilities to dump some wastes over the edge of a disposal trench with the packages falling and tumbling to the trench bottom where they ended up a random arrangement. This practice jeopardizes package integrity and does not permit access to voids between packages so that they could be backfilled. The assumption by the commentors that orderly emplacement necessitates increased handling by site operators with resultant higher radiation exposures is not necessarily the case. Lifting and stacking devices are currently in use for low level waste disposal that permit remote lifting and emplacement in the disposal trench without increased occupational exposure. The resulting emplacement meets the intent of protection of packaging integrity and access to void spaces. Since the term "orderly" was subject to misinterpretation, the requirement has been rewritten to remove the term and to specify the objectives of emplacement.

Six commenters addressed the requirement for maintaining a buffer zone of at least 100 feet. These comments generally supported the concept and purposes of a buffer zone, but questioned whether the specified 100 feet was sufficient. The Department of Interior suggested that the buffer zone should be three dimensional to include some distance below the disposal site.

In response to these comments, the Commission has restated the requirement in terms of the objective to carry out monitoring activities and take mitigative measures if needed, and has made the buffer zone three dimensional.

Several persons commented on the need to conduct ancillary activities at the disposal facility such as storage, waste treatment, truck terminals, etc. Concern was expressed over the language in §61.51(a)(7) that would seem to preclude such activities. Others felt that provisions should be made in Part 61 for the description and licensing of such activities.

The provisions of § 61.51 that caused the concern was that the disposal site shall be used exclusively for the disposal of radioactive wastes. The intent of this provision was to prevent the disposal of wastes such as toxic or hazardous chemicals which do not contain radioactive material at the facility. It was not intended, as could easily be inferred from the way the requirement was worded, that disposal is the only activity that could take place. Corrective word changes have been made to clarify this. The purpose of Part 61 is to specify the regulatory requirements for the disposal of radioactive waste. Existing requirements in Parts 30, 40, 70, et al., would govern the licensing of

other activities involving licensed radioactive materials, such as waste treatment or storage.

Several comments questioned the meaning of the term, "a few percent above background" as applied to the requirement that limits radiation levels at the surface of the disposal unit cover. Some suggested values from as low as 1 percent of background to as high as 1 mrem/hour (about 5000 percent of background). One commenter suggested that the radiation limit should not be confined to gamma radiation, but should be expressed as a dose rate to include other types of radiation.

The rules in Part 20 contain provisions for permissible levels of radiation in unrestricted areas in § 20.105. The Commission considers these to be appropriate for application at the time that the disposal facility license is transferred to the site owner for the period of institutional control. Although access to the site will be controlled to prevent inadvertent intrusion and the site could be viewed as a restricted area, the Commission believes it is not proper to consider those who do have access, such as caretakers and site maintenance personnel, as radiation workers who could receive much higher occupational exposures. Therefore, §61.52(a)(6) has been changed to reflect the Part 20 unrestricted limits.

A number of other individual comments and suggestions were considered and were addressed in the detailed analysis of comments. Some clarifying changes were made to the rule as a result.

Subpart D: § 61.53, Environmental Monitoring

Only nine commenters addressed the provisions for environmental monitoring. One commenter observed that analyses of release pathways should

be conducted so that they may be validated by data acquired from subsequent monitoring, a point with which the Commission agrees. Two comments addressed the 12-month preoperational monitoring requirement: one thought it too long, the other too short. While a one-year period of site specific data may not provide the range of fluctuations in data expected over a longer period, the site specific data can be augmented by reconnaissance level data or regional data that can be correlated with the site-specific data. These activities should be started early enough in the site development process that they do not interfere with a timely submittal of an application. Additional data may be obtained as the licensing process continues which can be used to update the application.

It was noted that the environmental monitoring requirements are not detailed or specific and at least one commenter suggested that highly detailed prescriptive requirements be set forth. Because of the wide variety of site-specific conditions, and a desire to avoid overly prescriptive requirements in Part 61, the Commission does not feel that this suggestion is practicable. A Branch Technical Position on monitoring is being prepared and will provide additional guidance.

It was pointed out that one important purpose of a monitoring system is to provide early warning of migration of radionuclides from the disposal site before they leave the site boundary. The Commission agrees, and has made a clarifying change to that effect.

The Department of Interior recommended that "geochemistry" be added to the site characteristics to be studied. This has been done.

Subpart D: § 61.55, Waste Classification

Over half of the commenters on Part 61 offered comments on one aspect or another of the waste classification provisions. Nearly 20 different issues were identified and addressed in the staff's detailed analysis of comments. In general, there was support for the concept of identifying wastes that were generally acceptable for near-surface disposal and further dividing this general category into more specific classes. Most of the comments were related to understanding how these categories were established and the basis for them; support for further identifying a class of waste that would not be of any regulatory concern because of its low radioactivity, i.e., a "de minimis" level; what should the upper limits be, particularly for certain radioisotopes such as the transuranic elements; what provisions will be made for disposal of wastes that exceed the limits for near-surface disposal; and how does a waste generator show compliance with the waste classification requirements. There were a large number of comments requesting clarification and restructuring of the requirements to make them more understandable, as well as a number of miscellaneous comments.

With respect to those comments that the numbers used to define waste classification were not adequately explained or supported in Part 61, it should be noted that most such comments were submitted before the supporting Draft Environmental Impact Statement (DEIS) for Part 61 became generally available. Since a considerable part of the DEIS is devoted to the derivation of the waste classification numbers, the Commission does not feel that the basis needs to be repeated in detail in the rule. The Commission is preparing an analysis of the comments received on the DEIS and these

comments will be factored into the final EIS to make the basis for waste classification values more understandable. Other commenters on the numerical values suggested the use of values reported in an earlier NRC contractor document, NUREG/CR-1005. The present waste classification scheme proposed in Part 61 drew on this and other earlier work; however, the earlier approaches to waste classification did not consider the effects of stability or waste form.

Table 1 proposed values for several radionuclides that were the same value regardless of the class of waste. This has lead to some confusion and misunderstanding. In the disposal of wastes, precautions are taken to provide protection against intrusion for the first several hundred years. These precautions include institutional controls, waste form requirements, and intruder barriers. There are certain radionuclides common to waste that are of such a long half-life that they will be present several hundred years from now in essentially the same concentration as when they were originally disposed. Therefore, the rule limits the initial concentrations of these radionuclides to values that will be acceptable after several hundred years when the intrusion protection measures are not considered to be effective.

Over one fourth of all commenters endorsed the concept of setting levels for wastes below which there is no regulatory concern, the so-called "de minimis" level. Some of the commenters supporting the de minimis concept made direct reference to the Commission's position that exempting particular waste streams from compliance with the Part 61 regulations was preferable to setting generic levels for all isotopes. Several disagreed with this position, although at least one of these commenters remarked that as there is not yet a consensus on a generic de

minimis level, any level chosen would be premature. A number of other commenters suggested that a de minimis classification be added to the Part 61 regulations, perhaps as an additional column in Table 1.

Several commenters suggested that NRC permit case-by-case review of requests for specific application of the de minimis concept during the period criteria are being developed. Others suggested specific values for specific waste streams or radioisotopes.

The fundamental concern of practically all commenters was not as much whether a generic or a case-by-case approach be taken, but rather that action to develop de minimis standard should be taken as soon as possible.

The Commission agrees with the importance of setting timely standards for disposal of certain wastes by less restrictive means. The Commission agrees with the commenters that establishment of such de minimis levels would reduce costs of disposal for many licensees and would also conserve space in disposal faciltities which are otherwise designed for wastes having much higher activities. The Commission also believes that establishment of de minimis levels is important in enhancing overall stability of a disposal facility, and therefore in reducing potential long-term site maintenance and corresponding costs, since de minimis levels would reduce the volume of Class A waste. This would also tend to reduce ground water migration impacts, since subsidence and water infiltration would be reduced.

Regarding the issue of setting de minimis levels on a generic or on a case-by-case basis, the Commission still believes that the current policy of examining waste streams on a case-by-case basis will result in the quickest and best results. It is recognized that setting generic limits

may be a desirable goal, and the Commission plans to work toward this goal over the next few years. Meanwhile, the Commission believes that the process of examining a few specific waste streams will facilitate the development of generic requirements and is accelerating its efforts on setting standards for disposal of wastes by less restrictive means. In this regard, the Commission staff is willing to accept petitions for rulemaking from licensees, licensee organizations, or others for declaring certain waste streams to be of no regulatory concern. Such petitions should provide at least the following information:

- a description of the process by which the waste is generated;
- a description of the waste generated, including chemical characteristics;
- the radionuclide content of the waste, including principal as well as trace contaminants;
- a description of the potential change in the radionuclide content as a function of process variations;
- a description of the process control and quality control programs by which the licensee would ensure compliance.

Waste streams common to a number of licensees and in which the radionuclide content is well known and relatively nonvarient are generally preferred. Individual licensees may also continue to request amendments for alternative disposal methods for the licensee's own waste pursuant to § 20.302.

Of all the values proposed in Table 1, the limits for contamination by alpha emitting transuranic elements received the most attention and comments. There were a number of issues raised related to the allowable concentration, ranging from its validity to the impacts of meeting the

limit. By far the most comments were related to the magnitude of the limit. Of the 23 commenters on the transuranic issue, four thought the 10 nCi/gm limit should be retained or lowered, while the remaining 19 suggested that the limit be raised. Those who suggested that the limit be raised presented a number of supporting arguments. Many, if not most, of the commenters suggested that the limit could be safely raised to 100 nCi/gm. One argument given is the advantage of enforceability of the higher limit. With current measurement techniques, it is argued that it is very difficult if not impossible to certify that waste contains less than 10 nCi/gm, but much less difficult to certify that it is less than 100 nCi/gm. Others pointed out that a 100 nCi/gm limit would encourage volume reduction through incineration and other means while conversely, the 10 nCi/gm limit would discourage volume reduction, contrary to the Commission's policy on volume reduction. The commenters cited a number of reports, documents, and ongoing activities as providing justification for their contentions, including a proposed revision to the Department of Energy Manual Chapter 0511. Some commenters felt that the Commission's calculations were excessively conservative. The most common comment in this regard was that the analysis did not consider dilution by other wastes, and if that dilution were considered, the allowable concentration could be increased by an order of magnitude or more.

The commenters that supported the 10 nCi/gm limit or did not want it raised generally made statements of endorsement for the value because of prior use or because of the view that wastes exceeding this limit should not be buried at commercial low-level waste disposal sites. Concern in this regard was also expressed over the provision in § 61.58

that the Commission could, on a case-by-case basis, grant exemptions to the waste classification requirement, thereby permitting disposal of higher concentrations of transuranic radionuclides.

In response to these comments, the Commission has reevaluated the analyses for disposal of waste containing transuranic nuclides, in an attempt to temper unnecessarily conservative assumptions, such as not considering the dilution by other wastes that decay to essentially inert levels with time, so that more realistic estimates of consequences will result. As a result, disposal limits for Class C, waste have been raised to 100 nCi/gm for long lived alpha emitting transuranic nuclides. For Class A wastes, the limit remains at 10 nCi/gm. The details and results of these analyses are presented in the Final Environmental Statement supporting Part 61.

Several commenters wanted to know what to do with waste containing Radium-226, a radioisotope which is not currently listed. It appears that there are two types of radium wastes to be considered: (1) small concentrated sources of radium such as radiation sources or luminescent dials, and (2) wastes which contain small amounts of radium incidential to other radioisotopes, such as radium contained in wastes from uranium separation processes. The former is not subject to regulation by the Commission, since radium is a naturally-occurring isotope and is not included in the provisions of the Atomic Energy Act of 1954, as amended. The Environmental Protection Agency has a program for collection of radium sources. This program may be phased out in the next few years. Such sources are expected to be transferred to the Department of Energy for storage and disposal. As for radium incidental to other types of waste, the Commission has made provisions for disposal of small quantities of

uranium tailings as Class A waste. For purposes of this provision, a small quantity is defined as 10,000 kilograms containing not more than 5 millicuries of radium-226. This concentration is typical of uranium mill tailings (0.5 nanocuries per gram). The quantity of radium-226 is that contained in 150 pounds of natural uranium at equilibrium with its daughter products. 10 CFR Part 40 permits any person to possess and use under general license 150 pounds of source material per year. Permitting the disposal of such a quantity in a near-surface disposal facility is judged to be acceptable. For larger amounts, specific approval would be required.

Several commenters expressed concern with a footnote in Table 1 and § 61.55(d) which indicate that greater concentrations than Class C limits may be determined to be acceptable for near-surface disposal under certain conditions. Commenters were either opposed to permitting any higher concentrations or asked for clarification of what the requirements would be for higher concentrations.

The Commission established the Class C limits using the performance objectives as criteria to ensure safe disposal of waste considering the degree of protection provided by "normal" near-surface disposal. To ensure that the performance objectives are met, disposal of higher concentrations of isotopes than those listed in Table 1 would have to be by disposal technologies having greater confinement capacity or protection than "normal" near-surface disposal. Such improved disposal technologies could, depending on the particular radioisotopes, involve better waste forms or packaging, or disposal by methods having additional barriers against intrusion (e.g., burial at depths greater than 5 meters). The Commission believes that some flexibility should be permitted, provided

the performance objectives are met, and therefore will evaluate exceptions on a case-by-case basis. In the meantime, the Commission is beginning studies to establish criteria for the disposal of wastes that are not normally suited for near-surface disposal. These would be the subject of future rulemaking.

Over one dozen commenters, nearly all of which were nuclear utilities or industry groups, expressed concern with how one determines compliance with the waste classification requirements. Most were concerned that the regulations would require them to routinely measure for every isotope in Table 1 within each package of waste. Many examples were given of the difficulty that this would present, citing heterogeneous waste mixtures, difficult to measure radioisotopes, increased costs, radiation exposures to personnel, etc. A number of suggestions were offered related to means of classifying the waste by its source, measuring key isotopes to infer quantities of more difficult-to-measure isotopes, and establishing different limits for every disposal site.

The Commission expects licensees to carry out individual programs to assure proper classification of waste. However, the Commission does not feel that detailed measurements routinely made on all waste packages are necessary or desirable. The Commission staff is developing guidance to licensees on a number of alternative methods by which compliance can be shown. At present, the Commission staff has identified four basic programs which may be used either individually or in combination by licensees. They are: materials accountability; classification by source; gross radioactivity measurements; and direct measurement of individual radionuclides including scaling some radionuclides based upon measurement

of others. These methods are discussed in the Branch Technical Position on Waste Classification being prepared.

Several commenters also raised the issue of averaging concentrations to comply with the concentration limits. One expressed concern about the potential for concentrated or "hot spots" of transuranic nuclides permitted under the proposed provision to allow concentrations to be averaged over the volume of the package. Since the trace transuranic nuclides in most shipments will be homogeneously distributed and incidental to the total activity, averaging over the packages is physically representative of the majority of wastes. Reprocessing or other future changes in waste streams which might change the transuranic character of the waste can be addressed in subsequent rule changes. Other commenters were concerned about potential ground water restricted inventory limits on radionuclides which are present in wastes in very low concentrations. Assay of individual packages for these nuclides is difficult as discussed in the preceding paragraph. Averaging the concentration of radionuclides such as Tc-99 or I-129 over the waste shipment or control on a total site inventory basis was suggested to minimize conservative over-reporting. Such over-reporting could exhaust site inventory limits and lead to inefficient use of the site. The Commission agrees. This issue will also be addressed in the Branch Technical Position on Waste Classification. The concentration averaging language in the final rule was changed to provide additional flexibility for the specific guidance being developed in the Branch Technical Position.

In a related issue, a few commenters remarked on the difficulty of inspection and enforcement to ensure compliance with the Part 61 requirements, citing past history of waste shippers not complying with the present DOT and NRC shipping requirements.

The Commission has recognized the importance of increasing inspection and enforcement activities in the processing, packaging, and transportation of waste. A number of programs have been initiated to improve compliance. At the present time, enforcement comes largely on the basis of provisions in the existing regulations (e.g., 10 CFR Parts 30, 40, and 70) that no licensee may transfer licensed material to another person unless that person is properly licensed to receive it. Requirements on waste form, concentrations, etc., are a part of the disposal site licensee's license. The Commission believes that issuing regulations to which all waste generators and disposal site operators would be subject will give the Commission a stronger basis for inspection and enforcement. Adoption of uniform requirements by Agreement States will greatly bolster the effectiveness of a national system of inspection and enforcement.

There were several commenters who argued that the waste classification scheme tends to discourage volume reduction, since this increases concentrations of radioisotopes and may result in a change in classification, or at the extreme, make the waste unacceptable for near-surface disposal. As long as the resulting concentrations of radioisotopes are within the limits set by Part 61, the Commission does not feel that waste classification necessarily discourages volume reduction. While a higher classification of waste might result in more stringent requirements on waste form and disposal methods, there are economic considerations that need to be considered by the waste generator. The cost of processing, shipping, and disposal of a small volume of higher classification waste needs to be compared with the transportation and disposal of a larger volume of a lower classification waste. There is no reason to believe that the balance will always be against volume reduction. For wastes

with concentrations that would place them not generally acceptable for near-surface disposal if they were volume reduced, the provisions for specific Commission approval of the disposal of such wastes provides a potential alternative for licensees considering volume reduction.

Several commenters were concerned with materials which may be present in low level radioactive waste which may be chemically toxic or hazardous. Some suggested that the Commission's waste classification system incorporate a "total hazard" approach that would consider both the radiological and chemical hazard of wastes. At least one comment did not favor the total hazard approach because of the very complex classification system that the commenter perceived would result.

The Commission has stated publicly on several occasions that if it were technically feasible to classify waste by total hazard, then it would make eminently good sense to do so. We do not now know of any scheme for such classification; however, the Department of Energy intends to support research into the development of a classification system for hazardous waste that might be compatible with Part 61. In the meantime, the Commission will study the chemical toxicity of low-level waste, with special emphasis on identifying any licensees who generate hazardous wastes subject to requirements of the Environmental Protection Agency. We will look then at what could be done, perhaps through processing, to minimize the hazard.

Furthermore, the Commission believes that the technical provisions of Part 61 generally meet or exceed those expected in the Environmental Protection Agency's rules for the disposal of hazardous wastes. Although it is not the Commission's intent to allow disposal of hazardous wastes in a radioactive waste disposal facility, as is noted in the regulation,

the Commission recognizes that such wastes may be present in low-level radioactive wastes. It is the Commission's view that disposal of these combined wastes in accordance with the requirements of Part 61 will adequately protect the public health and safety. Such hazardous wastes are expected to be such a small percentage of the total volume that dilution by other wastes would greatly minimize any risks. The Commission intends to work closely with the Environmental Protection Agency to assure continued compatibility. Further, EPA in its response to a resolution of the Conference of Radiation Control Program Directors indicated their willingness to work with other Federal agencies to address this problem.

Several commenters raised questions on the basis or criteria for setting site inventory limits for certain radionuclides, as was indicated in Table 1 of the proposed rule. Some correctly noted that such inventory limits would be site specific. The Commission established concentration limits for radionuclides based on a number of considerations, including protection of a potential intruder, operational safety, and long-term site stability. In addition to concentration limits, the Commission desires the ability to limit maximum site inventories for some isotopes that are of concern from a ground water point of view. Isotopes which are both mobile and long-lived are iodine-129, technetium-99, and carbon-14. Tritium is of concern due to its extreme mobility and its presence in waste in large quantities. Establishment of inventory limits through site-specific license conditions for such radionuclides will help ensure that the performance objectives for ground water migration are not exceeded. The Commission does not plan, as was suggested by a few commenters, to establish site inventory limits for every isotope to protect against potential intrusion. Inadvertent intruder exposures are mainly

controlled by the concentration of a particular isotope, and to a lessor degree by the site inventory.

Several commenters raised specific points about the cost and regulatory burden of the waste classification requirements. Much of the concern was related to the issue of costs for determining compliance with the concentration limits, as discussed earlier. The basis of the concentrations, in particular the 10 nanocurie per gram limit for transuanic nuclides was of concern and is discussed elsewhere. One commenter expressed the view that the classification requirements would raise the cost of disposal because of perceived increased cost for disposal of Class A waste and the cost of quality control activities.

While some costs will be associated with these concerns, when they are weighed against the longer term costs and institutional burdens that may result if the requirements are not adopted, the Commission judges the short-term costs to be warranted.

The State of Nevada, who regulates the Beatty site, expressed the view that the rule will increase the burden and expenses of the regulatory agencies. Two reasons cited related to monitoring the adequacy of site maintenance funds and inspection of waste generator packaging and classification activities.

Monitoring the adequacy of funding is already a part of the program for regulating disposal sites and is only peripherally related to waste classification in that stability is not assumed for Class A wastes. This is not different from the existing situation at disposal facilities where a large percentage of waste is not in a stable form. Thus, this does not appear to be a significant increase in regulatory burden. Inspection of waste generators for compliance with waste classification is more the

responsibility of the Commission or the Agreement State regulating the generator. Existing regulatory responsibilities include inspection of the packaging and shipment of radioactive waste. The incremental burden of reviewing a licensee's program for classifying these wastes should be small.

In addition to the above issues, a large number of commenters offered individual comments on a variety of points of clarification, format, definition, and completeness of the provisions for waste classification. While not summarized here, they are addressed in the detailed analysis of comments by the Commission staff, and to the extent practicable, these comments were reflected in the revision of § 61.55.

As a result of these comments, § 61.55 has been revised to present the classification values in two tables rather than one. Those radionuclides with long half-lives, along with some shorter-lived precursors of long-lived nuclides, are now listed separately in a new Table 1. The presence of these long-lived radionuclides will dominate the classification of the waste. If waste contains less than one tenth the concentration of such a nuclide listed in Table 1, it is Class A waste; greater than that, it is judged to be Class C waste provided the concentration does not exceed the value shown in Table 1. Shorter-lived radionuclides are listed with a range of concentrations in Table 2. Depending on the concentration, wastes containing only these shorter-lived nuclides will be judged to be Class A, B, or C. If waste contains nuclides listed in both tables, the mixture must be considered in determining the waste class. If Table 1 nuclides are present in concentrations less than one tenth the Table 1 limits, the class is determined by the Table 2 nuclide concentration. If Table 1 nuclides exceed one tenth of the Table 1 limits the waste is Class C regardless of the Table 2 concentrations.

The phrase "theoretical maximum specific activity" has been eliminated ana replaced with a notation of "no limit." A footnote to Table 2 explains that while there is no theoretical limit for concentrations of certain nuclides in Class B and C wastes, practical considerations such as radiation and heat generation will determine the limits.

Several radionuclides have been removed from the originally proposed table. Cesium-135 was removed because it is present in wastes in very small concentrations and classification will be determined by the presence of Cs-137 and because Cs-135 is a pure beta emitter which is very difficult to measure. Similarly, the radionuclides Ni-59 and Nb-94 have been removed except as they may be contained in activated metals. As examined in the draft environmental impact statement for Part 61, these nuclides are present in reactor wastes (other than activated metals) in such small concentrations as to be insignificant. Uranium has been removed as a radionuclide that must be considered for waste classification. The Commission's analysis shows that the types of uranium-bearing wastes being disposed of do not present a sufficient hazard to warrant limitation on the concentration of this naturally occurring material. Both depleted and enriched uranium do not contain daughter products in any quantity because of the relatively short time since the uranium was refined from ore, compared to the half-lives of the uranium isotopes. The daughter products are disposed of primarily as uranium mill tailings. Primarily for these reasons, the uranium limits were dropped.

For a number of radionuclides, the maximum allowable concentrations in Class C waste have been increased by a factor of ten. This came in response to a number of comments received on the proposed rule and the draft environmental impact statement that pointed out where unnecessarily

conservative assumptions had been incorporated into the calculations for intruder protection. These comments pointed out that waste disposed beneath five meters of cover would be difficult to contact even at 500 years and that such waste would be diluted by the other wastes whose radioactivity had decayed to extremely low levels. Additionally, the average concentrations tend to be only a fraction of the maximum permissible. At the present time, these are recognized by the Commission as conservative assumptions and the Commission has found that an order of magnitude increase in Class C limits is warranted. This order of magnitude increase has not changed the established framework of factors such as relying on up to 100 years of institutional control and a 500 mrem whole body limit for intruders.

The radionuclide, curium-242, was added to the nuclides in Table 1. While Cm-242 is a relatively short-lived nuclide (163 days) it decays to plutonium-238, a transuranic nuclide with a half life of nearly 90 years. The concentration of 20,000 nanocuries per gram for Cm-242 will result in a concentration of 100 nanocuries per gram of Pu-238.

To the extent practicable, the numerous footnotes originally found in the proposed Table 1 were eliminated and have been incorporated, where appropriate, into the textual part of the section on waste classification.

In response to a number of comments, a statement is made that permits the concentrations of nuclides in waste to be determined by means other than direct measurement. These methods may include such things as material accountability, where records of receipts, shipments, and inventories can confirm that waste concentrations could not exceed permissible concentrations. Other indirect methods might include "inferential" measurements where a ratio is established between nuclides in a mixture and the

concentrations of the difficult-to-measure nuclide is inferred based on measurement of some easier-to-measure nuclide. Whatever the indirect method used, there should be reasonable assurance that the values determined could be correlated with actual measurements. For example, in the case of inferential measurements, the ratio on which the value is determined should be based on previous actual measurements. In the other example above, the receipts, shipments, and inventories should be based on measured values.

Subpart D: § 61.56, Waste Characteristics

A large number of comments were received addressing both the minimum and the stability requirements for waste form characteristics in § 61.56. The following summarizes the comments on the minimum requirements.

One commenter objected to the use of absorbent material to immobilize liquids contained in Class A waste, stating that using absorbent materials was an obsolete technique. The State of South Carolina recommended that this requirement apply only to institutionally generated aqueous or biological waste forms. Since various absorbents have been shown to be effective with liquids, such as organic solvents, oils, etc., the Commission sees no reason to restrict the use of absorbent material to aqueous or biological waste. The Commission does not see any reason to restrict the use of absorbents to institutional generators.

Eighteen commenters stated that the requirement (proposed in Table 1, §61.55) to obtain specific approval to dispose of wastes containing greater than 0.1 percent chelating agents was too restrictive, and stated that utilities might decide against performing decontamination operations which could reduce occupational exposures. Several commenters requested the basis for the 0.1 percent limit. One commenter recommended that no chelating agents be permitted.

Since chelating agents have been shown to increase the migration of certain radionuclides at certain sites, the Commission desired to evaluate the disposal of large quantities of wastes containing high concentrations of chelating agents on a case-by-case basis. This approach was used when the Commission staff reviewed the disposal of wastes that would be generated in the decontamination operations at the Dresden Unit 1 Station. Because the disposal of wastes containing chelating agents is dependent on the characteristics of the disposal facility and on the properties of the waste form, the Commission has modified the chelating agent disposal requirements to reflect this. The Commission has placed on the disposal site license applicant the responsibility for describing the conditions for disposal of waste containing chelating agents. If approved by the Commission, site specific requirements will be placed on the disposal facility licensee. At this time the waste generator will be required only to identify such wastes in the information contained on the shipping manifest.

At the request of comments, definitions have been added for the terms, "hazardous," "pyrophoric," and "explosive."

Of five comments received on the prohibition against packaging waste in cardboard or fiberboard boxes, four felt the prohibition is unnecessary. One commenter supported the provision. After reviewing the comments, including the reasons presented, the Commission still believes that such a prohibition is needed. The experience cited by the Department of Energy, of successfully using cardboard containers for waste packages at their sites, does not include extensive handling and transportation that commercially generated wastes might encounter. The existing prohibition against cardboard and fiberboard containers at existing disposal facilities came

about as a result of unfavorable experience in receiving, handling, and disposing of wastes in such containers. No change has been made in this requirement.

Ten commenters addressed the requirements relating to waste in a gaseous form. Several noted an inconsistency between the provisions in §§ 61.56(a)(5) that prohibits wastes capable of generating toxic gases, and 61.56(a)(7) that permits up to 100 curies of activity in waste in a gaseous form. Several requested the basis for the 100 curie limit. A recommendation was made that gases should be processed into liquid or solid forms, and another felt that gases should be limited to several microcuries. The Department of Energy recommended that krypton 85 immobilized by zeolite encapsulation or ion implantation into metal be permitted with concentrations up to five million curies per cubic meter.

The intent of §61.56(a)(5) is to prohibit the disposal of wastes that are chemically reactive under ambient conditions and produce toxic gaseous reaction products. This section is not intended to prohibit the disposal of properly packaged gases such as H-3 or Kr-85 which occasionally require disposal. This section has been reworded to clarify the intent. The 100 curie limit derives from the existing limits at commercial disposal facilities. The Commission has studies underway to determine whether higher limits would be appropriate. Such limits, if justified, would be proposed in a future rulemaking. In lieu of a requirement that gases be converted to a liquid or a solid, the Commission is evaluating the significant generators of tritium wastes and investigating improved package designs for tritium wastes which would be capable of retaining the contents until they had decayed to innocuous levels. The requirements of Part 61 do not contemplate the disposal of millions of

curies of Kr-85 as suggested by the Department of Energy. The Commission is not prepared to set disposal requirements for this waste at this time, and since this waste is not liable to be generated by Commission licensees in the near future, the Commission believes there is ample time to assess the still emerging technology for krypton fixation and establish suitable disposal requirements through future technical guidance or rulemaking action.

Some commenters felt that the requirement in § 61.56(a)(1) that waste packages presented for disposal must comply with NRC and DOT transportation regulations implied that outer packaging such as shipping casks must also be disposed. This was not the Commission's intent. Since proper packaging for transportation purposes is specified in regulations elsewhere, the Commission feels that it is not necessary to restate them in Part 61, particularly in view of the confusion created. This requirement has been deleted.

As discussed earlier, the Commission is concerned with the possible hazards presented by non-radiological components of the radioactive waste. This was recognized in the requirement proposed that wastes containing biological, pathogenic, or infectious material must be treated to reduce the potential hazard to the maximum extent practicable. The Commission believes it is prudent to add hazardous properties to this requirement and has done so.

A variety of comments were received on the proposed requirements in §61.56(b) that pertain to the stability of Class B and C wastes. These are discussed below for the various aspects of the requirement.

Nine commenters commented on the statement that the requirements were intended to provide stability for at least 150 years. Three thought

that the 150 years was overly restrictive and two recommended 100 years to correspond to the institutional control period. Others observed that some nuclides would not decay to low levels during the 150 years, that Class A waste should also be stable because of the presence of Cs-137 and Sr-90, that steel drums could not be expected to last this long, and that high integrity containers have not been tested for 150 years.

The Commission has reviewed the 150 year stability requirement with respect to the scenarios used to calculate the waste classification values. The property of stability contributes to meeting successfully several of the performance objectives set forth in Part 61. A waste that is stable for a long period helps assure the long term stability of the site, eliminating the need for active maintenance after the site is closed. This stability helps to assure against water infiltration due to failure of the disposal unit covers and, with the improved leaching properties implicit in a stable waste form, minimizes the potential for radionuclide migration in groundwater. Stability also plays an important role in protecting an inadvertent intruder, since the stable waste form is recognizable for a long period of time and minimizes any effects from dispersion of the waste upon intrusion.

The 150 year period was initially chosen to approximate the active life of a near-surface disposal facility, along with the periods of post-closure observation and institutional controls. At the end of this period, the intrusion scenario is based on the intruder readily recognizing any uncovered waste as something out of the ordinary with the result that no further attempts at construction or agriculture would be attempted. When other aspects of the performance objectives are considered, however, a longer design life is called for. The waste should continue to maintain

its gross physical properties and maintain a measure of its identify for several hundred years more to provide site stability and to keep the Class B and C waste recognizable and unsuited to the construction and agriculture scenarios postulated. Consistent with its desire to avoid prescriptive requirements where possible, the 150 year specification has been removed. It is the Commission's belief, however, that to the extent that it is practicable, waste forms or containers should be designed to maintain gross physical properties and identity over 300 years, approximately the time required for Class B waste to decay to innocuous levels. This is reflected in Commission staff technical positions.

Fourteen commenters indicated that the proposed requirement that a stable waste form maintain its physical dimensions within five percent was overly restrictive and impossible to achieve due to the impracticality of filling containers to 95 percent capacity. Commenters also noted that asphalt and polymeric solidification agents would be incapable of meeting this requirement because of their viscoelastic creep properties. Commenters also observed that the limit could entail added expenses.

Upon review of the proposed requirement, the Commission has concluded that there is not sufficient basis at this time to support a numerical limit for deformation of stable waste. The five percent value has been removed from this requirement. Reliance will be placed on the requirements that void spaces within packages must be minimized, that wastes must be emplaced in a manner that permits void spaces between containers to be filled, and that these spaces must be filled.

With respect to void spaces in waste containers being reduced to the extent practicable, six comments were received. Several requested specific criteria on how this would be met and if filler materials were

needed. Two felt that economics would drive waste generators to package the maximum volume of waste into a container and that this requirement in the rule is unnecessary.

Due to the highly variable nature of wastes, the Commission believes that it is not possible or desirable to include specific criteria for minimizing voids. To the extent that void spaces can contribute to eventual instability of the waste, they should be eliminated or reduced as much as possible. This might be done in some cases by filling void spaces with other wastes or inert materials.

Eleven commenters objected to the specific requirement that the stability of waste be maintained under a compressive load of 50 pounds per square inch (psi). Most felt that the specific requirement should be deleted and replaced by a more general requirement to reflect actual disposal site conditions and operations.

In response to these comments, the 50 psi specification has been removed from the rule. The specification was based on conservatively assuming maximum burial depths up to 45 feet and waste or overburden density of 150 lb/ft^3 Testing performed on acceptable solidified waste specimens indicate that 50 psi compressive strength should be easily obtained. The Commission believes that while this is achievable, some latitude should be allowed for the design of waste forms and containers to reflect site conditions where burial depths may be less.

Since § 61.56(b) permits the stability of waste to be achieved by placing the waste in a suitable container for disposal, a number of comments addressed the properties such a container should exhibit and the uses to which it should be put. It was suggested that the Commission

reexamine design criteria for a high integrity container for highly dispersible forms, and one suggested that such container should be used for both high and low concentration wastes. A major supplier of waste solidification technology questioned whether the use of a container reflected the best available technology and the concepts of ALARA.

Three commenters, two of whom are suppliers of waste solidification technology and services, felt that ion exchange resins should all be solidified and that disposal of ion exchange media by dewatering is not within the concepts of ALARA and use of the best available technology.

The Commission staff is preparing a technical position on waste form criteria, including design criteria for a high integrity container. Draft copies have been made available to interested parties for their review and comment. In short, the technical position states that the container must provide as much assurance of stability for as long as required for a stable waste form or product. It should be designed, to the extent that it is practicable, to contain the waste and maintain gross physical properties and identity over 300 years, under the conditions of disposal. The Commission believes that the use of containers to achieve stability is consistent with the concept of ALARA and the use of the best available technology. Occupational exposures in using high integrity containers are expected to be similar to or less than waste solidification, either with mobile or installed systems.

Several commenters addressed the proposed limitation of free standing liquid which would require that such liquids be reduced to as low a level as is reasonably achievable, but in no case to exceed 1 percent. Further, the proposed rule stated that the liquid should be non-corrosive. There were no requests to increase the value. However, one waste solidification

service supplier recommended a limit of zero, while the State of South Carolina recommended implementing the limits in the license for the Barnwell disposal facility, i.e., 0.5 percent for solidified wastes, 1 percent for waste in high integrity containers. Several commenters asked for a definition of the term "non-corrosive."

The Commission has reexamined the proposed limit on free standing liquid and judged that solidified wastes and wastes in high integrity containers should be addressed separately. The Commission has concluded that existing waste solidification technology can produce a waste form that is essentially free of free standing liquid. In order to compensate for potential condensation of water vapor sealed in containers, the Commission believes that a limit of 0.5 percent by volume is appropriate for solidified wastes. For dewatered products, such as ion exchange resins, that are in a container designed to ensure stability, it is very difficult to ensure that such products would meet a 0.5 percent requirement following transport to a burial site. Therefore, for dewatered products, 1 percent should be allowed to account for settling during the transport period. The non-corrosive properties of the liquids will be defined and discussed in a staff technical position, rather than in the regulation. To provide a degree of consistency between Class A wastes and the Class B and C wastes, the limitations on liquids in Class A wastes have been modified. Liquid waste must be packaged with sufficient absorbent material to absorb twice the volume of the liquid. Solid wastes with incidental liquids must meet the 1 percent free standing liquid requirement.

Two commenters pointed out what they perceived as inconsistencies between Part 61 and other Commission rules or guides. One of the guides

referenced is the Effluent Treatment Systems Branch Technical Position 11-3. This document was revised in July 1981 and is consistent with Part 61 requirements. The Commission fails to see inconsistency between Part 61 and its supporting EIS, with Appendix I of Part 50, or guidelines for storage of waste, as claimed by the commenters.

Subpart D: § 61.57, Labeling

Several commenters offered suggestions or raised questions on the requirement that waste packages be labeled to show the classification of the contents. The commenters suggested color coding, different wording, consistency with DOT labeling, minimum standards, and asked for clarification of responsibilities.

The requirement for labeling is to provide the disposal facility operator with information as to whether the contents are Class A, B, or C wastes so that he will be able to dispose of them in the proper manner. The Commission does not feel that a Federal standard for such labeling is warranted, only that it be clear and legible. Individual facility operators may have operating procedures that could be enhanced by label location, size, color, etc. Since the label is to benefit the operator, it is more appropriate for him to set specifications through contractual arrangement. A suggestion to simplify the nomenclature on the labels was adopted and a minor change was made in § 61.57.

Waste classification labeling is in addition to labels required by DOT for transportation purposes. There is a similarity in nomenclature between the Class A and B wastes and the Type A and B packages used by DOT. DOT requires that packages be labeled as to whether they are Type A or B, therefore, there could be some confusion if the packages are labeled

to indicate the waste classification. However, DOT has a variety of numerical and alphabetical designations and it is difficult to avoid some similarity in designation.

Subpart D: § 61.59, Institutional Requirements

There were few comments on the requirement for State or Federal ownership of the disposal site. Those commenting expressed general support. One commenter suggested that the State should have an option to turn ownership and responsibility for long-term custody over to the Federal government. Such an option is not available under current law. In related comments, two commenters expressed concern over the State's responsibility and liability after accepting the disposal site for custodial care. Since the State does become responsible for the site, the State must be involved and aware of the operations and conditions at the site during its operation. This could be done through some independent oversight as landlord, or through participation with NRC in the review of the initial application as provided in Subpart F of Part 61.

About twenty commenters addressed the appropriateness of the 100 year limit on institutional controls and its effect on wastes acceptable for disposal under the conditions prescribed by Part 61. All commenters expressed support in one way or another for defining a time frame for institutional control related either to the hazard duration of the waste or assurance of continued government stability or concern. It was generally agreed that waste that was potentially hazardous after the end of the assured institutional controls should be disposed of by methods providing greater controls and assurances against potential exposure. These comments are judged to support the provisions of Part 61 that

combine institutional controls with waste form, site characteristics, and site design and operations to provide assurances that potential exposures will be within acceptable limits. Class A waste that is potentially accessible and unrecognizable is no longer hazardous after 100 years. Special provisions for waste being in a stable form and in some cases buried deep assure against potentially unacceptable exposures or releases for up to 500 years.

There were a number of suggestions that the period of institutional control should be raised from 100 to 300 years. There appear to be two basic reasons for these suggestions. One reason is that institutions such as a state or the Federal government can reasonably be expected to survive for much longer than 100 years. A second reason is that the 100 year restriction on institutional care affects the waste concentrations acceptable for disposal as Class A waste with resultant higher costs to the waste generator. With respect to the first reason, the Commission feels that it is not a question of how long the government can survive, but how long should they be expected to provide custodial care. Based on work done by EPA, public comments on a preliminary draft of Part 61 and an advanced notice of proposed rulemaking, and four regional workshops, a clear consensus was developed which supported the 100 year limit. The Commission has not seen any compelling reasons to change its view on the 100 year limit.

Some commenters expressed the view that the government landowner should have flexibility in controlling site access during the institutional control period and that productive uses of the land which would not affect site integrity should be permitted. The Commission agrees and words to that effect have been added to the Concepts section, 61.7.

Subpart E: Financial Assurances

Approximately two dozen commenters responded to the proposed financial assurance requirements for closure and post-closure care. In general, the commenters expressed support for the rule's establishment of financial assurances for closure and for long term care of a LLW disposal site. Commenters mentioned that the existing history of LLW disposal sites revealed a strong need to require licensees to demonstrate evidence of financial responsibility so that the public health and safety were protected and also so that potential liabilities do not rest with state taxpayers.

Several commenters felt that the financial requirements should provide more detail. The Commission agrees and has prepared a draft Branch Technical Position on Funding Arrangements for Closure and for Long-Term Care of a LLW Disposal Site that provides definitive guidance for evaluating all financial assurances, including surety bonds.

One of the major points raised by a variety of commenters was that the proposed regulation failed to address financial responsibility for unanticipated contingencies at a LLW disposal site. One group expressed concern that the regulations set the stage for a "tax-payer funded bailout" of poorly-run disposal sites. They felt the industry should bear these costs, and that the regulations should be written to make this explicit. Another commenter noted that the experience of the State of Kentucky with Maxey Flats emphasized the importance of making contingency funds available in the event that serious problems occur. They felt this issue should be addressed in the rulemaking. One State further noted that the rule failed to mention who would be financially responsible if

problems occur at the site that cost more than were budgeted on an assumption of normal operation. These questions cover such a variety of different scenarios (i.e., Acts of God, licensee negligence, etc.,) that it is not possible to specifically respond to all of the potential contingencies. However, a general response to the overall issue of responsibility for contingencies at a low-level waste disposal site is possible. These comments cover two different time periods--the post-closure period, when the original licensee is still responsible at the site, and the institutional control period, when the license has been transferred to the landowner of the site for a period of up to one hundred years. In the case of the post-closure care period, the licensee would be responsible for all activities at the site found necessary by the Commission to protect the public health and safety. Financial responsibility for activities during the institutional control period are a matter to be worked out between the site owner (i.e., the State or Federal Government) and the licensee in their lease or other legally binding arrangement. It is possible that if the site owner were a state, they would work out an arrangement whereby the site operator would collect a surcharge from waste generators for the institutional control period. The rights and responsibilities of the State and the licensee would be determined at such a time.

With regard to contingencies, one commenter also asked who would assume responsibility for a site and its accompanying waste when it was closed prematurely by NRC, due to rule violation. Responsibility for a site closed prematurely by the NRC would depend on the situation. Additionally, closure would be a last resort of the Commission, since the agency has other authorities, such as civil penalties, to require

licensee compliance. In the event it would become necessary to close the site for health and safety reasons, the rule provides that the licensee continues to be responsible until the license is terminated. In the event that the licensee's financial condition deteriorated so that he was unable to maintain the site to protect the public health and safety, then the Commission would probably require the site owner (either the State or Federal government) to assume responsibility at the site.

Regardless of who assumed responsibility for a prematurely closed site, the rules require that a licensee have available at all times during the site life, sufficient financial guarantees to ensure that sufficient funds are available for site closure and decommissioning. These funds would be available for properly maintaining the site if the original licensee were unable to do so.

Several commenters considered that the rule should resolve the issue of financial responsibility for contingencies by requiring liability insurance or specific language that licensees would be required to indemnify property owners in case of off-site migration. Although not proposed in the original rule, the staff evaluation of these public comments indicates there is a need for licensees to provide financial responsibility for liability coverage for off-site bodily injury and property damage. The Commission thinks the public health and safety and the environment would be protected from unanticipated contingencies by such coverage, as well as assisting the States in establishing disposal sites. Four existing LLW disposal facilities currently carry this type of liability coverage, and several other State and Federal agencies, including EPA have imposed similar requirements for hazardous and radioactive waste facilities in order to protect the public health and safety

and the environment. However, at the present time, the Commission's only statutory framework for establishing such a requirement is Section 170 of the Atomic Energy Act, also known as the "Price-Anderson" Act. This type of coverage is designed to cover "catastrophic events" primarily for nuclear reactor licensees, and the Commission feels this coverage would be in excess of the risk at a low-level waste facility. Therefore, the Commission has not established a third party liability requirement in this regulation. The Commission will strongly encourage licensees to continue to carry third party liability insurance coverage through the conventional insurance market.

A variety of comments were received concerning the short term financial assurances required for closure and decommissioning. Several commenters supported the rule's use of a variety of different options for closure, noting that flexibility was crucial if the proposed rule was to function in a reasonable manner.

Other commenters expressed support for the rule's provision requiring that the amount of surety liability change with changes in cost estimates. One commenter also was concerned that the financial surety arrangements increase in value over time to compensate for the effects of inflation. The rule allows the Commission to periodically assess the amount of funds collected for both closure and post-closure care of the site and if necessary, the Commission could require the financial assurances to be increased to account for inflation, unforeseen problems, and unanticipated costs.

Commenters expressed support for the variety of alternatives allowed to demonstrate short term financial responsibility. However, several commenters mentioned that no commercial market exists to provide surety

bonds of the type mentioned in the rule. In developing the rule, the Commission is aware that surety bonds of the type proposed in the rule may be unavailable at this time. However, the Commission included this alternative in the rule in the event that this type of coverage becomes available in the insurance market at a later time.

Commenters were also divided about whether the Commission should allow self-insurance as a financial assurance for closure. Several commenters felt that self-insurance would not satisfy the surety requirements, and they recommended that licensees should be required to place specific funds in escrow to cover costs of decontamination, closure and stabilization. Another commenter suggested that self-insurance be based on an annual submittal of financial reports, i.e., a financial test.

The Commission rejected the use of stand alone "self-insurance" based on the Commission's lack of confidence in this method to provide adequate assurances. Further, state officials have informally expressed the need to have tangible funds available from the licensee for site closure, so the State as landowner would not be left financially responsible. While not specifically allowing its use on a generic basis in the rule, the Commission will evaluate the use of financial tests proposed by licensees on a case-by-case basis.

Commenters also expressed support for the need to have a long-term care fund established at the time a license is issued. Some commenters wanted the rule to explicitly require the licensee to set aside funds for long-term care. However, the Commission currently lacks the authority to require a licensee to establish a fund to provide for long-term care of the site after the license is terminated. Instead, the Commission can only require a licensee to provide evidence of entering into a

lease or other binding arrangement with the site owner indicating that the two parties have established financial responsibility for long-term care between themselves. With regard to the lack of authority, one person suggested that the Commission ask Congress for authority to require financial assurances for licensees for the active institutional control period. The NRC has raised this issue with Congress both in testimony and in a letter commenting on waste legislation.

Subpart F: Participation by State Governments and Indian Tribes

Many of the comments on Subpart F were concerned with interpretations and clarifications. These have been answered in the detailed analysis of comments. Two noteworthy changes were made. In §61.71, a change was made to ensure that the Director shall make Commission staff available for discussion with the State or tribal governing body. At the request of the Department of the Interior, a statement was added to § 2.101 to indicate that the Commission will inform the U.S Bureau of Indian Affairs when tribes have been notified of the filing of an application.

The Commission has been examining ways by which the licensing process can be shortened in time. One way is to conduct activities in parallel where possible, rather than sequentially. One such area is in the submittal and evaluation of proposals by States and Indian tribes for participation in the NRC license review, as provided by Subpart F. As proposed, §61.72 would provide up to 120 days after an application was docketed for a State or tribe to submit a proposal for participation. The time from initial submittal of the application until it has been docketed is estimated to be 60 days or more. Thus, there is a potential

delay of 180 days between the time NRC would receive a proposal and could begin the serious consideration of the proposal. Until resolution were reached on the role a State or tribe would play in the review, the NRC's review of the application could be significantly hampered.

The Low Level Radioactive Waste Policy Act of 1980 clearly states that it is a State's responsibility to provide for the disposal of low level waste. The Act also provides for the formation of interstate compacts for this purpose, subject to Congressional approval. Thus, any application for a disposal facility license will have had State or compact participation and backing for a significant period of time before submittal. During this time, the Commission believes that the State will have had ample opportunity to determine what role it wants to play in the review of the application. This also holds true for other States that are parties to an interstate compact. Therefore, §61.72 is being changed to require that a proposal from the State in which the facility is proposed, or from any State involved in a compact with the State, must be submitted within 45 days after the application has been tendered. However, the Commission notes that a more prompt submittal by the State would help reduce delays.

Although it is to be hoped that the States will inform Indian tribes of plans for disposal facilities and provide them with sufficient information to permit them to make a proposal at an early time, there is no way of ensuring this. Therefore, Indian tribes and States not covered above will be given 120 days from the tendering of an application to submit their proposal. It is anticipated that the participation of Indian tribes and non-compact States will not impact the schedule of the licensing process as much and this additional time can be accommodated.

The Commission believes that there should be sufficient information in the tendered application on which to base a proposal and that it is not necessary to wait until the acceptance review is completed and the docketing procedure carried out.

By making these changes, review of proposals can be carried out earlier and in parallel with the other reviews. It is expected that this could reduce the licensing time by up to six months.

It should be noted that participation by States and Indian tribes pursuant to Subpart F of Part 61 is not through an adjudicatory hearing. If an adjudicatory hearing is requested, then 10 CFR Part 2 applies.

A provision was added to §61.25 to ensure that State, local, and Indian officials were notified of the opportunity for a hearing for certain types of amendments to the disposal facility license.

Subpart G: Records, Reports, Tests, and Inspections

Several commenters made suggestions on records and reports and the need for resident inspectors. Comments were also offered encouraging state involvement in records review and inspections. Two suggestions, relative to reporting any release of radioactivity and a requirement for maintaining duplicate sets of records were rejected as being impracticable. The Commission, however, would encourage protection of records so that they would not be vulnerable to loss because of fire, flood, or other occurrence. The other suggestions did not require modification of the regulations in order to accomplish what was suggested.

10 CFR Part 2: Rules of Practice

No major issues were raised by the several comments on the proposed amendments to Part 2.

10 CFR Part 20: § 20.311 Transfer for Disposal and Manifests

Because any licensee might make a waste shipment and thus be subject to the proposed manifest system requirements, the Commission mailed copies of the proposed rules to each of the Commission's approximately 9,000 licensees. In addition, some 12,000 copies were furnished to the Agreement States for distribution to their licensees. Out of this large group came a total of 29 letters commenting on the manifest system. These comments were wide ranging, with the majority of questions or suggestions being raised by only one commenter. Only a handful of issues drew more than one comment, with four being the largest number of comments on any issue. As a result of these comments, several changes were made to the proposed requirements to clarify some aspects.

To deal with the situation where a waste collector picks up waste directly from the generator, provisions are made for delivering the manifest to the collector at that time. The waste collector will not be required to attach copies of all waste generator manifests to his, as long as the collector's manifest has the information for each package that is required by § 20.311(b). The person transferring wastes will be required to maintain a signed copy of the manifest or equivalent documentation such as a computor generated printout from the transferee containing the same information and binding acknowledgment as the record required by Parts 30, 40 and 70 governing transfer of licensed material. This was done to provide inspectable records at the waste generator's facility which demonstrate compliance with the manifest requirements.

Changes were made in the requirements dealing with quality assurance. The term quality "assurance" has been changed to quality "control" and

management's role has been modified to require evaluation of audits rather than the conduct of such audits.

Of note is that only one commenter, a midwest utility, addressed the question of the burden that the manifest would represent to small entities. When the manifest requirements were proposed, the Commission judged that they would not have significant economic impact on small entities. Pursuant to the Regulatory Flexibility Act, the Commission solicited comments on this matter.

General Comments

Seventeen commenters expressed concern with the use of absolute terms in the rule such as "eliminate" and "prevent." One was concerned about the lack of absoluteness of "reasonable assurance."

As discussed elsewhere, most of the places where such terms were used were in the context of design objectives. Since total achievement of such absolute objectives is unlikely, modifications have been made to the requirements to require minimization or prevention to the extent practicable.

Twelve commenters made suggestions on the kinds of additional regulatory guidance they felt was needed. The Commission agrees with the need for regulatory guidance and has a program underway to provide such guidance, first in the form of staff technical positions, then as Regulatory Guides. Most of the topics addressed by the commenters are already under development. Consideration is being given to the development of guidance on other topics suggested by the commenters.

One commenter suggested exempting wastes in storage prior to the effective date of the regulation from the packaging and labeling requirements. This comment touches on a subject with broader implications, the phasing in of the Part 61 requirements, consistent with the ability of licensees, Agreement States, and applicants to make necessary changes to assure compliance.

The following sections and subparts will be considered a matter of compatibility for the Agreement States when the rule is adopted: Section 61.2, Definitions; Subpart C, Performance Objectives; Subpart D, Technical Requirements for Land Disposal Facilities; those portions of Subpart B that are necessary to implement the provisions of Subparts C and D; that portion of Subpart E requiring closure funding arrangements; and Section 20.311, Transfer for disposal and manifests. Meetings were held with Agreement State representatives and agreement was reached on a method for uniform implementation of the manifest requirements, waste classification, waste form, and the effective date of Section 20.311 which was set at 365 days after publication in the Federal Register.

Since all other provisions of the proposed rules would pertain only to applicants for new Commission-licensed disposal facilities, there are no reasons to delay the effective date of these requirements. The Commission is working with the Agreement States to develop model regulations to be adopted by the Agreement States in accordance with their agreements to maintain compatible state regulations.

Applicability of the requirements in Part 61 to Commission disposal facility licenses in effect on the effective date of the rule will be

determined on a case-by-case basis and implemented through terms and conditions of the license or by orders issued by the Commission.

There were a variety of comments related to commenters questions about the development of new sites, concerns over nuclear facilities becoming de facto disposal sites, the need for an environmental impact statement, and an extension of the comment period for Part 61 to correspond with that of the environmental impact statement. These comments are addressed in the detailed analysis of comments and had no effect on the rule. The comment period was, in fact, extended from October 22, 1981 to January 14, 1982 to correspond with that for the EIS.

About one third of all commenters offered editorial suggestions that were aimed at improving clarity, correcting grammatical errors, and noting typographical errors. These were very helpful in preparing the final version of the rule.

Employee Protection

A new 10 CFR 61.9 has been added concerning job protection for employees who provide information to the Commission. The new section is included in this final rulemaking to carryout the Commission's intent that all specific licensees will have similar responsibilities under its employee protection regulations. See the Federal Register notice (47 FR 30452) dated July 14, 1982 for the basis for this action.

New 10 CFR 61.9 emphasizes to employers - that is, licensees, applicants, and their contractors and subcontractors - that termination or other acts of job discrimination against employees who engage in activities furthering the purposes of the Atomic Energy Act and the Energy Reorganization Act is prohibited. In addition, new 10 CFR 61.9 makes

the employee aware that if discrimination of this nature is believed to have occurred, a remedy is available through the Wage and Hour Division of the Department of Labor. To ensure that employees of licensees and applicants are aware of these amendments, these organizations are required to post their premises with explanatory material related to the prohibition of discrimination and availability of a remedy in the event of discrimination.

Paperwork Reduction Act

As required by the Paperwork Reduction Act, P.L. 96-511, the recordkeeping and reporting requirements in the proposed amendments to 10 CFR 20 incorporated in the 10 CFR 61 rulemaking were submitted to the Office of Management and Budget and were approved. The proposed amendments to 10 CFR Part 20 were not significantly altered as a result of public comments so that approval remains valid. The application, reporting, and recordkeeping requirements contained in 10 CFR 61 apply only to land disposal facility operators and affect fewer than 10 persons and, therefore, are not subject to OMB clearance.

Regulatory Flexibility Act

Based upon the information available and on the public comments received on the proposed rule, and in accordance with the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission hereby certifies that this rulemaking will not, if promulgated, have a significant economic impact upon a substantial number of small entities.

The Regulatory Flexibility Act (Public Law 96-345) was signed into law in September 1980. The Act's principal objective is to make certain

that Federal agencies try, where possible, to fit regulatory requirements to the scale of the affected activity. Significant economic impacts on a substantial number of small entities is a major concern. Part 61 and accompanying rule changes will potentially impact a significant number of persons licensed by the Commission and the Agreement States. The following discussion addresses the factors in the analyses required by the Act and the public comments received. The draft and final EIS's for Part 61 provide additional background information and analysis of the impacts of this rulemaking action.

Section 604 of the Regulatory Flexibility Act requires that the need for the regulatory action be clearly established. The need for standards to govern the disposal of low-level radioactive wastes and new regulations to implement these standards was discussed in detail in the draft EIS. The majority of the public comments supported the rule and thus affirmed the need for the rule and the regulatory framework it establishes.

Section 609 of the Regulatory Flexibility Act requires that small entities have an opportunity to participate in the rulemaking when the rule will have a significant economic impact on a substantial number. Since the Commission's initial certification of no significant impact was a qualified one, special efforts to reach small entities were made. For example, the proposed rule was distributed to all Commission licensees (9,000) and made available to Agreement States (12,000 licensees) with a cover letter highlighting the points that might impact them. Comments were solicited from groups such as the Health Physics Society, a national organization of professionals concerned with radiation safety, many of whose members will have to prepare manifests and coordinate compliance with the rule. The Health Physics Society

publicized the rule in its newsletters to members. Of some 107 different commenters responding, none specifically addressed the Regulatory Flexibility Act or the summary analysis. One utility (which is not a small entity) did make a general qualitative reference to burdens on small entities. Twelve commenters representing a variety of sectors (not just small entities) addressed the potential burden of the manifest system.

Section 604 of the Regulatory Flexibility Act further requires a summary of the issues and a statement of any changes made in the proposed rule as a result of the comments. Two commenters were concerned about the burden of specifying chemical form. Four commenters objected to shipper responsibility for tracking shipments. Three commenters including one broker considered the system to be a paperwork burden and two, a general burden. Three supported the system and one indicated no problems in complying. Two objected to forwarding a copy of the manifest and one was concerned about the implications of generator certifications.

The proposed rule included relief language "as completely as practicable" for specifying chemical form. Small entities generate a significant percent of wastes and data on these wastes is needed, so no further relief was provided. Objections to shipper tracking and forwarding manifests stemmed primarily from the need to clarify intent of the rule on waste broker or collector role and responsibility. The transfer of papers and tracking responsibility is more clearly addressed in the final rule. The recommendation for simplifying the paperwork for brokers was adopted. These issues and concerns are addressed in more detail in the staff analysis of comments in the final EIS.

The comments on waste classification were discussed in the preceding summary and resulted in extensive revision of this portion of the rule to simplify and clarify the requirements. The detailed staff analysis in the final EIS provides further discussion of the issues raised.

Federal rules that overlap the proposed rule are primarily those of the Department of Transportation (DOT). The Commission and DOT have an established working relationship implemented through a formal Memorandum of Understanding. The rule itself acknowledges the need to comply with DOT rules, and the Commission currently inspects licensees for compliance with DOT requirements. The manifest required by this rulemaking is consistent with DOT shipping paper requirements, and the same document may be used by licensees to meet requirements of both agencies. Neither NRC nor DOT require a specific form and both allow such dual use. The waste form and packaging requirements are in addition to and compatible with DOT rules. In addition, the manifest terminology and requirements were compared to those in the proposed Uniform Hazardous Waste Manifest, the joint EPA/DOT proposed form published March 4, 1982 (47 FR 9336). A few minor procedural and terminology changes were made to conform to this proposed form. Licensees may use the Uniform Hazardous Waste Manifest, once it is implemented, as both a DOT shipping paper and a NRC manifest for radioactive wastes by using additional spaces to describe wastes and adding information to the back. These changes were made based on consultation with EPA and DOT staff and will help to reduce the burden on all licensees.

The following comment was received from EPA on possible duplicative requirements:

> "NRC solicited comments on possible duplicative requirements for effluent releases and broker activities under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). This "Superfund" law exempts from notification "any release of source, special nuclear, or byproduct material ... in compliance with a legally enforceable license, permit, regulations, or order issued pursuant to the Atomic Energy Act of 1954" (CERCLA Section 101(10)(K)). Radioactive releases from nuclear waste disposal facilities which are not in compliance with an NRC license, permit, regulation, or order fall within the reporting requirements of CERCLA. Furthermore, as part of the notification regulations under CERCLA, EPA is planning to develop a notification scheme for releases of radioactive materials not licensed under the Atomic Energy Act of 1954 or the Uranium Mill Tailings Radiation Control Act of 1978. EPA wishes to minimize duplicative reporting requirements for releases reported to other agencies. EPA intends to work with NRC to minimize duplicative reporting requirements to the extent possible."

The EPA also addressed the potential for duplicative costs to the two agencies for wastes that are a mixture of hazardous chemicals and radioactive materials. Close coordination and a memorandum of understanding were suggested. EPA has regulatory responsibility for the disposal of hazardous wastes under the Resource Conservation and Recovery Act (RCRA). NRC agrees that the two regulatory programs need to be coordinated, and will take action in that regard.

The Regulatory Flexibility Act also requires discussion of alternatives to the proposed action. The recordkeeping and reporting requirements impose such a minor incremental burden that no exemption was considered. Initial estimates were that about 2,000 of the Commission's 9,000 licensees are waste generators who might make waste shipments. Waste generators must provide more complete information on the manifest than is currently required to meet DOT shipping paper requirements and must report on investigations of missing shipments. The additional information required in the manifest includes the identities of solidification agents; presence

of any chelating agents; whether the waste is Class A, B, or C; and the total quantity of H-3, C-14, Tc-99, and I-129. The annual public burden for all licensees should be no more than about 4,500 staff hours for the preparation of the manifest versus DOT shipping papers and 1,000 hours for investigating and reporting on late or missing shipments. Less than half this burden should fall on small entities based on relative volumes of wastes shipped. The waste classification and characteristics portion of the rule does provide relief for most wastes produced by the small entities, i.e., Class A wastes. Where radiological hazard permits, segregated disposal has been provided as an option to complying with more restrictive waste acceptance requirements for Class B and C wastes.

The incremental burdens were initially judged small. Based on further staff evaluations and public comments on the rule, this initial judgment was correct and the rule will not have a significant economic impact. The rulemaking will not affect economic factors such as employment, business viability, or ability for affected entities to compete. The improvements in waste disposal practices and the contribution of those improvements to establishing new disposal capacity are judged to significantly outweigh the small economic impact on small entities.

List of Subjects in 10 CFR Parts 20 and 61

Part 20 - Byproduct material, Licensed material, Nuclear materials, Nuclear power plants and reactors, Occupational safety and health, Packaging and containers, Penalty, Radiation protection, Reporting requirements, Special nuclear material, Source material, and Waste treatment and disposal.

Part 61 - Low-level waste, Nuclear materials, Penalty, waste treatment and disposal.

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and section 553 of title 5 of the United States Code, the following new 10 CFR Part 61 and the following amendments to 10 CFR Parts 2, 19, 20, 21, 30, 40, 51, 70, 73, and 170 to Chapter 1 of Title 10, of the Code of Federal Regulations are published as a document subject to codification.

A new Part 61 is added to 10 CFR to read as follows:

PART 61 - LICENSING REQUIREMENTS FOR LAND DISPOSAL OF RADIOACTIVE WASTE

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Subpart B: Licenses

61.14 Institutional information.

61.15 Financial information.

61.16 Other information.

61.20 Filing and distribution of application.

61.21 Elimination of repetition.

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61.23 Standards for issuance of a license.

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61.26 Amendment of license.

61.27 Application for renewal or closure.

61.28 Contents of application for closure.

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Subpart C: Performance Objectives

61.40 General requirement.

61.41 Protection of the general population from releases of radioactivity.

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61.44 Stability of the disposal site after closure.

Subpart D: Technical Requirements for Land Disposal Facilities

61.50 Disposal site suitability requirements for land disposal.

61.51 Disposal site design for land disposal.

61.52 Land disposal facility operation and disposal site closure.

61.53 Environmental monitoring.

61.54 Alternative requirements for design and operations.

61.55 Waste classification.

61.56 Waste characteristics.

61.57 Labeling.

61.58 Alternative requirements for waste classification and characteristics.

61.59 Institutional requirements.

Subpart E: Financial Assurances

61.61 Applicant qualifications and assurances.

61.62 Funding for disposal site closure and stabilization.

61.63 Financial assurances for institutional controls.

Subpart F: Participation by State Governments and Indian Tribes

61.70 Scope.

61.71 State and Tribal government consultation.

61.72 Filing of proposals for State and Tribal participation.

61.73 Commission approval of proposals.

Subpart G: Records, Reports, Tests, and Inspections

61.80 Maintenance of records, reports, and transfers.

61.81 Tests at land disposal facilities.

61.82 Commission inspections of land disposal facilities.

61.83 Violations.

AUTHORITY: Secs. 53, 57, 62, 63, 65, 81, 161, 182, 183, 68 Stat. 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2073, 2077, 2092, 2093, 2095, 2111, 2201, 2232, 2233); Secs. 202, 206, 88 Stat. 1244, 1246

(42 U.S.C. 5842, 5846); secs. 10 and 14, Pub. L. 95-601, 92 Stat. 2951 (42 U.S.C. 2021a and 5851).

For the purposes of sec. 223, 68 Stat. 958, as amended, (42 U.S.C. 2273): Tables 1 and 2, §§ 61.3, 61.24, 61.25, 61.27(a), 61.41 through .43, 61.52, 61.53, 61.55, 61.56, and 61.61 through 61.63 issued under sec. 161b, 68 Stat. 948 as amended (42 U.S.C. 2201(b)); §§ 61.10 through 61.16, 61.24, and 61.80 issued under sec. 161o, 68 Stat.950, as amended (42 U.S.C. 2201(o)).

Subpart A: General Provisions

§61.1 Purpose and scope.

(a) The regulations in this part establish, for land disposal of radioactive waste, the procedures, criteria, and terms and conditions upon which the Commission issues licenses for the disposal of radioactive wastes containing byproduct, source and special nuclear material received from other persons. Disposal of waste by an individual licensee is set forth in Part 20 of this chapter. Applicability of the requirements in this Part to Commission licenses for waste disposal facilities in effect on the effective date of this rule will be determined on a case-by-case basis and implemented through terms and conditions of the license or by orders issued by the Commission.

(b) Except as provided in Part 150 of this chapter, which addresses assumption of certain regulatory authority by Agreement States, and §61.6 "Exemptions," the regulations in this part apply to all persons in the United States. The regulations in this part do not apply to (1) disposal

of high-level waste as provided for in Part 60 of this chapter; (2) disposal of uranium or thorium tailings or wastes (byproduct material as defined in §40.4(a-1)) as provided for in Part 40 of this chapter in quantities greater than 10,000 kilograms and containing more than five (5) millicuries of radium-226; or (3) disposal of licensed material as provided for in Part 20 of this chapter.

§61.2 Definitions.

As used in this part:

"Active maintenance" means any significant remedial activity needed during the period of institutional control to maintain a reasonable assurance that the performance objectives in §§61.41 and 61.42 are met. Such active maintenance includes ongoinq activities such as the pumping and treatment of water from a disposal unit or one-time measures such as replacement of a disposal unit cover. Active maintenance does not include custodial activities such as repair of fencing, repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, minor repair of disposal unit covers, and general disposal site upkeep such as mowing grass.

"Buffer zone" is a portion of the disposal site that is controlled by the licensee and that lies under the disposal units and between the disposal units and the boundary of the site.

"Chelating agent" means amine polycarboxylic acids (e.g., EDTA, DTPA), hydroxy-carboxylic acids, and polycarboxylic acids (e.g., citric acid, carbolic acid, and glucinic acid).

"Commencement of construction" means any clearing of land, excavation, or other substantial action that would adversely affect the environment of a land disposal facility. The term does not mean disposal site exploration, necessary roads for disposal site exploration, borings to determine foundation conditions, or other preconstruction monitoring or testing to establish background information related to the suitability of the disposal site or the protection of environmental values.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Custodial Agency" means an agency of the government designated to act on behalf of the government owner of the disposal site.

"Director" means the Director, Office of Nuclear Material Safety and Safeguards, U. S. Nuclear Regulatory Commission.

"Disposal" means the isolation of radioactive wastes from the biosphere inhabited by man and containing his food chains by emplacement in a land disposal facility.

"Disposal site" means that portion of a land disposal facility which is used for disposal of waste. It consists of disposal units and a buffer zone.

"Disposal unit" means a discrete portion of the disposal site into which waste is placed for disposal. For near-surface disposal the unit is usually a trench.

"Engineered barrier" means a man-made structure or device that is intended to improve the land disposal facility's ability to meet the performance objectives in Subpart C.

"Explosive material" means any chemical compound, mixture, or device, which produces a substantial instantaneous release of gas and heat spontaneously or by contact with sparks or flame.

"Government agency" means any executive department, commission, independent establishment, or corporation, wholly or partly owned by the United States of America which is an instrumentality of the United States; or any board, bureau, division, service, office, officer, authority, administration, or other establishment in the executive branch of the government.

"Hazardous waste" means those wastes designated as hazardous by Environmental Protection Agency regulations in 40 CFR Part 261.

"Hydrogeologic unit" means any soil or rock unit or zone which by virtue of its porosity or permeability, or lack thereof, has a distinct influence on the storage or movement of groundwater.

"Inadvertent intruder" means a person who might occupy the disposal site after closure and engage in normal activities, such as agriculture, dwelling construction, or other pursuits in which the person might be unknowingly exposed to radiation from the waste.

"Indian Tribe" means an Indian tribe as defined in the Indian Self-Determination and Education Assistance Act (25 USC 450).

"Intruder barrier" means a sufficient depth of cover over the waste that inhibits contact with waste and helps to ensure that radiation exposures to an inadvertent intruder will meet the performance objectives set forth in this part, or engineered structures that provide equivalent protection to the inadvertent intruder.

"Land disposal facility" means the land, buildings, and equipment which is intended to be used for the disposal of radioactive wastes into the subsurface of the land. For purposes of this chapter, a geologic repository as defined in Part 60 is not considered a land disposal facility.

"License" means a license issued under the regulations in Part 61 of this chapter. "Licensee" means the holder of such a license.

"Monitoring" means observing and making measurements to provide data to evaluate the performance and characteristics of the disposal site.

"Near-surface disposal facility" means a land disposal facility in which radioactive waste is disposed of in or within the upper 30 meters of the earth's surface.

"Person" means (1) any individual, corporation, partnership, firm. association, trust, estate, public or private institution, group, government agency other than the Commission or the Department of Energy, (except that the Department of Energy is considered a person within the meaning of the regulations in this part to the extent that its facilities and activities are subject to the licensing and related regulatory authority of the Commission pursuant to section 202 of the Energy Reorganization Act of 1974 (88 Stat. 1244)), any State or any political subdivision of or any political entity within a State, any foreign government or nation or any political subdivision of any such government or nation, or other entity; and (2) any legal successor, representative, agent, or agency of the foregoing.

"Pyrophoric liquid" means any liquid that ignites spontaneously in dry or moist air at or below 130°F (54.5°C). A pyrophoric solid is any solid material, other than one classed as an explosive, which under normal conditions is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation, handling, or disposal hazard. Included are spontaneously combustible and water-reactive materials.

"Site closure and stabilization" means those actions that are taken upon completion of operations that prepare the disposal site for custodial care and that assure that the disposal site will remain stable and will not need ongoing active maintenance.

"State" means any State, Territory, or possession of the United States, Puerto Rico, and the District of Columbia.

"Stability" means structural stability.

"Surveillance" means observation of the disposal site for purposes of visual detection of need for maintenance, custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.

"Tribal Governing Body" means means a Tribal organization as defined in the Indian Self-Determination and Education Assistance Act (25 USC 450).

"Waste", means those low-level radioactive wastes containing source, special nuclear, or byproduct material that are acceptable for disposal in a land disposal facility. For the purposes of this definition, low-level waste has the same meaning as in the Low-Level Waste Policy Act, that is, radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as

defined in section 11 e.(2) of the Atomic Energy Act (uranium or thorium tailings and waste).

§61.3 License required.

(a) No person may receive, possess, and dispose of radioactive waste containing source, special nuclear, or byproduct material at a land disposal facility unless authorized by a license issued by the Commission pursuant to this part, or unless exemption has been granted by the Commission under § 61.6 of this part.

(b) Each person shall file an application with the Commission and obtain a license as provided in this part before commencing construction of a land disposal facility. Failure to comply with this requirement may be grounds for denial of a license.

§61.4 Communications.

Except where otherwise specified, all communications and reports concerning the regulations in this part and applications filed under them should be addressed to the Director, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555. Communications, reports, and applications may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C. or 7915 Eastern Avenue, Silver Spring, Maryland.

§61.5 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by any

officer or employee of the Commission other than a written interpretation by the General Counsel will be considered binding upon the Commission.

§61.6 Exemptions.

The Commission may, upon application by any interested person, or upon its own initiative, grant any exemption from the requirements of the regulations in this part as it determines is authorized by law, will not endanger life or property or the common defense and security, and is otherwise in the public interest.

§61.7 Concepts.

(a) The disposal facility.

(1) Part 61 is intended to apply to land disposal of radioactive waste and not to other methods such as sea or extraterrestrial disposal. Part 61 contains procedural requirements and performance objectives applicable to any method of land disposal. It contains specific technical requirements for near-surface disposal of radioactive waste which involves disposal in the uppermost portion of the earth, approximately 30 meters. Burial deeper than 30 meters may also be satisfactory. Technical requirements for alternative methods will be added in the future.

(2) Near-surface disposal of radioactive waste takes place at a near-surface disposal facility, which includes all of the land and buildings necessary to carry out the disposal. The disposal site is that portion of the facility which is used for disposal of waste and consists of disposal units and a buffer zone. A disposal unit is a discrete portion of the disposal site into which waste is placed for

disposal. For near-surface disposal, the disposal unit is usually a trench. A buffer zone is a portion of the disposal site that is controlled by the licensee and that lies under the site and between the boundary of the disposal site and any disposal unit. It provides controlled space to establish monitoring locations which are intended to provide an early warning of radionuclide movement, and to take mitigative measures if needed. In choosing a disposal site, site characteristics should be considered in terms of the indefinite future and evaluated for at least a 500 year time frame.

(b) Waste Classification and Near-Surface Disposal.

(1) Disposal of radioactive waste in near-surface disposal facilities has the following safety objectives: protection of the general population from releases of radioactivity, protection of individuals from inadvertent intrusion, and protection of individuals during operations. A fourth objective is to ensure stability of the site after closure.

(2) A cornerstone of the system is stability--stability of the waste and the disposal site so that once emplaced and covered, the access of water to the waste can be minimized. Migration of radionuclides is thus minimized, long-term active maintenance can be avoided, and potential exposures to intruders reduced. While stability is a desirable characteristic for all waste much radioactive waste does not contain sufficient amounts of radionuclides to be of great concern from these standpoints; this waste, however, tends to be unstable, such as ordinary trash type wastes. If mixed with the higher activity waste, their deterioration could lead to failure of the system and permit water to penetrate the disposal unit and cause problems with the higher activity

waste. Therefore, in order to avoid placing requirements for a stable waste form on relatively innocuous waste, these wastes have been classed as Class A waste. The Class A waste will be disposed of in separate disposal units at the disposal site. However, Class A waste that is stable may be mixed with other classes of waste. Those higher activity wastes that should be stable for proper disposal are classed as Class B and C waste. To the extent that it is practicable, Class B and C waste forms or containers should be designed to be stable, i.e., maintain gross physical properties and identity, over 300 years. For certain radionuclides prone to migration, a maximum disposal site inventory based on the characteristics of the disposal site may be established to limit potential exposure.

(3) It is possible but unlikely that persons might occupy the site in the future and engage in normal pursuits without knowing that they were receiving radiation exposure. These persons are referred to as inadvertent intruders. Protection of such intruders can involve two principal controls: institutional control over the site after operations by the site owner to ensure that no such occupation or improper use of the site occurs; or, designating which waste could present an unacceptable risk to an intruder, and disposing of this waste in a manner that provides some form of intruder barrier that is intended to prevent contact with the waste. This regulation incorporates both types of protective controls.

(4) Institutional control of access to the site is required for up to 100 years. This permits the disposal of Class A and Class B waste without special provisions for intrusion protection, since these classes of waste contain types and quantities of radioisotopes that will

decay during the 100-year period and will present an acceptable hazard to an intruder. The government landowner administering the active institutional control program has flexibility in controlling site access which may include allowing productive uses of the land provided the integrity and long-term performance of the site are not affected.

(5) Waste that will not decay to levels which present an acceptable hazard to an intruder within 100 years is designated as Class C waste. This waste is disposed of at a greater depth than the other classes of waste so that subsequent surface activities by an intruder will not disturb the waste. Where site conditions prevent deeper disposal, intruder barriers such as concrete covers may be used. The effective life of these intruder barriers should be 500 years. A maximum concentration of radionuclides is specified for all wastes so that at the end of the 500 year period, remaining radioactivity will be at a level that does not pose an unacceptable hazard to an intruder or public health and safety. Waste with concentrations above these limits is generally unacceptable for near-surface disposal. There may be some instances where waste with concentrations greater than permitted for Class C would be acceptable for near-surface disposal with special processing or design. These will be evaluated on a case-by-case basis. Class C waste must also be stable.

(c) The Licensing Process.

(1) During the preoperational phase, the potential applicant goes through a process of disposal site selection by selecting a region of interest, examining a number of possible disposal sites within the area of interest and narrowing the choice to the proposed site. Through a detailed investigation of the disposal site characteristics the potential

applicant obtains data on which to base an analysis of the disposal site's suitability. Along with these data and analyses, the applicant submits other more general information to the Commission in the form of an application for a license for land disposal. The Commission's review of the application is in accordance with administrative procedures established by rule and may involve participation by affected State governments or Indian tribes. While the proposed disposal site must be owned by a State or the Federal government before the Commission will issue a license, it may be privately owned during the preoperational phase if suitable arrangements have been made with a State or the Federal government to take ownership in fee of the land before the license is issued.

(2) During the operational phase, the licensee carries out disposal activities in accordance with the requirements of this regulation and any conditions on the license. Periodically, the authority to conduct the above ground operations and dispose of waste will be subject to a license renewal, at which time the operating history will be reviewed and a decision made to permit or deny continued operation. When disposal operations are to cease, the licensee applies for an amendment to his license to permit site closure. After final review of the licensee's site closure and stabilization plan, the Commission may approve the final activities necessary to prepare the disposal site so that ongoing active maintenance of the site is not required during the period of institutional control.

(3) During the period when the final site closure and stabilization activities are being carried out, the licensee is in a disposal site closure phase. Following that, for a period of 5 years, the licensee must remain at the disposal site for a period of post-closure

observation and maintenance to assure that the disposal site is stable and ready for institutional control. The Commission may approve shorter or require longer periods if conditions warrant. At the end of this period, the licensee applies for a license transfer to the disposal site owner.

(4) After a finding of satisfactory disposal site closure, the Commission will transfer the license to the State or Federal government that owns the disposal site. If the Department of Energy is the Federal agency administering the land on behalf of the Federal government the license will be terminated because the Commission lacks regulatory authority over the Department for this activity. Under the conditions of the transferred license, the owner will carry out a program of monitoring to assure continued satisfactory disposal site performance, physical surveillance to restrict access to the site and carry out minor custodial activities. During this period, productive uses of the land might be permitted if those uses do not affect the stability of the site and its ability to meet the performance objectives. At the end of the prescribed period of institutional control, the license will be terminated by the Commission.

§61.8 Reporting, recordkeeping, and application requirements: OMB approval not required.

The information collection requirements contained in this part affect fewer than ten persons. Therefore, under section 3506(c)(5) of the Paperwork Reduction Act of 1980 (Pub.L. 96-511), OMB clearance is not required for these information collection requirements.

§61.9 Employee protection.

(a) Discrimination by a Commission licensee, an applicant for a Commission licensee, or a contractor or subcontractor of a Commission licensee or applicant against an employee for engaging in certain protected activities is prohibited. Discrimination includes discharge and other actions that relate to compensation, terms, conditions, and privileges of employment. The protected activities are established in Section 210 of the Energy Reorganization Act of 1974, as amended, and in general are related to the administration or enforcement of a requirement imposed under the Atomic Energy Act or the Energy Reorganization Act.

(1) The protected activities include but are not limited to -

(i) providing the Commission information about possible violations of requirements imposed under either of the above statutes;

(ii) requesting the Commission to institute action against his or her employer for the administration or enforcement of these requirements; or

(iii) testifying in any Commission proceeding.

(2) These activities are protected even if no formal proceeding is actually initiated as a result of the employee assistance or participation.

(3) This section has no application to any employee alleging discrimination prohibited by this section who, acting without direction from his or her employer (or the employer's agent), deliberately causes a violation of any requirement of the Energy Reorganization Act of 1974, as amended, or the Atomic Energy Act of 1954, as amended.

(b) Any employee who believes that he or she has been discharged or otherwise discriminated against by any person for engaging in the protected activities specified in paragraph (a)(1) of this section may seek a remedy for the discharge or discrimination through an administrative proceeding in the Department of Labor. The administrative proceeding must be initiated within 30 days after an alleged violation occurs by filing a complaint alleging the violation with the Department of Labor, Employment Standards Administration, Wage and Hour Division. The Department of Labor may order reinstatement, back pay, and compensatory damages.

(c) A violation of paragraph (a) of this section by a Commission licensee, an applicant for a Commission license, or a contractor or subcontractor of a Commission licensee or applicant may be grounds for -

(1) Denial, revocation, or suspension of the license.

(2) Imposition of a civil penalty on the licensee or applicant.

(3) Other enforcement action.

(d) Actions taken by an employer, or others, which adversely affect an employee may be predicated upon nondiscriminatory grounds. The prohibition applies when the adverse action occurs because the employee has engaged in protected activities. An employee's engagement in protected activities does not automatically render him or her immune from discharge or discipline for legitimate reasons or from adverse action dictated by non-prohibited considerations.

(d) Each licensee and each applicant shall post Form NRC-3, "Notice to Employees," on its premises. Posting must be at locations sufficient to permit employees protected by this section to observe a copy on the way to or from their place of work. Premises must be posted not later

than 30 days after an application is docketed and remain posted while the application is pending before the Commission, during the term of the license, and for 30 days following license termination.

NOTE: Copies of Form NRC-3 may be obtained by writing to the Regional Administrator of the appropriate U.S. Nuclear Regulatory Commission Regional Office listed in Appendix D, Part 20 of this chapter or the Director, Office of Inspection and Enforcement, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Subpart B: Licenses

§61.10 Content of application.

(a) An application to receive from others, possess and dispose of wastes containing or contaminated with source, byproduct or special nuclear material by land disposal must consist of general information, specific technical information, institutional information, and financial information as set forth in §§61.11 through 61.16. An environmental report prepared in accordance with Part 51 of this chapter must accompany the application.

§61.11 General information.

The general information must include each of the following:

(a) Identity of the applicant including:

(1) The full name, address, telephone number and description of the business or occupation of the applicant;

(2) If the applicant is a partnership, the name, and address of each partner and the principal location where the partnership does business;

(3) If the applicant is a corporation or an unincorporated association, (i) the state where it is incorporated or organized and the principal location where it does business, and (ii) the names and addresses of its directors and principal officers; and

(4) If the applicant is acting as an agent or representative of another person in filing the application, all information required under this paragraph must be supplied with respect to the other person.

(b) Qualifications of the applicant:

(1) The organizational structure of the applicant, both offsite and onsite, including a description of lines of authority and assignments of responsibilities, whether in the form of administrative directives, contract provisions, or otherwise;

(2) The technical qualifications, including training and experience, of the applicant and members of the applicant's staff to engage in the proposed activities. Minimum training and experience requirements for personnel filling key positions described in Paragraph 61.11(b)(1) must be provided.

(3) A description of the applicant's personnel training program; and

(4) The plan to maintain an adequate complement of trained personnel to carry out waste receipt, handling, and disposal operations in a safe manner.

(c) A description of:

(1) The location of the proposed disposal site;

(2) The general character of the proposed activities;

(3) The types and quantities of radioactive waste to be received, possessed, and disposed of;

(4) Plans for use of the land disposal facility for purposes other than disposal of radioactive wastes; and

(5) The proposed facilities and equipment.

(d) Proposed schedules for construction, receipt of waste, and first emplacement of waste at the proposed land disposal facility.

§61.12 Specific technical information.

The specific technical information must include the following information needed for demonstration that the performance objectives of Subpart C of this part and the applicable technical requirements of Subpart D of this part will be met:

(a) A description of the natural and demographic disposal site characteristics as determined by disposal site selection and characterization activities. The description must include geologic, geotechnical, hydrologic, meteorologic, climatologic, and biotic features of the disposal site and vicinity.

(b) A description of the design features of the land disposal facility and the disposal units. For near-surface disposal, the description must include those design features related to infiltration of water; integrity of covers for disposal units; structural stability of backfill, wastes, and covers; contact of wastes with standing water; disposal site drainage; disposal site closure and stabilization; elimination to the extent practicable of long-term disposal site maintenance; inadvertent intrusion; occupational exposures; disposal site monitoring; and adequacy of the size of the buffer zone for monitoring and potential mitigative measures.

(c) A description of the principal design criteria and their relationship to the performance objectives.

(d) A description of the design basis natural events or phenomena and their relationship to the principal design criteria.

(e) A description of codes and standards which the applicant has applied to the design and which will apply to construction of the land disposal facilities.

(f) A description of the construction and operation of the land disposal facility. The description must include as a minimum the methods of construction of disposal units; waste emplacement; the procedures for and areas of waste segregation; types of intruder barriers; onsite traffic and drainage systems; survey control program; methods and areas of waste storage; and methods to control surface water and groundwater access to the wastes. The description must also include a description of the methods to be employed in the handling and disposal of wastes containing chelating agents or other non-radiological substances that might affect meeting the performance objectives in Subpart C of this part.

(g) A description of the disposal site closure plan, including those design features which are intended to facilitate disposal site closure and to eliminate the need for ongoing active maintenance.

(h) An identification of the known natural resources at the disposal site, the exploitation of which could result in inadvertent intrusion into the low-level wastes after removal of active institutional control.

(i) A description of the kind, amount, classification and specifications of the radioactive material proposed to be received, possessed, and disposed of at the land disposal facility.

(j) A description of the quality control program for the determination of natural disposal site characteristics and for quality control during the design, construction, operation and closure of the land disposal facility and the receipt, handling, and emplacement of waste. Audits and managerial controls must be included.

(k) A description of the radiation safety program for control and monitoring of radioactive effluents to ensure compliance with the performance objective in §61.41 of this part and occupational radiation exposure to ensure compliance with the requirements of Part 20 of this chapter and to control contamination of personnel, vehicles, equipment, buildings, and the disposal site. Both routine operations and accidents must be addressed. The program description must include procedures, instrumentation, facilities, and equipment.

(l) A description of the environmental monitoring program to provide data to evaluate potential health and environmental impacts and the plan for taking corrective measures if migration of radionuclides is indicated.

(m) A description of the administrative procedures that the applicant will apply to control activities at the land disposal facility.

§61.13 Technical analyses.

The specific technical information must also include the following analyses needed to demonstrate that the performance objectives of Subpart C of this part will be met:

(a) Pathways analyzed in demonstrating protection of the general population from releases of radioactivity must include air, soil, groundwater, surface water, plant uptake, and exhumation by burrowing animals. The analyses must clearly identify and differentiate between the roles performed by the natural disposal site characteristics and design features in isolating and segregating the wastes. The analyses must clearly demonstrate that there is reasonable assurance that the exposures to humans from the release of radioactivity will not exceed the limits set forth in §61.41.

(b) Analyses of the protection of individuals from inadvertent intrusion must include demonstration that there is reasonable assurance the waste classification and segregation requirements will be met and that adequate barriers to inadvertent intrusion will be provided.

(c) Analyses of the protection of individuals during operations must include assessments of expected exposures due to routine operations and likely accidents during handling, storage, and disposal of waste. The analyses must provide reasonable assurance that exposures will be controlled to meet the requirements of Part 20 of this chapter.

(d) Analyses of the long-term stability of the disposal site and the need for ongoing active maintenance after closure must be based upon analyses of active natural processes such as erosion, mass wasting, slope failure, settlement of wastes and backfill, infiltration through covers over disposal areas and adjacent soils, and surface drainage of the disposal site. The analyses must provide reasonable assurance that there will not be a need for ongoing active maintenance of the disposal site following closure.

§61.14 Institutional information.

The institutional information must include:

(a) A certification by the Federal or State government which owns the disposal site that the Federal or State government is prepared to accept transfer of the license when the provisions of §61.30 are met, and will assume responsibility for custodial care after site closure and postclosure observation and maintenance.

(b) Where the proposed disposal site is on land not owned by the Federal or a State government, the applicant must submit evidence that arrangements have been made for assumption of ownership in fee by the Federal or a State government before the Commission issues a license.

§61.15 Financial information.

The financial information must be sufficient to demonstrate that the financial qualifications of the applicant are adequate to carry out the activities for which the license is sought and meet other financial assurance requirements as specified in Subpart E of this part.

§61.16 Other information.

Depending upon the nature of the wastes to be disposed of, and the design and proposed operation of the land disposal facility, additional information may be requested by the Commission including the following:

(a) Physical security measures, if appropriate. Any application to receive and possess special nuclear material in quantities subject to the requirements of Part 73 of this chapter shall demonstrate how the physical security requirements of Part 73 will be met. In determining whether receipt and possession will be subject to the requirements of

Part 73, the applicant shall not consider the quantity of special nuclear material that has been disposed of.

(b) Safety information concerning criticality, if appropriate.

(1) Any application to receive and possess special nuclear material in quantities that would be subject to the requirements of §70.24, "Criticality accident requirements" of Part 70 of this chapter shall demonstrate how the requirements of that section will be met, unless the applicant requests an exemption pursuant to § 70.24(d). In determining whether receipt and possession would be subject to the requirements of §70.24, the applicant shall not consider the quantity of special nuclear material that has been disposed of.

(2) Any application to receive and possess special nuclear material shall describe proposed procedures for avoiding accidental criticality, which address both storage of special nuclear material prior to disposal and waste emplacement for disposal.

§61.20 Filing and distribution of application.

(a) An application for a license under this part, and any amendments thereto, shall be filed with the Director, must be signed by the applicant or the applicant's authorized representative under oath, and must consist of 1 signed original and 2 copies.

(b) Another 85 copies of the application and environmental report must be retained by the applicant for distribution in accordance with written instructions from the Director or designee.

(c) Fees. Application, amendment, and inspection fees applicable to a license covering the receipt and disposal of radioactive wastes in a land disposal facility are required by Part 170 of this chapter.

§61.21 Elimination of repetition.

In its application or environmental report, the applicant may incorporate by reference information contained in previous applications, statements, or reports filed with the Commission if these references are clear and specific.

§61.22 Updating of application and environmental report.

(a) The application and environmental report must be as complete as possible in the light of information that is available at the time of submittal.

(b) The applicant shall supplement its application or environmental report in a timely manner, as necessary, to permit the Commission to review, prior to issuance of a license, any changes in the activities proposed to be carried out or new information regarding the proposed activities.

§61.23 Standards for issuance of a license.

A license for the receipt, possession, and disposal of waste containing or contaminated with source, special nuclear, or byproduct material will be issued by the Commission upon finding that the issuance of the license will not be inimical to the common defense and security and will not constitute an unreasonable risk to the health and safety of the public, and:

(a) The applicant is qualified by reason of training and experience to carry out the disposal operations requested in a manner that protects health and minimizes danger to life or property.

(b) The applicant's proposed disposal site, disposal design, land disposal facility operations (including equipment, facilities, and procedures), disposal site closure, and postclosure institutional control are adequate to protect the public health and safety in that they provide reasonable assurance that the general population will be protected from releases of radioactivity as specified in the performance objective in §61.41, Protection of the general population from releases of radioactivity.

(c) The applicant's proposed disposal site, disposal site design, land disposal facility operations (including equipment, facilities, and procedures), disposal site closure, and postclosure institutional control are adequate to protect the public health and safety in that they will provide reasonable assurance that individual inadvertent intruders are protected in accordance with the performance objective in §61.42, Protection of individuals from inadvertent intrusion.

(d) The applicant's proposed land disposal facility operations, including equipment, facilities, and procedures, are adequate to protect the public health and safety in that they will provide reasonable assurance that the standards for radiation protection set out in Part 20 of this chapter will be met.

(e) The applicant's proposed disposal site, disposal site design, land disposal facility operations, disposal site closure, and post-closure institutional control are adequate to protect the public health and safety in that they will provide reasonable assurance that long-term stability of the disposed waste and the disposal site will be achieved and will eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure.

(f) The applicant's demonstration provides reasonable assurance that the applicable technical requirements of Subpart D of this part will be met.

(g) The applicant's proposal for institutional control provides reasonable assurance that institutional control will be provided for the length of time found necessary to ensure the findings in paragraphs (b)-(e) of this section and that the institutional control meets the requirements of §61.59, Institutional requirements.

(h) The information on financial assurances meets the requirements of Subpart E of this part.

(i) The applicant's physical security information provides reasonable assurance that the requirements of Part 73 of this chapter will be met, insofar as they are applicable to special nuclear material to be possessed before disposal under the license.

(j) The applicant's criticality safety procedures are adequate to protect the public health and safety and provide reasonable assurance that the requirements of §70.24, Criticality accident requirements, of Part 70 of this chapter will be met, insofar as they are applicable to special nuclear material to be possessed before disposal under the license.

(k) Any additional information submitted as requested by the Commission pursuant to §61.16, Other information, is adequate.

(l) The requirements of Part 51 of this chapter have been met.

§61.24 Conditions of licenses.

(a) A license issued under this part, or any right thereunder, may be transferred, assigned, or in any manner disposed of, either voluntarily

or involuntarily, directly or indirectly, through transfer of control of the license to any person, only if the Commission finds, after securing full information, that the transfer is in accordance with the provisions of the Atomic Energy Act and gives its consent in writing in the form of a license amendment.

(b) The licensee shall submit written statements under oath upon request of the Commission, at any time before termination of the license, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked.

(c) The license will be transferred to the site owner only on the full implementation of the final closure plan as approved by the Commission, including post-closure observation and maintenance.

(d) The licensee shall be subject to the provisions of the Atomic Energy Act now or hereafter in effect, and to all rules, regulations, and orders of the Commission. The terms and conditions of the license are subject to amendment, revision, or modification, by reason of amendments to, or by reason of rules, regulations, and orders issued in accordance with the terms of the Atomic Energy Act.

(e) Any license may be revoked, suspended or modified in whole or in part for any material false statement in the application or any statement of fact required under Section 182 of the Act, or because of conditions revealed by any application or statement of fact or any report, record, or inspection or other means which would warrant the Commission to refuse to grant a license to the original application, or for failure to operate the facility in accordance with the terms of the license, or for any violation of, or failure to observe any of the terms

and conditions of the Act, or any rule, regulation, license or order of the Commission.

(f) Each person licensed by the Commission pursuant to the regulations in this part shall confine possession and use of materials to the locations and purposes authorized in the license.

(g) No radioactive waste may be disposed of until the Commission has inspected the land disposal facility and has found it to be in conformance with the description, design, and construction described in the application for a license.

(h) The Commission may incorporate in any license at the time of issuance, or thereafter, by appropriate rule, regulation or order, additional requirements and conditions with respect to the licensee's receipt, possession, and disposal of source, special nuclear or byproduct material as it deems appropriate or necessary in order to:

(1) Promote the common defense and security;

(2) Protect health or to minimize danger to life or property;

(3) Require reports and the keeping of records, and to provide for inspections of activities under the license that may be necessary or appropriate to effectuate the purposes of the Act and regulations thereunder.

(i) Any licensee who receives and possesses special nuclear material under this part in quantities that would be subject to the requirements of §70.24 of Part 70 of this chapter shall comply with the requirements of that section. The licensee shall not consider the quantity of special nuclear material that has been disposed of.

(j) The authority to dispose of wastes expires on the date stated in the license except as provided in § 61.27(a) of this part.

§61.25 Changes.

(a) Except as provided for in specific license conditions, the licensee shall not make changes in the land disposal facility or procedures described in the license application. The license will include conditions restricting subsequent changes to the facility and the procedures authorized which are important to public health and safety. These license restrictions will fall into three categories of descending importance to public health and safety as follows: (1) those features and procedures which may not be changed without (i) 60 days prior notice to the Commision, (ii) 30 days notice of opportunity for a prior hearing, and (iii) prior Commission approval; (2) those features and procedures which may not be changed without (i) 60 days prior notice to the Commission, and (ii) prior Commission approval; and (3) those features and procedures which may not be changed without 60 days prior notice to the Commission. Features and procedures falling in paragraph (a)(3) of this section may not be changed without prior Commission approval if the Commission, after having received the required notice, so orders.

(b) Amendments authorizing site closure, license transfer, or license termination shall be included in paragraph (a)(1) of this section.

(c) The Commission shall provide a copy of the notice for opportunity for hearings provided in paragraph (a)(1) of this section to State and local officials or tribal governing bodies specified in § 2.104(e) of Part 2 of this chapter.

§61.26 Amendment of license.

(a) An application for amendment of a license must be filed in accordance with §61.20 and shall fully describe the changes desired.

(b) In determining whether an amendment to a license will be approved, the Commission will apply the criteria set forth in §61.23.

§61.27 Application for renewal or closure.

(a) Any expiration date on a license applies only to the above ground activities and to the authority to dispose of waste. Failure to renew the license shall not relieve the licensee of responsibility for carrying out site closure, postclosure observation and transfer of the license to the site owner. An application for renewal or an application for closure under §61.28 must be filed at least 30 days prior to license expiration.

(b) Applications for renewal of a license must be filed in accordance with §§61.10 through 61.16 and 61.20. Applications for closure must be filed in accordance with §§61.20 and 61.28. Information contained in previous applications, statements or reports filed with the Commission under the license may be incorporated by reference if the references are clear and specific.

(c) In any case in which a licensee has timely filed an application for renewal of a license, the license for continued receipt and disposal of licensed materials does not expire until the Commission has taken final action on the application for renewal.

(d) In determining whether a license will be renewed, the Commission will apply the criteria set forth in §61.23.

§61.28 Contents of application for closure.

(a) Prior to final closure of the disposal site, or as otherwise directed by the Commission, the applicant shall submit an application to amend the license for closure. This closure application must include a final revision and specific details of the disposal site closure plan included as part of the license application submitted under §61.12(g) that includes each of the following:

(1) Any additional geologic, hydrologic, or other disposal site data pertinent to the long-term containment of emplaced radioactive wastes obtained during the operational period.

(2) The results of tests, experiments, or any other analyses relating to backfill of excavated areas, closure and sealing, waste migration and interaction with emplacement media, or any other tests, experiments, or analysis pertinent to the long-term containment of emplaced waste within the disposal site.

(3) Any proposed revision of plans for:

(i) Decontamination and/or dismantlement of surface facilities;

(ii) Backfilling of excavated areas; or

(iii) Stabilization of the disposal site for post-closure care.

(4) Any significant new information regarding the environmental impact of closure activities and long-term performance of the disposal site.

(b) Upon review and consideration of an application to amend the license for closure submitted in accordance with paragraph (a) of this section, the Commission shall issue an amendment authorizing closure if

there is reasonable assurance that the long-term performance objectives of Subpart C of this part will be met.

§61.29 Post-closure observation and maintenance.

Following completion of closure authorized in §61.28, the licensee shall observe, monitor, and carry out necessary maintenance and repairs at the disposal site until the license is transferred by the Commission in accordance with §61.30. Responsibility for the disposal site must be maintained by the licensee for 5 years. A shorter or longer time period for post-closure observation and maintenance may be established and approved as part of the site closure plan, based on site-specific conditions.

§61.30 Transfer of license.

(a) Following closure and the period of post-closure observation and maintenance, the licensee may apply for an amendment to transfer the license to the disposal site owner. The license shall be transferred when the Commission finds:

(1) That the closure of the disposal site has been made in conformance with the licensee's disposal site closure plan, as amended and approved as part of the license;

(2) That reasonable assurance has been provided by the licensee that the performance objectives of Subpart C of this part are met;

(3) That any funds and necessary records for care will be transferred to the disposal site owner;

(4) That the post-closure monitoring program is operational for implementation by the disposal site owner; and

(5) That the Federal or State government agency which will assume responsibility for institutional control of the disposal site is prepared to assume responsibility and ensure that the institutional requirements found necessary under §61.23(g) will be met.

§61.31 Termination of license.

(a) Following any period of institutional control needed to meet the requirements found necessary under §61.23, the licensee may apply for an amendment to terminate the license.

(b) This application must be filed, and will be reviewed, in accordance with the provision of §61.20 and of this section.

(c) A license is terminated only when the Commission finds:

(1) That the institutional control requirements found necessary under §61.23(g) have been met; and

(2) That any additional requirements resulting from new information developed during the institutional control period have been met, and that permanent monuments or markers warning against intrusion have been installed.

Subpart C: Performance Objectives

§61.40 General requirement.

Land disposal facilities must be sited, designed, operated, closed, and controlled after closure so that reasonable assurance exists that exposures to humans are within the limits established in the performance objectives in §§61.41 through 61.44.

§61.41 Protection of the general population from releases of radioactivity.

Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.

§61.42 Protection of individuals from inadvertent intrusion.

Design, operation, and closure of the land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste at any time after active institutional controls over the disposal site are removed.

§61.43 Protection of individuals during operations.

Operations at the land disposal facility must be conducted in compliance with the standards for radiation protection set out in Part 20 of this chapter, except for releases of radioactivity in effluents from the land disposal facility, which shall be governed by § 61.41 of this part. Every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable.

§61.44 Stability of the disposal site after closure.

The disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

Subpart D: Technical Requirements for Land Disposal Facilities

§61.50 Disposal site suitability requirements for land disposal.

(a) Disposal site suitability for near-surface disposal.

(1) The purpose of this section is to specify the minimum characteristics a disposal site must have to be acceptable for use as a near-surface disposal facility. The primary emphasis in disposal site suitability is given to isolation of wastes, a matter having long-term impacts, and to disposal site features that ensure that the long-term performance objectives of Subpart C of this part are met, as opposed to short-term convenience or benefits.

(2) The disposal site shall be capable of being characterized, modeled, analyzed and monitored.

(3) Within the region or state where the facility is to be located, a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives of Subpart C of this part.

(4) Areas must be avoided having known natural resources which, if exploited, would result in failure to meet the performance objectives of Subpart C of this part.

(5) The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year flood plain, coastal high-hazard area or wetland, as defined in Executive Order 11988, "Floodplain Management Guidelines."

(6) Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate waste disposal units.

(7) The disposal site must provide sufficient depth to the water table that ground water intrusion, perennial or otherwise, into the waste will not occur. The Commission will consider an exception to this requirement to allow disposal below the water table if it can be conclusively shown that disposal site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives of Subpart C of this part being met. In no case will waste disposal be permitted in the zone of fluctuation of the water table.

(8) The hydrogeologic unit used for disposal shall not discharge ground water to the surface within the disposal site.

(9) Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of Subpart C of this part, or may preclude defensible modeling and prediction of long-term impacts.

(10) Areas must be avoided where surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives of Subpart C of this part, or may preclude defensible modeling and prediction of long-term impacts.

(11) The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives of Subpart C of this part or significantly mask the environmental monitoring program.

(b) Disposal site suitability requirements for land disposal other than near-surface (reserved).

§61.51 Disposal site design for land disposal.

(a) Disposal site design for near-surface disposal.

(1) Site design features must be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure.

(2) The disposal site design and operation must be compatible with the disposal site closure and stabilization plan and lead to disposal site closure that provides reasonable assurance that the performance objectives of Subpart C of this part will be met.

(3) The disposal site must be designed to complement and improve, where appropriate, the ability of the disposal site's natural characteristics to assure that the performance objectives of Subpart C of this part will be met.

(4) Covers must be designed to minimize to the extent practicable water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geologic processes and biotic activity.

(5) Surface features must direct surface water drainage away from disposal units at velocities and gradients which will not result in erosion that will require ongoing active maintenance in the future.

(6) The disposal site must be designed to minimize to the extent practicable the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal.

(b) Disposal site design for other than near-surface disposal (reserved).

§61.52 Land disposal facility operation and disposal site closure.

(a) Near-surface disposal facility operation and disposal site closure.

(1) Wastes designated as Class A pursuant to §61.55, must be segregated from other wastes by placing in disposal units which are sufficiently separated from disposal units for the other waste classes so that any interaction between Class A wastes and other wastes will not result in the failure to meet the performance objectives in Subpart C of this Part. This segregation is not necessary for Class A wastes if they meet the stability requirements in § 61.56(b) of this part.

(2) Wastes designated as Class C pursuant to §61.55, must be disposed of so that the top of the waste is a minimum of 5 meters below the top surface of the cover or must be disposed of with intruder barriers that are designed to protect against an inadvertent intrusion for at least 500 years.

(3) All wastes shall be disposed of in accordance with the requirements of paragraphs (a)(4) through (11) of this section.

(4) Wastes must be emplaced in a manner that maintains the package integrity during emplacement, minimizes the void spaces between packages, and permits the void spaces to be filled.

(5) Void spaces between waste packages must be filled with earth or other material to reduce future subsidence within the fill.

(6) Waste must be placed and covered in a manner that limits the radiation dose rate at the surface of the cover to levels that at a

minimum will permit the licensee to comply with all provisions of § 20.105 of this chapter at the time the license is transferred pursuant to § 61.30 of this part.

(7) The boundaries and locations of each disposal unit (e.g., trenches) must be accurately located and mapped by means of a land survey. Near-surface disposal units must be marked in such a way that the boundaries of each unit can be easily defined. Three permanent survey marker control points, referenced to United States Geological Survey (USGS) or National Geodetic Survey (NGS) survey control stations, must be established on the site to facilitate surveys. The USGS or NGS control stations must provide horizontal and vertical controls as checked against USGS or NGS record files.

(8) A buffer zone of land must be maintained between any buried waste and the disposal site boundary and beneath the disposed waste. The buffer zone shall be of adequate dimensions to carry out environmental monitoring activities specified in § 61.53(d) of this part and take mitigative measures if needed.

(9) Closure and stabilization measures as set forth in the approved site closure plan must be carried out as each disposal unit (e.g., each trench) is filled and covered.

(10) Active waste disposal operations must not have an adverse effect on completed closure and stabilization measures.

(11) Only wastes containing or contaminated with radioactive materials shall be disposed of at the disposal site.

(b) Facility operation and disposal site closure for land disposal facilities other than near-surface (reserved).

§61.53 Environmental monitoring.

(a) At the time a license application is submitted, the applicant shall have conducted a preoperational monitoring program to provide basic environmental data on the disposal site characteristics. The applicant shall obtain information about the ecology, meteorology, climate, hydrology, geology, geochemistry, and seismology of the disposal site. For those characteristics that are subject to seasonal variation, data must cover at least a twelve month period.

(b) The licensee must have plans for taking corrective measures if migration of radionuclides would indicate that the performance objectives of Subpart C may not be met.

(c) During the land disposal facility site construction and operation, the licensee shall maintain a monitoring program. Measurements and observations must be made and recorded to provide data to evaluate the potential health and environmental impacts during both the construction and the operation of the facility and to enable the evaluation of long-term effects and the need for mitigative measures. The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.

(d) After the disposal site is closed, the licensee responsible for post-operational surveillance of the disposal site shall maintain a monitoring system based on the operating history and the closure and stabilization of the disposal site. The monitoring system must be capable of providing early warning of releases of radionuclides from the disposal site before they leave the site boundary.

§61.54 Alternative requirements for design and operations.

The Commission may, upon request or on its own initiative, authorize provisions other than those set forth in §§61.51 through 61.53 for the segregation and disposal of waste and for the design and operation of a land disposal facility on a specific basis, if it finds reasonable assurance of compliance with the performance objectives of Subpart C of this part.

§61.55 Waste classification.

(a) Classification of waste for near surface disposal.

(1) Considerations. Determination of the classification of radioactive waste involves two considerations. First, consideration must be given to the concentration of long-lived radionuclides (and their shorter-lived precursors) whose potential hazard will persist long after such precautions as institutional controls, improved waste form, and deeper disposal have ceased to be effective. These precautions delay the time when long-lived radionuclides could cause exposures. In addition, the magnitude of the potential dose is limited by the concentration and availability of the radionuclide at the time of exposure. Second, consideration must be given to the concentration of shorter-lived radionuclides for which requirements on institutional controls, waste form, and disposal methods are effective.

(2) Classes of waste.

(i) Class A waste is waste that is usually segregated from other waste classes at the disposal site. The physical form and characteristics of Class A waste must meet the minimum requirements set forth

in §61.56(a). If Class A waste also meets the stability requirements set forth in §61.56(b), it is not necessary to segregate the waste for disposal.

(ii) Class B waste is waste that must meet more rigorous requirements on waste form to ensure stability after disposal. The physical form and characteristics of Class B waste must meet both the minimum and stability requirements set forth in §61.56.

(iii) Class C waste is waste that not only must meet more rigorous requirements on waste form to ensure stability but also requires additional measures at the disposal facility to protect against inadvertent intrusion. The physical form and characteristics of Class C waste must meet both the minimum and stability requirements set forth in §61.56.

(iv) Waste that is not generally acceptable for near-surface disposal is waste for which waste form and disposal methods must be different, and in general more stringent, than those specified for Class C waste. In the absence of specific requirements in this part, proposals for disposal of this waste may be submitted to the Commission for approval, pursuant to §61.58 of this part.

(3) Classification determined by long-lived radionuclides. If radioactive waste contains only radionuclides listed in Table 1, classification shall be determined as follows:

(i) If the concentration does not exceed 0.1 times the value in Table 1, the waste is Class A.

(ii) If the concentration exceeds 0.1 times the value in Table 1 but does not exceed the value in Table 1, the waste is Class C.

(iii) If the concentration exceeds the value in Table 1, the waste is not generally acceptable for near-surface disposal.

(iv) For wastes containing mixtures of radionuclides listed in Table 1, the total concentration shall be determined by the sum of fractions rule described in paragraph (a)(7) of this section.

Table 1

Radionuclide	Concentration Curies/cubic meter
C-14	8
C-14 in activated metal	80
Ni-59 in activated metal	220
Nb-94 in activated metal	0.2
Tc-99	3
I-129	0.08
Alpha emitting transuranic nuclides with half-life greater than five years	100*
Pu-241	3,500*
Cm-242	20,000*

*Units are nanocuries per gram

(4) Classification determined by short-lived radionuclides. If radioactive waste does not contain any of the radionuclides listed in Table 1, classification shall be determined based on the concentrations shown in Table 2. However, as specified in paragraph (6) of this section, if radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A.

(i) If the concentration does not exceed the value in Column 1, the waste is Class A.

(ii) If the concentration exceeds the value in Column 1, but does not exceed the value in Column 2, the waste is Class B.

(iii) If the concentration exceeds the value in Column 2, but does not exceed the value in Column 3, the waste is Class C.

(iv) If the concentration exceeds the value in Column 3, the waste is not generally acceptable for near-surface disposal.

(v) For wastes containing mixtures of the nuclides listed in Table 2, the total concentration shall be determined by the sum of fractions rule described in paragraph (a)(7) of this section.

Table 2

Radionuclide	Concentration, Curies/cubic meter Column 1	Column 2	Column 3
Total of all nuclides with less than 5 year half life	700	**	**
H-3	40	**	**
Co-60	700	**	**
Ni-63	3.5	70	700
Ni-63 in activated metal	35	700	7000
Sr-90	0.04	150	7000
Cs-137	1	44	4600

** There are no limits established for these radionuclides in Class B or C wastes. Practical considerations such as the effects of external radiation and internal heat generation on transportation, handling, and disposal will limit the concentrations for these wastes. These wastes shall be Class B unless the concentrations of other nuclides in Table 2 determine the waste to the Class C independent of these nuclides.

(5) Classification determined by both long- and short-lived radionuclides. If radioactive waste contains a mixture of radionuclides, some of which are listed in Table 1, and some of which are listed in Table 2, classification shall be determined as follows:

(i) If the concentration of a nuclide listed in Table 1 does not exceed 0.1 times the value listed in Table 1, the class shall be that determined by the concentration of nuclides listed in Table 2.

(ii) If the concentration of a nuclide listed in Table 1 exceeds 0.1 times the value listed in Table 1 but does not exceed the value in Table 1, the waste shall be Class C, provided the concentration of nuclides listed in Table 2 does not exceed the value shown in Column 3 of Table 2.

(6) Classification of wastes with radionuclides other than those listed in Tables 1 and 2. If radioactive waste does not contain any nuclides listed in either Table 1 or 2, it is Class A.

(7) The sum of the fractions rule for mixtures of radionuclides. For determining classification for waste that contains a mixture of radionuclides, it is necessary to determine the sum of fractions by dividing each nuclide's concentration by the appropriate limit and adding the resulting values. The appropriate limits must all be taken from the same column of the same table. The sum of the fractions for the column must be less than 1.0 if the waste class is to be determined by that column. Example: A waste contains Sr-90 in a concentration of 50 Ci/m^3 and Cs-137 in a concentration of 22 Ci/m^3. Since the concentrations both exceed the values in Column 1, Table 2, they must be compared to Column 2 values. For Sr-90 fraction, 50/150 = 0.33; for Cs-137 fraction, 22/44 = 0.5; the sum of the fractions = 0.83. Since the sum is less than 1.0, the waste is Class B.

(8) Determination of concentrations in wastes. The concentration of a radionuclide may be determined by indirect methods such as use of scaling factors which relate the inferred concentration of one radionuclide to another that is measured, or radionuclide material

accountability, if there is reasonable assurance that the indirect methods can be correlated with actual measurements. The concentration of a radionuclide may be averaged over the volume of the waste, or weight of the waste if the units are expressed as nanocuries per gram.

§61.56 Waste characteristics.

(a) The following requirements are minimum requirements for all classes of waste and are intended to facilitate handling at the disposal site and provide protection of health and safety of personnel at the disposal site.

(1) Wastes must not be packaged for disposal in cardboard or fiberboard boxes.

(2) Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.

(3) Solid wastes containing liquid shall contain as little free standing and non corrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.

(4) Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

(5) Waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged in accordance with paragraph (a)(7) of this section.

(6) Wastes must not be pyrophoric. Pyrophoric materials contained in wastes shall be treated, prepared, and packaged to be nonflammable.

(7) Wastes in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C. Total activity must not exceed 100 curies per container.

(8) Wastes containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practicable the potential hazard from the non-radiological materials.

(b) The requirements in this section are intended to provide stability of the waste. Stability is intended to ensure that the waste does not structurally degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration. Stability is also a factor in limiting exposure to an inadvertent intruder, since it provides a recognizable and nondispersible waste.

(1) Waste must have structural stability. A structurally stable waste form will generally maintain its physical dimensions and its form, under the expected disposal conditions such as weight of overburden and compaction equipment, the presence of moisture, and microbial activity, and internal factors such as radiation effects and chemical changes. Structural stability can be provided by the waste form itself, processing the waste to a stable form, or placing the waste in a disposal container or structure that provides stability after disposal.

(2) Notwithstanding the provisions in §§61.56(a)(2) and (3), liquid wastes, or wastes containing liquid, must be converted into a form that contains as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume of the waste when the waste is in a disposal container designed to

ensure stability, or 0.5% of the volume of the waste for waste processed to a stable form.

(3) Void spaces within the waste and between the waste and its package must be reduced to the extent practicable.

§61.57 Labeling.

Each package of waste must be clearly labeled to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §61.55.

§61.58 Alternative requirements for waste classification and characteristics.

The Commission may, upon request or on its own initiative, authorize other provisions for the classification and characteristics of waste on a specific basis, if, after evaluation, of the specific characteristics of the waste, disposal site, and method of disposal, it finds reasonable assurance of compliance with the performance objectives in Subpart C of this part.

§61.59 Institutional requirements

(a) Land ownership. Disposal of radioactive waste received from other persons may be permitted only on land owned in fee by the Federal or a State government.

(b) Institutional control. The land owner or custodial agency shall carry out an institutional control program to physically control access to the disposal site following transfer of control of the disposal site from the disposal site operator. The institutional control program must also include, but not be limited to, carrying out an

environmental monitoring program at the disposal site, periodic surveillance, minor custodial care, and other requirements as determined by the Commission; and administration of funds to cover the costs for these activities. The period of institutional controls will be determined by the Commission, but institutional controls may not be relied upon for more than 100 years following transfer of control of the disposal site to the owner.

Subpart E: Financial Assurances

§61.61 Applicant qualifications and assurances.

Each applicant shall show that it either possesses the necessary funds or has reasonable assurance of obtaining the necessary funds, or by a combination of the two, to cover the estimated costs of conducting all licensed activities over the planned operating life of the project, including costs of construction and disposal.

§61.62 Funding for disposal site closure and stabilization.

(a) The applicant shall provide assurances that sufficient funds will be available to carry out disposal site closure and stabilization, including: (1) decontamination or dismantlement of land disposal facility structures; and (2) closure and stabilization of the disposal site so that following transfer of the disposal site to the site owner, the need for ongoing active maintenance is eliminated to the extent practicable and only minor custodial care, surveillance, and monitoring are required. These assurances shall be based on Commission-approved cost estimates reflecting the Commission-approved plan for disposal site closure and stabilization. The applicant's cost estimates must take

into account total capital costs that would be incurred if an independent contractor were hired to perform the closure and stabilization work.

(b) In order to avoid unnecessary duplication and expense, the Commission will accept financial sureties that have been consolidated with earmarked financial or surety arrangements established to meet requirements of other Federal or State agencies and/or local governing bodies for such decontamination, closure and stabilization. The Commission will accept this arrangement only if they are considered adequate to satisfy these requirements and that the portion of the surety which covers the closure of the disposal site is clearly identified and committed for use in accomplishing these activities.

(c) The licensee's surety mechanism will be annually reviewed by the Commission to assure that sufficient funds are available for completion of the closure plan, assuming that the work has to be performed by an independent contractor.

(d) The amount of surety liability should change in accordance with the predicted cost of future closure and stabilization. Factors affecting closure and stabilization cost estimates include: inflation; increases in the amount of disturbed land; changes in engineering plans; closure and stabilization that has already been accomplished and any other conditions affecting costs. This will yield a surety that is at least sufficient at all times to cover the costs of closure of the disposal units that are expected to be used before the next license renewal.

(e) The term of the surety mechanism must be open ended unless it can be demonstrated that another arrangement would provide an equivalent level of assurance. This assurance could be provided with a surety mechanism which is written for a specified period of time (e.g., five

years) yet which must be automatically renewed unless the party who issues the surety notifies the Commission and the beneficiary (the site owner) and the principal (the licensee) not less than 90 days prior to the renewal date of its intention not to renew. In such a situation the licensee must submit a replacement surety within 30 days after notification of cancellation. If the licensee fails to provide a replacement surety acceptable to the Commission, the site owner may collect on the original surety.

(f) Proof of forfeiture must not be necesssary to collect the surety so that in the event that the licensee could not provide an acceptable replacement surety within the required time, the surety shall be automatically collected prior to its expiration. The conditions described above would have to be clearly stated on any surety instrument which is not open-ended, and must be agreed to by all parties. Liability under the surety mechanism must remain in effect until the closure and stabilization program has been completed and approved by the Commission and the license has been transferred to the site owner.

(g) Financial surety arrangements generally acceptable to the Commission include: surety bonds, cash deposits, certificates of deposit, deposits of government securities, escrow accounts, irrevocable letters or lines of credit, trust funds, and combinations of the above or such other types of arrangements as may be approved by the Commission. However, self-insurance, or any arrangement which essentially constitutes pledging the assets of the licensee, will not satisfy the surety requirement for private sector applicants since this provides no additional assurance other than that which already exists through license requirements.

§61.63 Financial assurances for institutional controls.

(a) Prior to the issuance of the license, the applicant shall provide for Commission review and approval a copy of a binding arrangement, such as a lease, between the applicant and the disposal site owner that ensures that sufficient funds will be available to cover the costs of monitoring and any required maintenance during the institutional control period. The binding arrangement will be reviewed periodically by the Commission to ensure that changes in inflation, technology and disposal facility operations are reflected in the arrangements.

(b) Subsequent changes to the binding arrangement specified in paragraph (a) of this section relevant to institutional control shall be submitted to the Commission for approval.

Subpart F: Participation by State Governments and Indian Tribes

§61.70 Scope.

This subpart describes mechanisms through which the Commission will implement a formal request from a State or tribal government to participate in the review of a license application for a land disposal facility. Nothing in this subpart may be construed to bar the State or tribal governing body from participating in subsequent Commission proceedings concerning the license application as provided under Federal law and regulations.

§61.71 State and Tribal government consultation.

Upon request of a State or tribal governing body, the Director shall make available Commission staff to discuss with representatives of the State or tribal governing body information submitted by the applicant,

applicable Commission regulations, licensing procedures, potential schedules, and the type and scope of State activities in the license review permitted by law. In addition, staff shall be made available to consult and cooperate with the State or tribal governing body in developing proposals for participation ih the license review.

§61.72 Filing of proposals for State and tribal participation.

(a) A State or tribal governing body whose interest is affected by a near-surface disposal facility at the proposed site may submit to the Director a proposal for participation in the review of a license application. Proposals must be submitted within the following time periods:

(1) For the State in which the disposal facility will be located, or any State that is member of an interstate compact that includes the State in which the disposal facility is located, no later than 45 days following publication in the Federal Register of the notice of tendering of an application submitted under §61.20.

(2) For any other State, or for a tribal governing body, no later than 120 days following publication in the Federal Register of the notice of tendering of an application submitted under §61.20.

(b) Proposals for participation in the licensing process must be made in writing and must be signed by the Governor of the State or the official otherwise provided for by State or tribal law.

(c) At a minimum, proposals must contain each of the following items of information:

(1) A general description of how the State or tribe wishes to participate in the licensing process specifically identifying those issues it wishes to review.

(2) A description of material and information which the State or tribe plans to submit to the Commission for consideration in the licensing process. A tentative schedule referencing steps in the review and calendar dates for planned submittals should be included.

(3) A description of any work that the State or tribe proposes to perform for the Commission in support of the licensing process.

(4) A description of State or tribal plans to facilitate local government and citizen participation.

(5) A preliminary estimate of the types and extent of impacts which the State expects, should a disposal facility be located as proposed.

(6) If desired, any requests for educational or information services (seminars, public meetings) or other actions from the Commission such as establishment of additional Public Document Rooms or exchange of State personnel under the Intergovernmental Personnel Act.

§61.73 Commission approval of proposals.

(a) Upon receipt of a proposal submitted in accordance with § 61.72, the Director shall arrange for a meeting between the representatives of the State or tribal governing body and the Commission staff to discuss the proposal and to ensure full and effective participation by the State or tribe in the Commission's license review.

(b) If requested by a State or tribal governing body, the Director may approve all or any part of a proposal if the Director determines that:

(1) The proposed activities are within the scope of Commission statutory responsibility and the type and magnitude of impacts which the

State or tribe may bear are sufficient to justify their participation; and

(2) The proposed activities will contribute productively to the licensing review.

(c) The decision of the Director will be transmitted in writing to the governor or the designated official of the tribal governing body.

(d) Participation by a State or Indian tribe shall not affect their rights to participate in an adjudicatory hearing as provided by Part 2 of this chapter.

Subpart G: Records, Reports, Tests, and Inspections

§61.80 Maintenance of records, reports, and transfers.

(a) Each licensee shall maintain any records and make any reports in connection with the licensed activities as may be required by the conditions of the license or by the rules, regulations, and orders of the Commission.

(b) Records which are required by the regulations in this part or by license conditions must be maintained for a period specified by the appropriate regulations in this chapter or by license condition. If a retention period is not otherwise specified, these records must be maintained and transferred to the officials specified in paragraph (e) of this section as a condition of license termination unless the Commission otherwise authorizes their disposition.

(c) Records which must be maintained pursuant to this part may be the original or a reproduced copy or microfilm if this reproduced copy or microfilm is capable of producing copy that is clear and legible at the end of the required retention period.

(d) If there is a conflict between the Commission's regulations in this part, license condition, or other written Commission approval or authorization pertaining to the retention period for the same type of record, the longest retention period specified takes precedence.

(e) Notwithstanding paragraphs (a) through (d) of this section, copies of records of the location and the quantity of radioactive wastes contained in the disposal site must be transferred upon license termination to the chief executive of the nearest municipality, the chief executive of the county in which the facility is located, the county zoning board or land development and planning agency, the state governor and other State, local and Federal governmental agencies as designated by the Commission at the time of license termination.

(f) Following receipt and acceptance of a shipment of radioactive waste, the licensee shall record the date of disposal of the waste, the location in the disposal site, the condition of the waste packages as received, any discrepancies between materials listed on the manifest and those received, and any evidence of leaking or damaged packages or radiation or contamination levels in excess of limits specified in Department of Transportation and Commission regulations. The licensee shall briefly describe any repackaging operations of any of the waste packages included in the shipment, plus any other information required by the Commission as a license condition.

(g) Each licensee shall comply with the safeguards reporting requirements of §§30.55, 40.64, 70.53 and 70.54 of this chapter if the quantities or activities of materials received or transferred exceed the limits of these sections. Inventory reports required by these sections are not required for materials after disposal.

(h) Each licensee authorized to dispose of radioactive waste received from other persons shall file a copy of its financial report or a certified financial statement annually with the Commission in order to update the information base for determining financial qualifications.

(i)(1) Each licensee authorized to dispose of waste materials received from other persons, pursuant to this part, shall submit annual reports to the appropriate Commission regional office shown in Appendix D of Part 20 of this chapter, with copies to the Director of the Office of Inspection and Enforcement and the Director of the Division of Waste Management, USNRC, Washington, D.C., 20555. Reports shall be submitted by the end of the first calendar quarter of each year for the preceding year; (2) The reports shall include (i) specification of the quantity of each of the principal radionuclides released to unrestricted areas in liquid and in airborne effluents during the preceding year, (ii) the results of the environmental monitoring program, (iii) a summary of licensee disposal unit survey and maintenance activities, (iv) a summary, by waste class, of activities and quantities of radionuclides disposed of, (v) any instances in which observed site characteristics were significantly different from those described in the application for a license; and (vi) any other information the Commission may require. If the quantities of radioactive materials released during the reporting period, monitoring results, or maintenance performed are significantly different from those expected in the materials previously reviewed as part of the licensing action, the report must cover this specifically.

(j) Each licensee shall report in accordance with the requirements of §70.52 of this chapter.

(k) Any transfer of byproduct, source, and special nuclear materials by the licensee is subject to the requirements in §§30.41, 40.51, and 70.42 of this chapter. Byproduct, source and special nuclear material means materials as defined in these parts, respectively.

§61.81 Tests at land disposal facilities.

(a) Each licensee shall perform, or permit the Commission to perform, any tests as the Commission deems appropriate or necessary for the administration of the regulations in this part, including tests of:

(1) Radioactive wastes and facilities used for the receipt, storage, treatment, handling and disposal of radioactive wastes.

(2) Radiation detection and monitoring instruments; and

(3) Other equipment and devices used in connection with the receipt, possession, handling, treatment, storage, or disposal of radioactive waste.

§61.82 Commission inspections of land disposal facilities.

(a) Each licensee shall afford to the Commission at all reasonable times opportunity to inspect radioactive waste not yet disposed of, and the premises, equipment, operations, and facilities in which radioactive wastes are received, possessed, handled, treated, stored, or disposed of.

(b) Each licensee shall make available to the Commission for inspection, upon reasonable notice, records kept by it pursuant to the regulations in this chapter. Authorized representatives of the Commission may copy and take away copies of, for the Commission's use, any record required to be kept pursuant to this part.

§61.83 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Atomic Energy Act of 1954, as amended, or any regulation or order issued thereunder. A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act, or section 206 of the Energy Reorganization Act of 1974, or any rule.

The following amendments are also made to existing parts of the regulations in this chapter

PART 2 - RULES OF PRACTICE

2. In §2.101, paragraph (a)(2), (b), and (d) are revised to read as follows:

§2.101 Filing of application.

(a) * * *

(2) Each application for a license for a facility will be assigned a docket number. However, to allow a determination as to whether an application for a construction permit or operating license for a production or utilization facility is complete and acceptable for docketing, it will be initially treated as a tendered application after it is received and a copy of the tendered application will be available for public inspection in the Commission's Public Document Room, 1717 H Street NW., Washington, D.C. Generally, that determination will be made within a period of thirty (30) days. However, in selected construction permit applications, the Commission may decide to determine acceptability on

the basis of the technical adequacy of the application as well as its completeness. In such cases, the Commission, pursuant to §2.104(a), will direct that the notice of hearing be issued as soon as practicable after the application has been tendered, and the determination of acceptability will generally be made within a period of sixty (60) days.

*   *   *   *   *

(b) Each application for a license to receive radioactive waste from other persons for disposal under Part 61 of this chapter and the accompanying environmental report shall be processed in accordance with the provisions of this paragraph.

(1) To allow a determination as to whether the application or environmental report is complete and acceptable for docketing, it will be initially treated as a tendered document, and a copy will be available for public inspection in the Commission's Public Document Room 1717 H Street NW., Washington D.C. One original and two copies shall be filed to enable this determination to be made.

(i) Upon receipt of a tendered application, the Commission will publish in the Federal Register notice of the filed application and will notify the governors, legislatures and other appropriate State, county, and municipal officials and tribal governing bodies of the States and areas containing or potentially affected by the activities at the proposed site and the alternative sites. The Commission will inform these officials that the Commission staff will be available for consultation pursuant to §61.71 of this chapter. The Federal Register notice will note the opportunity for interested persons to submit views and comments on the tendered application for consideration by the Commission and

applicant. The Commission will also notify the U.S. Bureau of Indian Affairs when tribal governing bodies are notified.

(ii) The Commission will also post a public notice in a newspaper or newspapers of general circulation in the affected States and areas summarizing information contained in the applicant's tendered application and noting the opportunity to submit views and comments.

(iii) When the Director of Nuclear Material Safety and Safeguards determines that the tendered document is complete and acceptable for docketing, a docket number will be assigned and the applicant will be notified of the determination. If it is determined that all or any part of the tendered document is incomplete and therefore not acceptable for processing, the applicant will be informed of this determination and the aspects in which the document is deficient.

(2) With respect to any tendered document that is acceptable for docketing, the applicant will be requested to (i) submit to the Director of Nuclear Material Safety and Safeguards such additional copies as the regulations in Parts 61 and 51 of this chapter require, (ii) serve a copy on the chief executive of the municipality in which the waste is to be disposed of or, if the waste is not to be disposed of within a municipality, serve a copy on the chief executive of the county in which the waste is to be disposed of, (iii) make direct distribution of additional copies to Federal, State, Indian Tribe, and local officials in accordance with the requirements of this chapter and written instructions from the Director of Nuclear Material Safety and Safeguards, and (iv) serve a notice of availability of the application and environmental report on the chief executives or governing bodies of the municipalities

or counties which have been identified in the application and environmental report as the location of all or part of the alternative sites if copies are not distributed under paragraph (b)(2)(iii) of this section to the executives or bodies. All distributed copies shall be completely assembled documents identified by docket number. Subsequently distributed amendments, however, may include revised pages to previous submittals and, in such cases, the recipients will be responsible for inserting the revised pages. In complying with the requirements of paragraph (b) of this section the applicant shall not make public distribution of those parts of the application subject to §2.790(d).

(3) The tendered document will be formally docketed upon receipt by the Director of Nuclear Material Safety and Safeguards of the required additional copies. Distribution of the additional copies shall be deemed to be complete as of the time the copies are deposited in the mail or with a carrier prepaid for delivery to the designated addressees. The date of docketing shall be the date when the required copies are received by the Director of Nuclear Material Safety and Safeguards. Within ten (10) days after docketing, the applicant shall submit to the Director of Nuclear Material Safety and Safeguards a written statement that distribution of the additional copies to Federal, State, Indian Tribe, and local officials has been completed in accordance with requirements of this section and written instructions furnished to the applicant by the Director of Nuclear Material Safety and Safeguards.

(4) Amendments to the application and environmental report shall be filed and distributed and a written statement shall be furnished to the Director of Nuclear Material Safety and Safeguards in the same manner as for the initial application and environmental report.

(5) The Director of Nuclear Material Safety and Safeguards will cause to be published in the Federal Register a notice of docketing which identifies the State and location of the proposed waste disposal facility and will give notice of docketing to the governor of that State and other officials listed in paragraph (b)(3) of this section and, in a reasonable period thereafter, publish in the Federal Register a notice pursuant to §2.105 offering opportunity for a hearing to the applicant and other affected persons.

* * * * *

(d) The Director of Nuclear Reactor Regulation or Director of Nuclear Material Safety and Safeguards, as appropriate, will give notice of the docketing of the public health and safety, common defense and security, and environmental parts of an application for a license for a waste disposal facility to the Governor or other appropriate official of the State in which the facility is to be located or the activity is to be conducted and will cause to be published in the Federal Register a notice of docketing of the application which states the purpose of the application and specifies the location at which the proposed activity would be conducted.

* * * * *

3. Section 2.103 (a) is revised to read as follows:

§2.103 Action on applications for byproduct, source, special nuclear material, and operator licenses.

(a) If the Director of Nuclear Reactor Regulation or the Director of Nuclear Material Safety and Safeguards, as appropriate, finds that an application for a byproduct, source, special nuclear material, or operator

license complies with the requirements of the Act, the Energy Reorganization Act, and this chapter, he will issue a license. If the license is for a facility or if it is to receive and possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter, the Director of Nuclear Reactor Regulation or the Director of Nuclear Material Safety and Safeguards, as appropriate, will inform the State, tribal and local officials specified in §2.104(e) of the issuance of the license. For notice of issuance requirements for licenses issued pursuant to Part 61 of this chapter, see paragraph 2.106(d) of this part.

*   *   *   *   *

4. Section 2.104(e) is revised to read as follows:

§2.104 Notice of hearing.

*   *   *   *   *

(e) The Secretary will give timely notice of the hearing to all parties and to other persons, if any, entitled by law to notice. The Secretary will transmit a notice of hearing on an application for a facility license or for a license for receipt of waste radioactive material from other persons for the purpose of disposal under Part 61 of this chapter or for a license to receive and possess high-level radioactive waste at a geologic repository operations area pursuant to Part 60 of this chapter to the governor or other appropriate official of the State and to the chief executive of the municipality in which the facility is to be located or the activity is to be conducted or, if the facility is not to be located or the activity conducted within a municipality, to the chief executive of the county (or to the Tribal organization, if it is to be so located or conducted within an Indian reservation).

5. Section 2.105(a)(2) is revised to read as follows:

§2.105 Notice of proposed action.

(a) * * *

(2) A license for receipt of waste radioactive material from other persons for disposal by the waste disposal licensee under Part 61 of this chapter.

* * * * *

6. Section 2.106 is amended by adding a new paragraph (d) to read as follows:

§2.106 Notice of issuance.

* * * * *

(d) The Director of Nuclear Material Safety and Safeguards will also cause to be published in the Federal Register notice of, and will inform the State and local officials or tribal governing body specified in §2.104(e) of any licensing action with respect to a license to receive radioactive waste from other persons for disposal under Part 61 of this chapter or the amendment of such a license for which a notice of proposed action has been previously published.

7. A new Section 2.765 is added to read as follows:

§2.765 Immediate effectiveness of initial decision directing issuance or amendment of licenses under Part 61 of this chapter.

An initial decision directing the issuance of a license under Part 61 of this chapter (relating to land disposal of radioactive waste) or any amendment to such a license authorizing actions which may significantly affect the health and safety of the public, will become effective

only upon order of the Commission. The Director of Nuclear Material Safety and Safeguards may not issue a license under Part 61 of this chapter, or any amendment to such a license which may significantly affect the health and safety of the public, until expressly authorized to do so by the Commission.

*   *   *   *   *

PART 19 - NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS

§19.2 [Amended]

8. Section 19.2 is amended by adding "61," following "40, 60."

§19.3 [Amended]

9. In §19.3, paragraph (d) is amended by adding "61," following "40, 60."

PART 20 - STANDARDS FOR PROTECTION AGAINST RADIATION

§20.2 [Amended]

10. Section 20.2 is amended by adding "61," following "40, 60."

§20.3 [Amended]

11. In §20.3, paragraph (a)(9) is amended by adding "61," following 40, 60."

12. In §20.301 paragraph (a) is amended by adding "61," following "40, 60," and paragraph (b) is revised to read as follows:

§20.301 General requirement.

*   *   *   *   *

(b) As authorized under §20.302 or Part 61 of this chapter; or

*   *   *   *   *

§20.302 [Amended]

13. In §20.302, paragraph (b) is removed and paragraph (c) is redesignated as paragraph (b).

14. A new §20.311 is added to read as follows:

§ 20.311 Transfer for disposal and manifests.

(a) Purpose. The requirements of this section are designed to control transfers of radioactive waste intended for disposal at a land disposal facility and establish a manifest tracking system and supplement existing requirements concerning transfers and recordkeeping for such wastes. The reporting and recordkeeping requirements contained in this section have been approved by the Office of Management and Budget; OMB approval No. 3150-0014.

(b) Each shipment of radioactive waste to a licensed land disposal facility must be accompanied by a shipment manifest that contains the name, address, and telephone number of the person generating the waste. The manifest shall also include the name, address, and telephone number or the name and EPA hazardous waste identification number of the person transporting the waste to the land disposal facility. The manifest must also indicate as completely as practicable: a physical description of the waste; the volume; radionuclide identity and quantity; the total radioactivity; and the principal chemical form. The solidification agent must be specified. Wastes containing more than 0.1% chelating agents by weight must be identified and the weight percentage of the chelating agent estimated. Wastes classified as Class A, Class B, or Class C in §61.55 of this chapter must be clearly identified as such in the manifest. The

total quantity of the radionuclides H-3, C-14, Tc-99 and I-129 must be shown. The manifest required by this paragraph may be shipping papers used to meet Department of Transportation or Environmental Protection Agency regulations or requirements of the receiver, provided all the required information is included. Copies of manifests required by this section may be legible carbon copies or legible photocopies.

(c) Each manifest must include a certification by the waste generator that the transported materials are properly classified, described, packaged, marked, and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation and the Commission. An authorized representative of the waste generator shall sign and date the manifest.

(d) Any generating licensee who transfers radioactive waste to a land disposal facility or a licensed waste collector shall comply with the requirements in subparagraphs (1) through (8). Any generating licensee who transfers waste to a licensed waste processor who treats or repackages waste shall comply with the requirements of subparagraphs (4) through (8). A licensee shall:

(1) Prepare all wastes so that the waste is classified according to §61.55 and meets the waste characteristics requirements in §61.56 of this chapter;

(2) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §61.55 of this chapter;

(3) Conduct a quality control program to assure compliance with §§61.55 and 61.56 of this chapter; the program must include management evaluation of audits;

(4) Prepare shipping manifests to meet the requirements of §§20.311(b) and (c) of this part;

(5) Forward a copy of the manifest to the intended recipient, at the time of shipment; or, deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation from the collector;

(6) Include one copy of the manifest with the shipment;

(7) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter; and,

(8) For any shipments or any part of a shipment for which acknowledgement of receipt has not been received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(e) Any waste collector licensee who handles only prepackaged waste shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation;

(2) Prepare a new manifest to reflect consolidated shipments; the new manifest shall serve as a listing or index for the detailed generator manifests. Copies of the generator manifests shall be a part of the new manifest. The waste collector may prepare a new manifest without attaching the generator manifests, provided the new manifest contains for each package the information specified in paragraph (b) of this section. The collector licensee shall certify that nothing has been done to the waste which would invalidate the generator's certification.

(3) Forward a copy of the new manifest to the land disposal facility operator at the time of shipment;

(4) Include the new manifest with the shipment to the disposal site;

(5) Retain a copy of the manifest and documentation of acknowledgement of receipt as the record of transfer of licensed material as required by Parts 30, 40, and 70 of this chapter, and retain information from generator manifests until disposition is authorized by the Commission; and,

(6) For any shipments or any part of a shipment for which acknowledgement of receipt is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(f) Any licensed waste processor who treats or repackages wastes shall:

(1) Acknowledge receipt of the waste from the generator within one week of receipt by returning a signed copy of the manifest or equivalent documentation.

(2) Prepare a new manifest that meets the requirements of paragraphs (b) and (c) of this section. Preparation of the new manifest reflects that the processor is responsible for the waste;

(3) Prepare all wastes so that the waste is classified according to §61.55 and meets the waste characteristics requirements in §61.56 of this chapter.

(4) Label each package of waste to identify whether it is Class A waste, Class B waste, or Class C waste, in accordance with §§61.55 and 61.57 of this chapter.

(5) Conduct a quality control program to assure compliance with §§61.55 and 61.56 of this chapter. The program shall include management evaluation of audits;

(6) Forward a copy of the new manifest to the disposal site operator or waste collector at the time of shipment, or deliver to a collector at the time the waste is collected, obtaining acknowledgement of receipt in the form of a signed copy of the manifest or equivalent documentation by the collector.

(7) Include the new manifest with the shipment;

(8) Retain copies of original manifests and new manifests and documentation of acknowledgement of receipt as the record of transfer of licensed material required by Parts 30, 40, and 70 of this chapter.

(9) For any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, conduct an investigation in accordance with paragraph (h) of this section.

(g) The land disposal facility operator shall:

(1) Acknowledge receipt of the waste within one week of receipt by returning a signed copy of the manifest or equivalent documentation to the shipper. The shipper to be notified is the licensee who last possessed the waste and transferred the waste to the operator. The returned copy of the manifest or equivalent documentation shall indicate any discrepancies between materials listed on the manifest and materials received.

(2) Maintain copies of all completed manifests or equivalent documentation until the Commission authorizes their disposition; and

(3) Notify the shipper (i.e., the generator, the collector, or processor) and the Director of the nearest Commission Regional Office listed in Appendix D of this part when any shipment or part of a shipment has not arrived within 60 days after the advance manifest was received.

(h) Any shipment or part of a shipment for which acknowledgement is not received within the times set forth in this section, must:

(1) Be investigated by the shipper if the shipper has not received notification of receipt within 20 days after transfer; and

(2) Be traced and reported. The investigation shall include tracing the shipment and filing a report with the nearest Commission Regional Office listed in Appendix D of this part. Each licensee who conducts a trace investigation shall file a written report with the nearest Commission's Regional office within 2 weeks of completion of the investigation.

15. In §20.401, paragraphs (b) and (c)(3) are revised to read as follows:

§20.401. Records of surveys, radiation monitoring, and disposal.

* * * * *

(b) Each licensee shall maintain records in the same units used in this part, showing the results of surveys required by §20.201(b), monitoring required by §§20.205(b) and 20.205(c), and disposals made under §§20.302, 20.303, deleted §20.304[1], and Part 61 of this chapter.

(c) * * *

(3) Records of disposal of licensed materials made pursuant to §§20.302, 20.303, deleted § 20.304[1], and Part 61 of this chapter are to be maintained until the Commission authorizes their disposition.

* * * * *

16. Section 20.408 is amended by adding a new paragraph (a)(7) to read as follows:

§20.408 Reports of personnel monitoring on termination of employment or work.

(a) * * *

(7) Receive radioactive waste from other persons for disposal under Part 61 of this chapter.

* * * * *

PART 21 - REPORTING OF DEFECTS AND NONCOMPLIANCE

§21.2 [Amended]

17. Section 21.2 is amended by inserting "61," after "40, 60," in the third line, and after "40, 60" in both the first and second sentences.

§21.3 [Amended]

18. In §21.3, paragraphs (a)(2), (a) (a-1)(1), (a) (a-1)(2), and (k) are amended by adding "61," after "50, 60."

19. Section 21.21 is revised by adding "61," after "50, 60," in paragraphs (b)(1)(i) and (b)(1)(ii).

PART 30 - RULES OF GENERAL APPLICABILITY TO DOMESTIC LICENSING OF BYPRODUCT MATERIAL

20. A new paragraph (d) is added to Section 30.11 to read as follows:

§30.11 Specific exemptions.

* * * * *

(d) Except as specifically provided in Part 61 of this chapter, any licensee is exempt from the requirements of this part to the extent

that its activities are subject to the requirements of Part 61 of this chapter,

21. In §30.32, paragraph 30.32(f) is amended to read as follows:

§30.32 Application for specific licenses.

* * * * *

(f) An application for a license to receive and possess byproduct material for the conduct of any activity which the Commission determines will significantly affect the quality of the environment shall be filed at least 9 months prior to commencement of construction of the plant or facility in which the activity will be conducted and shall be accompanied by any Environmental Report required pursuant to Part 51 of this chapter.

22. In §30.33, paragraph (a)(5) is revised to read as follows:

§30.33 General requirements for issuance of specific licenses.

(a) * * *

(5) In the case of an application for a license to receive and possess byproduct material for the conduct of any activity which the Commission determines will significantly affect the quality of the environment, the Director of Nuclear Material Safety and Safeguards or his designee, before commencement of construction of the plant or facility in which the activity will be conducted, on the basis of information filed and evaluations made pursuant to Part 51 of this chapter, has concluded, after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, that the action called for is the issuance of the proposed license, with any appropriate conditions to protect environmental values. Commencement of construction prior to such conclusion shall be grounds for denial of a

license to receive and possess byproduct material in such plant or facility. As used in this paragraph the term "commencement of construction" means any clearing of land, excavation, or other substantial action that would adversely affect the environment of a site. The term does not mean site exploration, necessary roads for site exploration, borings to determine foundation conditions, or other preconstruction monitoring or testing to establish background information related to the suitability of the site or the protection of environmental values.

*   *   *   *   *

PART 40 - DOMESTIC LICENSING OF SOURCE MATERIAL

23. In §40.14, a new paragraph (d) is added to read as follows:

§40.14 Specific exemptions.

*   *   *   *   *

(d) Except as specifically provided in Part 61 of this chapter any licensee is exempt from the requirements of this part to the extent that its activities are subject to the requirements of Part 61 of this chapter,

24. In §40.31, paragraph (f) is revised to read as follows:

§40.31 Applications for specific licenses.

*   *   *   *   *

(f) An application for a license to possess and use source material for uranium milling, production of uranium hexafluoride, or for the conduct of any other activity which the Commission determines will significantly affect the quality of the environment shall be filed at least 9 months prior to commencement of construction of the plant or facility in which the

activity will be conducted and shall be accompanied by any Environmental Report required pursuant to Part 51 of this chapter.

* * * * *

25. In §40.32, paragraph (e) is revised to read as follows:

§40.32 General requirements for issuance of specific licenses.

* * * * *

(e) In the case of an application for a license to possess and use source and byproduct material for uranium milling, production of uranium hexafluoride, or for the conduct of any other activity which the Commission determines will significantly affect the quality of the environment, the Director of Nuclear Material Safety and Safeguards or his designee, before commencement of construction of the plant or facility in which the activity will be conducted, on the basis of information filed and evaluations made pursuant to Part 51 of this chapter, has concluded, after weighing the environmental, economic, technical and other benefits against environmental costs and considering available alternatives, that the action called for is the issuance of the proposed license, with any appropriate conditions to protect environmental values. Commencement of construction prior to such a conclusion shall be grounds for denial of a license to possess and use source and byproduct material in such plant or facility. As used in this paragraph the term "commencement of construction" means any clearing of land, excavation, or other substantial action that would adversely affect the environment of a site. The term does not mean site exploration, necessary roads for site exploration, borings to determine foundation conditions, or other preconstruction monitoring or testing to

establish background information related to the suitability of the site or the protection of environmental values.

*　　　　*　　　　*　　　　*　　　　*

PART 51 - LICENSING AND REGULATORY POLICY AND PROCEDURES FOR ENVIRONMENTAL PROTECTION

26. In §51.5, paragraphs (a)(6) and (b)(4)(iii) are revised, paragraph (b)(6) is amended by inserting "61" following "50, 60,", and (d)(3) is amended by inserting "61" following "50, 60." The revised paragraphs read as follows:

§51.5 Actions requiring preparation of environmental impact statements, negative declarations, environmental impact appraisals; actions excluded.

(a) *　*　*

(6) Issuance of a license authorizing receipt and disposal of radioactive waste from other persons under Part 61 of this chapter;

*　　　　*　　　　*　　　　*　　　　*

(b) *　*　*

(4) *　*　*

(iii) Authorizing receipt and disposal of radioactive waste from other persons under Part 61 of this chapter.

*　　　　*　　　　*　　　　*　　　　*

§51.40 [Amended]

27. In §51.40, paragraph (c) is amended by inserting "61" after "30, 40."

PART 70 - DOMESTIC LICENSING OF SPECIAL NUCLEAR MATERIAL

28. In §70.14, a new paragraph (d) is added to read as follows:

§70.14 Specific exemptions.

* * * * *

(d) Except as specifically provided in Part 61 of this chapter, any licensee is exempt from the requirements of the regulations in this part to the extent that its activities are subject to the requirements of Part 61 of this chapter,

29. In §70.21, paragraph (f) is revised to read as follows:

§70.21 Filing.

* * * * *

(f) An application for a license to possess and use special nuclear material for processing and fuel fabrication, scrap recovery or conversion of uranium hexafluoride, or for the conduct of any other activity which the Commission determines will significantly affect the quality of the environment shall be filed at least 9 months prior to commencment of construction of the plant or facility in which the activity will be conducted, and shall be accompanied by an Environmental Report required under Part 51*** of this chapter.

* * * * *

30. In §70.23, paragraph (a)(7) is revised to read as follows:

§70.23 Requirements for the approval of applications.

(a) * * *

(7) Where the proposed activity is processing and fuel fabrication, scrap recovery, conversion of uranium hexafluoride, or any other activity which the Commission determines will significantly affect the quality of the environment, the Director of Nuclear Material Safety and Safeguards or his designee, before commencement of construction of the plant or facility in which the activity will be conducted, on the basis of information filed and evaluations made pursuant to Part 51 of this chapter, has concluded, after weighing the environmental, economic, technical, and other benefits against environmental costs and considering available alternatives, that the action called for is the issuance of the proposed license, with any appropriate conditions to protect environmental values. Commencement of construction prior to such conclusions shall be grounds for denial to possess and use special nuclear material in such plant or facility. As used in this paragraph the term "commmencement of construction" means any clearing of land, excavation, or other substantial action that would adversely affect the environment of a site. The term does not mean site exploration, necessary roads for site exploration, borings to determine foundation conditions, or other preconstruction monitoring or testing to establish background information related to the suitability of the site or the protection of environmental values.

* * * * *

PART 73 - PHYSICAL PROTECTION OF PLANTS AND MATERIALS

31. In §73.1, paragraph (b)(1)(iii) is revised to read as follows:

§73.1 Purpose and scope.

* * * * *

(b) * * *

(1) * * *

(iii) the physical protection of special nuclear material by any person who, pursuant to the regulations in Parts 61 or 70 of this chapter, possesses or uses at any site or contiguous sites subject to the control by the licensee, formula quantities of strategic special nuclear material or special nuclear material of moderate strategic significance or special nuclear material of low strategic significance.

* * * * *

PART 170 - FEES FOR FACILITIES AND MATERIALS LICENSES AND OTHER REGULATORY SERVICES UNDER THE ATOMIC ENERGY ACT OF 1954, AS AMENDED*

32. Section 170.2 is revised to read as follows:

§170.2 Scope.

Except for persons who apply for or hold the permits, licenses, or approvals exempted in §170.11, the regulations in this part apply to a person who is an applicant for, or holder of, a specific byproduct material license issued pursuant to Parts 30 and 32-35 of this chapter, a specific source material license issued pursuant to Part 40 of this chapter, a specific materials license issued under Part 61 of this chapter, a specific special nuclear material license issued pursuant to Part 70 of this chapter, a specific license for the storage of spent fuel issued pursuant to Part 72 of this Chapter, a specific approval of spent fuel casks and shipping containers issued pursuant to Part 71 of this chapter, a specific request for approval of sealed sources and devices containing byproduct material, source material, or special nuclear material, or a production or utilization facility construction permit and operating

license issued pursuant to Part 50 of this chapter, to routine safety and safeguards inspections of a licensed person, to a person who applies for approval of a reference standardized design of a nuclear steam supply system or balance of plant, for review of a facility site prior to the submission of an application for a construction permit, for review of an independent spent fuel storage installation pursuant to Part 72 of this chapter, and for a special project review which the Commission completes or makes whether or not in conjunction with a license application on file or which may be filed.

(Amendments to all parts are issued pursuant to citations of authority presently codified or, in the case of 10 CFR Part 61, as set out after the list of sections in the new Part 61.)

Dated at Washington, D.C. this _____ day of _________, 1982.

For the U.S. Nuclear Regulatory Commission.

Samuel J. Chilk
Secretary of the Commission.

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16. ABSTRACT *(200 words or less)*

The three-volume final environmental impact statement (FEIS) is prepared to guide and support publication of a final regulation, 10 CFR Part 61, for the land disposal of low-level radioactive waste. The FEIS is prepared in response to public comments received on the draft environmental impact statement (DEIS) on the proposed Part 61 regulation. The DEIS was published in September 1981 as NUREG-0782. Public comments received on the proposed Part 61 regulation separate from the DEIS are also considered in the FEIS. The FEIS is not a rewritten version of the DEIS, which contains an exhaustive and detailed analysis of alternatives, but rather references the DEIS and presents the final decision bases and conclusions (costs and impacts) which are reflected in the Part 61 requirements. Four cases are specifically considered in the FEIS representing the following: past disposal practice, existing disposal practice, Part 61 requirements, and an upper bound example.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

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groundwater migration
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10 CFR Part 61
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17b. IDENTIFIERS/OPEN-ENDED TERMS

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
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OFFICIAL BUSINESS