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IMPACTS-BRC, Version 2.1

Code and Data Verification

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Abstract

In the Federal Register, Volume 51, Number 168, NRC has intended the use of IMPACTS-BRC to evaluate petitions for evaluating radioactive waste streams as below regulatory concern. IMPACTS-BRC is a generic radiological assessment code that allows calculation of potential impacts to maximum individuals, waste disposal workers, and the general population resulting from exemption of very low-level radioactive wastes from regulatory control. The code allows calculations to be made of human exposure to the waste by many pathways and exposure scenarios.

This document describes the code history and the quality assurance work that has been carried out on IMPACTS-BRC. The report includes a summary of all the literature reviews pertaining to IMPACTS-BRC up to Version 2.0. The new code and data verification work necessary to produce IMPACTS-BRC, Version 2.1 is presented. General comments about the models and treatment of uncertainty in IMPACTS-BRC are also given

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Executive Summary

IMPACTS-BRC is a computer program developed to conduct scoping analyses for use in supporting rulemaking on petitions for exemption of waste streams from multiple producers. It was not initially intended for use on individual license applications for specific sites. However, the Federal Register, Volume 51, Number 168, specifies that IMPACTS-BRC be used to evaluate incoming license applications. This creates a problem since IMPACTS-BRC is not being used for its intended purpose. It is a generic code that is now being used for site specific applications. This is only a valid procedure if it can be shown that generic results from IMPACTS-BRC are conservative when compared to results from site specific models. Otherwise, IMPACTS-BRC should not be used.

The purpose of this report was to verify that IMPACTS-BRC works as specified in its user's guides. In other words, Sandia National Laboratories (SNL) has determined that the mathematical models given in the user's guide are correctly implemented into the computer code. No direct work has been done to verify that the mathematical models used in the code are appropriate for the purpose that they are being used. In fact, scrutiny of the groundwater transport models in IMPACTS-BRC has led us to recommend that alternate geosphere models should be used.

Other work carried out for this project included verifying that the input data for IMPACTS-BRC is correct and traceable. This was carried out, and a new version of the data with these qualities was produced. The new version of the data was used with the verified IMPACTS-BRC, Version 2.0 to produce IMPACTS-BRC, Version 2.1. Note that no code changes were made in the evolution to Version 2.1: performance differences between Version 2.0 and 2.1 are caused by the updated data.

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1.0 Introduction

1.1 Background

The Low-Level Waste Policy Amendments Act requires the U.S. Nuclear Regulatory Commission (NRC) to develop the technical capability for evaluating petitions to classify very low-level radioactive waste streams as Below Regulatory Concern (BRC). The NRC published a policy statement on BRC waste in the Federal Register, Volume 51, Number 168. This explicitly stipulates that IMPACTS-BRC shall be used to evaluate petitions for BRC classifications. It therefore provides a strong incentive to petitioners to use the code, although it does not require the code's use in a BRC petition. However, petitioners are requested, at a minimum, to provide NRC with the IMPACTS-BRC input data [Forstom and Goode, 1986].

IMPACTS-BRC is a generic radiological assessment code that allows calculation of potential impacts to maximally exposed individuals, waste treatment and disposal workers, and the general population resulting from exemption of very low-level radioactive wastes from regulatory control. The code allows radiation dose calculations to be made of human exposure to the waste by many pathways and exposure scenarios. These scenarios encompass transportation, treatment, disposal, and post-disposal activities. Default environmental and populational parameters are included in the code for three geographical locations: a highly populated, humid Northeast site, a moderately populated, humid Southeast site, and a sparsely populated, arid Southwest site. Default parameters are also included that are representative of treatment and disposal facilities that allow calculation of radiation doses to workers on a generic basis. Several options are available to the user related to facility design and treatment options.

1.2 Purpose of this Report

Because of the primacy of IMPACTS-BRC in the petition process and the potentially contentious atmosphere in which the code may be used, there is a strong requirement for the code to be as defensible as possible. To some extent, the defensibility of the code is linked to the adequacy of the verification that has been done to ensure that the code functions as specified in its documentation.

This report summarizes previous broad and extensive verification work that has been done on IMPACTS-BRC by several independent investigators. These activities consist of data and code verification, reviews for completeness, and comparisons with other modeling approaches. For IMPACTS-BRC, Version 1.0 a summary is given of past assessments and evaluations. In addition, details are given of the code verification and quality assurance activities conducted during the development of Version 2.0.

Independent review and verification of data in Version 2.0 input files was conducted, and code verification was performed on portions of the code that were not exercised by the existing sample problems. New sample problems have been developed to check the untested sections of the code, and the results of these tests also are discussed. The process of verifying the code and the data resulted in a new version of the code denoted IMPACTS-BRC, Version 2.1.

This document is intended to be a supplement to the IMPACTS-BRC, Version 2.0 user's guide [O'Neal and Lee, 1990] and is not intended as a stand-alone user's manual. The user is referred to O'Neal and Lee [1990], Forstom and Goode [1986], and Oztunali and Roles [1984] for details of operation and theory.

1.3 Code History

IMPACTS-BRC has its roots in the De Minimis Waste Impacts Methodology developed by Oztunali and Roles [1984] and uses many of the same approaches developed for the Impacts Analysis Methodology for low-level radioactive waste disposal [Oztunali *et al.*, 1981; Oztunali and Roles, 1986]. The original structure of the methodology was two codes, IMPACTS and INVIMPS, that implemented the recommended modeling methods. The purpose of IMPACTS was to estimate radiological impacts on individuals and populations using pathway analysis to evaluate waste treatment or disposal options. The purpose of INVIMPS was to translate a user-specified dose limitation criterion to concentration limitations in the waste.

Forstom and Goode [1986] updated and modified the Impacts Methodology to produce a code for below regulatory concern waste: IMPACTS-BRC, Version 1.0. IMPACTS-BRC is a single computer code designed to run on a DOS-based personal computer. Other modifications include changes to the types of facilities considered, and changes designed to make the results of the code easier to interpret.

Forstom and Goode [1986] changed parameters used in the ground-water impact assessment to make the code yield more conservative results. More specifically, ground-water travel times, retardation factors, and leachate concentration ratio data in the source were altered. Dispersion also was eliminated from the analysis of ground-water impacts.

For a more in depth discussion of the differences between the original IMPACTS code and IMPACTS-BRC Version 1.0, including analyses of a potential BRC waste stream using both codes, see the review by Chan *et al.* [1988].

Users of Version 1.0 expressed concern that there was limited verification work done on the code (*e.g.*, Parrish *et al.*, [1989]). Consequently, Sandia National Laboratories (SNL) was contracted by NRC to evaluate IMPACTS-BRC, Version 1.0, and to conduct extensive data and code verification and revision of the code. The resulting code, IMPACTS-BRC, Version 2.0, was documented in a user's manual [O Neal and Lee, 1990]. Improvements over Version 1.0 include a user-friendly shell that simplifies editing input files, an update of all dose conversion factors, some updated scenario parameters, improved file management, and correction of inconsistencies in transport calculations. The user's manual discusses the improvements made to Version 1.0 to create Version 2.0, but does not document all the verification activities that were performed on Version 1.0.

Following the release of Version 2.0, possible inconsistencies between Version 2.0 and its documentation were identified. Also, there has been a continuing need to develop additional sample problems that completely exercise the code and permit assurance that all aspects of the code function as advertised. The resolution of these issues was accomplished by producing a new version of the code following a careful quality assurance program of data and code verification, and including production of new sample problems. The resulting version of the code, documented herein, is Version 2.1. No code changes were made in going from Version 2.0 to Version 2.1, since the code was verified to perform as advertised. The differences in performance between Version 2.0 and Version 2.1 occur because of the updated data input files.

1.4 Approaches to Building Confidence

The purpose of this document is to build confidence in the IMPACTS-BRC code. There are four general approaches to building confidence in models implemented in computer codes. First, the code may be assessed for completeness. That is, there must be models available in the code to evaluate any of the important physical or chemical processes that could result in significant exposure to radionuclides as a result of exemption of wastes from regulatory control.

Second, the code must go through a quality assurance verification process that provides confidence that the chosen models are correctly implemented in the code. Part of verification is the comparison of code results with hand calculations or analytical solutions. When analytical solutions are unavailable, one can verify that the models are implemented correctly in the code by benchmarking it against other similar codes that purport to implement the same physics or chemistry. Benchmarking exercises provide confidence that the equations are correctly implemented in the code.

A third approach to confidence building is intercomparison, which is comprised of comparing the code's results to other modeling approaches for the same physical processes. Intercomparison can provide a different sort of confidence than verification: confidence that the modeling approach is reasonable compared to other possible modeling approaches. The difference between benchmarking and intercomparison is that benchmarking compares models that implement similar physics while intercomparison compares different models for the same processes.

Fourth, the models in the code may be subjected to validation. Validation is the process of providing "assurance that a model, as embodied in a computer code, is a correct representation of the process or system for which it is intended"[1]. Consequently, the validation

[1] NRC, A Revised Modeling Strategy Document for High-Level Waste Performance Assessment, U. S. NRC, 1984

process consists of comparing model results with experimental data, and using the results to build confidence in the model for that specific application. The validation process should not be viewed as an attempt to produce "validated" models. In fact, it is not possible to "validate" typical models used in performance assessments [NEA, 1991], owing to the time scales, space scales, and empirical nature of the models used in these analyses. The validation process is more correctly directed toward demonstrating that the model is "not invalid" rather than attempting to demonstrate "validity" [Davis *et al.*, 1991]. Furthermore, the validation process is site-specific, and cannot be performed on a generic basis [Davis *et al.*, 1991]. A further issue in conducting validation on IMPACTS-BRC is that the code is intended to provide deliberately conservative results. Therefore, validation of the code should not consist of evaluating the accuracy of the code, but rather its adequacy for providing conservative results. IMPACTS-BRC may well provide inaccurate results in some cases, but the results may be considered adequate if they are demonstrably conservative.

There are no known attempts at validation of IMPACTS-BRC in the open literature. If such validation exercises did exist, the site-specific confidence derived from them would not necessarily be transferable to a new site. Consequently, even if there were existing validation studies on the code, these may not lend confidence to a new application, and hence would be of limited utility in developing confidence in the code on a generic basis.

In this report, we discuss applications of all these confidence-building approaches to IMPACTS-BRC, except validation. Instead, we report on assessments of completeness, on verifications of data and coding using hand calculations and benchmarking, and on intercomparisons. There has been extensive work done on each of these confidence-building areas by independent investigators.

1.5 Treatment of Uncertainty

Uncertainties arise from several different sources in radiological assessments. The general types of uncertainty are uncertainty about the future state of the site, conceptual model uncertainty, mathematical model uncertainty, and parameter uncertainty [Davis *et al.*, 1990].

This report is directed towards addressing uncertainties about the future, and mathematical model uncertainties associated with IMPACTS-BRC, but the other aspects of uncertainty are outside the scope of this report.

The uncertainty about the future nature of the site is accounted for in IMPACTS-BRC by explicitly modeling alternate future scenarios, and identifying the impacts associated with them. Of primary importance in this approach is that the list of scenarios be reasonably complete.

Mathematical model uncertainty refers to uncertainty caused by the assumptions that are needed to solve the mathematical equations. This type of uncertainty may include, for instance, differences between a differential equation and its discrete numerical representation, coding errors, or truncation errors associated with summing infinite series. Approaches to reducing mathematical model uncertainty primarily consist of verification and quality assurance [Davis *et al.*, 1990].

Uncertainties about the future are addressed by reviews for completeness of the pathways and scenarios included in the code. Mathematical model uncertainties are addressed by appropriate verification and intercomparison, which are reviewed in this report.

In the remainder of this section we briefly review parameter and conceptual model uncertainties, and identify how they should be addressed while using IMPACTS-BRC.

In the present context, parameter uncertainty refers to an incomplete knowledge of the model constitutive coefficients used in the assessment. In part, this uncertainty is identified with uncertainty in the values, and the statistical and spatial distributions of data used to infer the model parameters. This type of uncertainty can be addressed by associating a continuous probability density function with each input variable [NCRP, 1984]. The effect of the uncertainty on modeling results may be determined by sampling from each distribution and propagating the resulting finite number of parameter sets through the model to approximate an output probability distribution. This approach, known as Monte Carlo analysis, provides a way to assess whether the maximum result has been generated by the input variable distributions.

Uncertainties in the conceptual model arise from many sources, including inadequacies in site-characterization data, data misinterpretation, and limitations of the current models to describe adequately processes that occur at the actual site. When using simple generic models at specific sites, as is done in IMPACTS-BRC, it is important to assure that the model is conservative for the actual site. The best way to do this is by collecting site-specific data, and conducting validation exercises using the data.

The modeling approaches used in IMPACTS-BRC are intended to be conservative; assessment modeling conducted this way attempts to bound the parametric and model uncertainties in the radiological assessment [Starmer *et al.*, 1988; Deering and Kozak, 1990]. However, to have confidence that the analysis bounds the uncertainty, both conservative models and conservative parameters are used. This requires that the analyst be able to select the most conservative combination of models and parameters *a priori*.

The key point here is that to bound both conceptual model and parameter uncertainties, a combination of conservative models and conservative parameters must be used. Lessening the conservatism of either will lead to increased likelihood of underpredicting the radiological impacts [NCRP, 1984]. If the analysis produces doses that are far below the regulatory limit, this may not be a concern. However, if the doses are near the limit, it may be unclear whether the standard has been violated.

In this report, we have not fully addressed conceptual model uncertainty, although we have commented on the models used in the code. We have primarily reviewed intercomparisons between codes, which may lend confidence that the model in the code is conservative compared to other possible modeling approaches. The assessment of conceptual model conservatism should be done on a site-specific basis. To ensure that generic models bound the site-specific conceptual model uncertainty, the generic models should be very conservative.

We have not fully addressed parameter uncertainty; in general, this is also a site-specific issue. We have identified where and when the parameters were justified for use in the code (a quality assurance approach), but have not assessed them for their use as generic conservative parameters. Again, to bound the uncertainty in the analysis, it is desirable that the generic parameters be very conservative, and that less conservative values should be justified on a site-specific basis.

Previous evaluations of conservatism in IMPACTS-BRC have suggested that portions of the code are overly conservative for specific applications [Rogers and Murphy, 1988; Kennedy *et al.*, 1989]. These results are not general, and cannot be completely transferred to other specific cases. Instead, either generic (but very conservative) analyses may be used, or site-specific (less conservative) analyses may be used if the reduction of conservatism has been justified using site-specific information.

1.6 Structure of the Report

The results of previous assessments of various versions of IMPACTS-BRC are presented in Chapter 2. For the assessments of early versions of the code, we have presented only the results that are still pertinent to the present version of the code. Hence we have omitted concerns about coding errors and difficulties using the code that have been resolved in the evolution to Version 2.1. Furthermore, many early comments about data and code verification have been omitted, since these comments have received comprehensive attention in the documentation of Versions 2.0 and 2.1. The remaining attention of the reviewers was dedicated to reviews for completeness, to benchmarking, and to intercomparison exercises, including assessments of conservatism of both data and modeling approaches. These exercises were directed toward the models in IMPACTS-BRC rather than the implementation of those models in the code. Consequently, many of the results of these exercises are pertinent today.

In Chapter 3, we discuss the procedure and findings of our review of IMPACTS-BRC, Version 2.0. We have included details of the quality-assurance procedures used in the assessment process. This process has ensured that all data in the code are traceable and correspond to appropriate literature values, and that the most important portions of the code have been exercised in verification activities. New sample problems have been developed, which are documented in Chapter 3. In Chapter 4, we discuss general concerns about IMPACTS-BRC that have arisen during our close scrutinization of the code. Chapter 5 summarizes our verification work, while Chapter 6 gives information about the distribution of IMPACTS-BRC, Version 2.1.

2.0 Previous Evaluations of IMPACTS-BRC

The purpose of this chapter is to review the literature pertaining to IMPACTS-BRC. Most of the existing reviews are done for IMPACTS-BRC, Version 1.0, and not for the more current versions. Therefore, not all the information may be pertinent to higher version numbers. This chapter is organized in sections that detail each review of the computer program.

2.1 Evaluation of Version 1.0 by Kennedy *et al.* [1989]

Kennedy *et al.* [1989] conducted an extensive review of IMPACTS-BRC Version 1.0 [Forstom and Goode, 1986]. The scope of their review encompassed four objectives: (1) evaluate the reasonableness of the dose assessment modeling, (2) determine the amount of conservatism in the code, (3) assess the sensitivity of doses to modeling parameters and assumptions, and (4) review the dose pathways for completeness. The evaluation produced the following results for each of these objectives.

2.1.1 Reasonableness of Dose Assessment Modeling

The evaluation of reasonableness incorporated both code verification, and intercomparison with alternate modeling approaches. Verification against hand calculations was performed for selected radionuclides and scenarios using the sample problems included with the code. The verification was performed on an overall basis rather than a line-by-line code comparison. Based on this, Kennedy *et al.* [1989] concluded that the program was operating correctly.

Kennedy *et al.* [1989] compared IMPACTS-BRC, Version 1.0 with the approaches used in ONSITE/MAXI1 [Kennedy *et al.*, 1986; Kennedy *et al.*, 1987], and with a recommended International Atomic Energy Authority (IAEA) approach for exempting radiation sources and practices from regulatory control [IAEA, 1987]. The intercomparison was conducted for four scenarios: (1) onsite incineration, (2) intruder construction at a closed sanitary landfill, (3) intruder agriculture at a closed sanitary landfill, and (4) intruder well at a closed sanitary landfill.

Kennedy *et al.* [1989] state that numerous modifications to the IAEA results were necessary to put them on the same basis for comparison with IMPACTS-BRC for the incinerator scenario. Differences in the pathway analyses for H-3 and C-14 were attributed as the cause of the differences between the results for those nuclides. The IAEA uses an equilibrium model for the uptake of these radionuclides by biota, while IMPACTS-BRC uses the approach recommended in NRC Regulatory Guide 1.109 [NRC, 1977a]. The results for the other radionuclides examined were in close agreement.

A similar comparison was conducted between IMPACTS-BRC and ONSITE/MAXI1. In all cases tested, IMPACTS-BRC provides either good agreement or a slightly conservative estimate of the dose from the incinerator scenario. Differences between the results were attributed by Kennedy *et al.* [1989] to be the result of using different dose conversion factors in the two codes. We note that these differences have probably been altered for IMPACTS-BRC version 2.0 or greater, since all dose conversion factors have been updated.

Kennedy *et al.* [1989] noted that numerous modifications were necessary to the IAEA approach in order to make the comparison for the intruder construction scenario, since the IAEA assumed much less dilution in the analysis, and applied somewhat different assumptions about exposure conditions in the pathway analysis. Kennedy *et al.* [1989] corrected the IAEA doses to account for additional dilution, but did not account for other differences in the analysis methods. The doses calculated by IMPACTS-BRC are generally lower than the IAEA results, and Kennedy *et al.* [1989] attributed these differences to the differences in pathway assumptions, and to differences in external exposure dose conversion factors. Again, we note that the external dose conversion factors used in IMPACTS-BRC, Version 2.0 are different from the ones in this comparison, so the results may appear somewhat different if a comparable analysis were performed using the updated IMPACTS-BRC. Differences resulting from pathway assumptions should still exist.

Differences between the results from IMPACTS-BRC, Version 1.0 and ONSITE/MAXI for the intruder construction scenario were explained by Kennedy *et al.*

[1989] as follows. Differences between H-3 and C-14 doses were caused by differences in dose conversion factors and by modeling differences in the pathway analysis. The ONSITE/MAXI1 program uses a specific activity approach to estimating the concentrations of H-3 and C-14 in foods. The ratios of H-3 and C-14 to stable hydrogen and carbon are assumed to be the same in the food as in the surrounding environment in which the food is located. Differences in Pu-239 and Pu-241 doses were attributed to a higher air concentration (higher by a factor of 100) used by IMPACTS-BRC, and to other inhalation exposure parameters used in the analysis.

Kennedy *et al.* [1989] also compared the modeling approaches for the intruder agriculture scenario. Again, modifications were made to the IAEA results to put them on a comparable basis with IMPACTS-BRC, Version 1.0. For this case, the IAEA analysis used different dilution-factor and pathway assumptions. Kennedy *et al.* attributed the difference in Sr-90 dose to the use of the parameter M_0 in IMPACTS-BRC to account for the effects of waste packaging in retarding root uptake. The IAEA approach does not account for this mitigating mechanism. For the radionuclides that have inhalation or external exposure as critical pathways, the comparison was concluded to be good. Again, for H-3 and C-14 the two methods use different models for the uptake analysis, and this accounts for some of the differences for these two radionuclides.

The comparison between IMPACTS-BRC, Version 1.0 and ONSITE/MAXI1 for the intruder agriculture scenario was complicated by the inclusion of the parameter M_0 in IMPACTS-BRC, since ONSITE/MAXI1 does not account for the effect of packaging on the release rate to the biosphere. Kennedy *et al.* [1989] concluded that when the dose is dominated by external exposure, the two codes compare well, and attributed differences between results from the two codes to minor differences in the dose conversion factors. There were also discrepancies caused by differences in the models for inhalation exposure, and because of the use of a specific-activity model for H-3 and C-14 in ONSITE/MAXI1. Given these differences, Kennedy *et al.* [1989] concluded that the two codes compared relatively well.

A comparison was made between IMPACTS-BRC, Version 1.0 and ONSITE/MAXI1 for the intruder well scenario. Differences in the H-3 and C-14 doses were again attributed to differences in pathway modeling. The IMPACTS-BRC modeling approach was also qualitatively compared to the conservative approach recommended by Goode *et al.* [1986]. It was concluded that the IMPACTS-BRC ground-water model was both less conservative and more realistic than the model of Goode *et al.* It was also concluded that the IMPACTS-BRC ground-water model more adequately accounts for time-dependent releases.

The exposure model for the transportation worker was compared with results from ISOSHLD [Engle *et al.*, 1966]. ISOSHLD analyses were conducted (assuming an infinite slab geometry) for a number of radionuclides. ISOSHLD analysis results were compared to the pathway dose conversion factor used to determine impacts from direct gamma radiation exposure to contaminated soils in IMPACTS-BRC, Version 1.0. It was concluded that the results for the limiting radionuclide, Co-60, compared well for both approaches, but for other radionuclides there was considerable variation. We note that the Tc-99 result deviates greatly, with all other results being in reasonable agreement.

Kennedy *et al.* [1989] also performed an analysis of the truck-driver dose using a finite dimension source in ISOSHLD. Based on this analysis, they found the dose to the driver that was lower than the IMPACTS-BRD dose by about an order of magnitude compared to the results for the infinite source. They also stated that a combination of scenario-specific parameters in IMPACTS-BRC also should lower the dose by about an order of magnitude, which should make the results from the two codes agree well but they apparently did not conduct the comparable analysis.

Kennedy *et al.* [1989] provided a qualitative evaluation of the differences in the overall result caused by thicker shielding and altered travel distance and velocity. They concluded that the truck-driver exposure scenario doses calculated using IMPACTS-BRC were conservative by about a factor of 10 compared to the results from ISOSHLD.

Kennedy *et al.* [1989] concluded that the assumptions and parameters used in IMPACTS-BRC appeared generally to be reasonable, and that the program operated consistently with its documentation. The code was found to compare generally well with ONSITE/MAXI1 and the modified IAEA analysis results. The ground-water transport analysis was concluded to be reasonably conservative, and more realistic than other simpler modeling approaches. A caution was added that unaware users may obtain results that do not represent the conditions intended to be modeled.

2.1.2 Sensitivity Analysis

Several sensitivity analyses were performed by Kennedy *et al.*, from which they concluded that varying option-selection indices only affects the dose in a few cases: (1) the processing index affected doses for scenarios involving elevated releases, (2) intruder scenario doses were small for short-lived radionuclides, (3) the accessibility index activated metals option affected ground-water doses, and (4) the sensitivity to region index varied for different scenarios.

Parameter sets were generated using Monte Carlo analysis with Latin Hypercube sampling [Iman *et al.*, 1981]. A large number of parameter sets was generated (960) and IMPACTS-BRC analyses were performed for each of these sets. The results of these analyses were evaluated by generating scatter plots, which pictorially identify correlations between input parameters and output doses.

The results were only defined in a qualitative manner (increase or decrease); the functional form of the correlation was not evaluated. In each case, it was found that the code produced the expected correlation.

2.1.3 Review for Completeness

Kennedy *et al.* [1989] concluded that the pathways and scenarios included in IMPACTS-BRC are quite complete and reasonable, except for situations such as salvage of discrete sources or exposure to nonhomogeneous sources.

2.1.4 Summary of the Review by Kennedy *et al.* [1989]

Kennedy *et al.* [1989] reviewed IMPACTS-BRC for completeness of pathways and scenarios, and for reasonableness of the modeling approaches (including an assessment of conservatism). The code results were compared to results generated using ONSITE/MAXII and an IAEA study. The review was not a benchmark analysis, since one would not expect ONSITE/MAXII, IMPACTS-BRC, and the IAEA approach to produce identical results. Instead, the review constituted a comparison of different modeling approaches. The approaches agreed reasonably well for all cases. However, some of the assumptions in the truck driver scenario in IMPACTS-BRC were identified as potentially overly conservative compared to the results from other programs.

In addition, Kennedy *et al.* conducted sensitivity analyses to determine whether the code produced expected correlations, and found that in each case the code performed as expected. Again, these sensitivity studies are related to the overall reasonableness of the modeling approaches, rather than the verification of the code.

The study of IMPACTS-BRC, Version 1.0 by Kennedy *et al.* provides confidence that the code is complete in pathways and scenarios, although it was suggested that more attention may be in order for discrete sources. It also provides confidence that IMPACTS-BRC modeling approaches are in substantial agreement, for the scenarios studied, with other existing modeling approaches.

2.2 Evaluation of Version 1.0 by Rogers and Murphy [1988]

An evaluation of IMPACTS-BRC, Version 1.0 was conducted by Rogers and Murphy [1988]. Their report had three objectives: (1) assessment of the sensitivity of dose results to modeling parameters and assumptions, (2) determination of the amount of conservatism in the code, and (3) verification that the code correctly performs dose calculations as described in NUREG/CR-3585, the De Minimis methodology.

These objectives were pursued using three activities: (1) a series of computer runs were made using the code to evaluate sensitivities to parameter values, and to identify the crucial pathways, (2) a review was conducted of the default parameters used in the code to assess their reasonableness or conservatism, and (3) a comparison was made between the source code and the description of the methodology in Oztunali and Roles [1984], with hand calculations being performed to verify the results of the code. These activities are described in more detail in the following sections.

2.2.1 Sensitivity Analyses

The sensitivity analyses conducted by Rogers and Murphy were intended to be complementary to the analyses reported by Kennedy *et al.* [1989]. A series of computer runs was made to assess which scenarios and pathways tended to produce the largest influence on doses. Runs were also made to assess the sensitivity of IMPACTS-BRC, Version 1.0 results to changes in waste composition, facility options, and waste treatment and disposal options.

A survey was conducted of electric utilities that operate nuclear power plants to identify ranges of values for parameters to be used in IMPACTS-BRC. Data were requested on landfill capacity, mass of waste received annually, distance from the power plant to the disposal facility, and information on the use of incinerators. The responses to this survey were used to identify a reasonable range for parameters to be used in the code.

A number of computer runs were made in which waste density, weight percent of combustible material, percent of BRC waste in a truckload of material, waste processing option, and annual volume of non-BRC waste disposed were varied. These parameters were varied over fairly wide ranges, which lends confidence that the range of variation of dose as a function of these parameters has been spanned.

Rogers and Murphy concluded that in all of the analyses, IMPACTS-BRC identified the transportation worker doses and the incinerator worker doses as the greatest. Intruder doses were calculated to be about two orders of magnitude smaller than these, and doses for other pathways and scenarios were 3 to 5 orders of magnitude smaller than the maximum dose. It was therefore concluded that analyses of power plant wastes using IMPACTS-BRC would typically be limited by transportation and incinerator worker doses. These doses would then limit the radionuclide concentrations in power-plant wastes that could be considered for BRC disposal.

2.2.2 Assessment of Conservatism

Rogers and Murphy primarily considered the extent of conservatism in the calculation of dose to a transportation worker, dose to an incinerator worker, and dose to a disposal site worker, since their sensitivity analyses had determined these to be the limiting exposures for power plant wastes. However, for the sake of completeness they also considered the conservatism of the calculations of doses to inadvertent intruder and from releases to ground water.

The transportation worker dose calculated using IMPACTS-BRC, Version 1.0 was compared to the dose calculated using MICROSHIELD [Grove Engineering, 1985]. The truck was modeled as a 7 ft x 7 ft x 14 ft rectangular solid. Two comparisons were made: in the first, the shielding from the metal truck sides was not accounted for, and, in the second, the sides were modeled as 1/8-inch steel. The dose per trip was calculated assuming the worker spent 2 hours 1 meter from the 7 ft x 7 ft face of the truck bed (in the cab) and 1/2 hour 1 meter from the 7 ft x 14 ft face. The comparison between IMPACTS-BRC and MICROSHIELD is shown in Table 2.1. The results for the 10 percent BRC waste load were in good agreement, and for the 100 percent BRC waste the IMPACTS-BRC waste dose is slightly lower. It was concluded by Rogers and Murphy that the IMPACTS-BRC results were satisfactory for this application.

Table 2.1: Transportation Worker Dose (mR/trip) Comparison Between MICROSHIELD and IMPACTS-BRC*

	IMPACTS-BRC	MICROSHIELD (no shielding)	MICROSHIELD (shielding)
100% BRC Waste in Load	1.7	2.4	2.30
10% BRC Waste in Load	0.3	0.3	0.3

* Rogers and Murphy [1988]

The other assessments of conservatism were more qualitative in nature. The conservatism of a number of default parameters for incinerator worker and disposal site worker doses was assessed accounting for the results of the survey of waste generators (see section 2.2.1). They concluded that some of the default parameters used in assessing the transport scenario were conservative when compared to values from the survey. However, we note that the survey results were based on a 60 percent response rate from the surveyed utilities, and therefore should be treated with caution. Several other parameter values were identified as being conservative; these were reviewed and changes were made by O'Neal and Lee [1990] when the changes were considered appropriate. These changes are described in the executive summary in O'Neal and Lee [1990].

2.2.3 Verification Activities

Rogers and Murphy verified portions of the code against hand calculations, summarized incorrect coding, and made recommendations about revisions to be made to the code. These issues were reviewed and addressed by O'Neal and Lee [1990] in the production of IMPACTS-BRC, Version 2.0. Consequently they will not be discussed here.

2.2.4 Summary of the Assessment by Rogers and Murphy [1988]

Rogers and Murphy extended the sensitivity analysis begun by Kennedy *et al.* [1989], assessed the conservatism of the code through intercomparison and parameter review, and conducted verification activities on portions of the code. The sensitivity analysis indicated that the dose to the transportation worker was the limiting exposure pathway for the reactor wastes examined. Comparisons of the dose to the transportation worker showed that IMPACTS-BRC provides accurate or slightly lower doses than a comparable analysis using MICROSHIELD.

Rogers and Murphy's evaluation was reviewed by O'Neal and Lee [1990], and changes were made to the code where appropriate. These changes are documented in O'Neal and Lee [1990].

2.3 Evaluation of Version 1.0 by Smith *et al.* [1988]

Smith *et al.* [1988] conducted a screening study designed to identify the most important radionuclides and pathways for demonstrating compliance with BRC guidelines. The intent of this study was not to provide a critical review of the IMPACTS-BRC, Version 1.0, thus coding and default parameters were accepted as correct. Consequently their results are of limited utility here. However, Smith *et al* [1988] varied input parameters over quite wide ranges, and their results provide complementary information both to Kennedy *et al.* [1989] and to Rogers and Murphy [1988]. Smith *et al.* [1988] found that for offsite disposal, the transportation and incineration pathways were typically the most important. For onsite disposal, they found the intruder agriculture and intruder construction scenarios to be the most important. These results corroborate the results of both Kennedy *et al.* [1989] and Rogers and Murphy [1988].

2.4 Evaluation of Version 1.0 by Hertel *et al.* [1988]

Hertel *et al.* [1988] identified the transportation-worker dose to be a key exposure for BRC waste petitions. Consequently, they conducted an intercomparison of the IMPACTS-BRC, Version 1.0 truck-driver dose analysis with the results from a Texas Low-Level Radioactive Waste Disposal Authority study [Baird *et al.*, 1985; Rogers and Baird, 1986; Rogers and Baird, 1987], with MICROSHIELD [Grove Engineering, 1985] and with QAD-CGGP [ORNL, 1986]. Both of the latter codes use point-kernel shielding approaches to model the exposure. The Texas study transportation-worker analysis was effectively a modified IMPACTS-BRC analysis that took greater credit for shielding provided by the truck, and replaced the pathway dose conversion factor with an approach consistent with the Environmental Protection Agency (EPA) methodology.

Unfortunately, the details of the intercomparison were omitted from the conference proceedings. We therefore contacted Dr. Hertel directly to obtain the results of this comparison, which are shown in Table 2.2. The concentrations in the table were calculated in the Texas study to be the limiting concentrations that gave a 1.0 mR/yr exposure.

Table 2.2: Comparison Between IMPACTS-BRC, MICROSHIELD, and QAD-CGGP for Transportation Worker Exposure (Concentrations Gave 1.0 mR/yr Exposure in the Texas study)*

Nuclide	Waste Conc. (Ci/Yr)	IMPACTS-BRC (mR/yr)	MICROSHIELD (mR/yr)	QAD-CGGP (mR/yr)
Sc-46	0.002	5.4	2.3	2.1
Cr-51	0.6	24.0	14.0	14.0
Fe-59	0.005	8.0	3.0	2.8
Co-57	0.06	11.0	3.2	6.8
Mo-99	0.05	8.3	3.5	3.7
Tc-99m	1.0	32.0	[illegible]2.0	26.0
I-131	0.004	18.0	9.5	9.2
Ce-141	0.4	32.0	10.0	22.0
Ir-192	0.01	**	5.8	5.4
Hg-203	0.1	**	10.0	14.0

* N. E. Hertel, personal communication, University of Texas, Austin 1991.

** Radionuclides not included in the IMPACTS-BRC list.

Hertel *et al.* [1988] concluded that MICROSHIELD and QAD-CGGP were in good agreement for all radionuclides except Tc-99m and Ce-141. In addition, we note that there are large relative errors between MICROSHIELD and QAD-CGGP for Co-57 and Hg-203. The reasons for these discrepancies were unknown, but were tentatively attributed to the buildup factor [Trubey and Harima, 1987] and the dose conversion factors. Differences between IMPACTS-BRC and the Texas study were attributed to additional credit taken in the Texas study for shielding, to differences in dose conversion factors, and to the use of an area source to approximate a volume source in the Texas study, which omits buildup in the waste. Differences between the Texas study and both point-kernel analyses were attributed primarily to this omission of buildup in the waste, and to differences in the geometry factors used in the analyses. Accounting for buildup brought the Texas study results quite close to the results from MICROSHIELD and QAD-CGGP. In addition, when the geometry factors were accounted for, Hertel *et al.* stated that both the IMPACTS-BRC results and the Texas study results would be lower by about a factor of

5.0. This means that the IMPACTS-BRC results would be somewhat lower than the MICROSHIELD and QAD-CGGP results, and that the Texas study results would be low by about a factor of 5.0.

2.5 Evaluation of Version 1.0 by O'Neal and Lee [1990]

O'Neal and Lee [1990], in the process of developing IMPACTS-BRC, Version 2.0, conducted an extensive evaluation and verification of Version 1.0. They took the recommendations of Rogers and Murphy [1988] as a starting point, and addressed concerns raised in that evaluation. In addition, they conducted an independent review and evaluation. These code evaluation activities are mentioned in O'Neal and Lee [1990], but details of the process have only been documented in letter reports to date. [2,3,4] This section documents the evaluation of the code as it is described in the above mentioned letter reports.

The code was reviewed for completeness by comparing its capabilities with other similar codes. It was verified against hand calculations, and portions of it were benchmarked or compared with other codes that perform similar analyses.

2.5.1 Evaluation for Completeness

Much of the first letter report[2] relates to issues about Version 1.0 and are no longer pertinent for version numbers 2.0 and higher, and hence are not discussed further. However, this report also includes a scenario and pathway comparison with similar available codes. The primary codes considered in the comparison were PRESTO [EPA, 1985], several forms of PATHRAE [Rogers *et al.*, 1985; Merrell, *et al.*, 1986; Rogers and Hung, 1987] and DOSTOMAN [Root, 1981], with consideration given to RESRAD[5] and MILDOS [Strenge and Bander, 1981]. This comparison was primarily conducted to evaluate IMPACTS-BRC for completeness, and to compare modeling approaches used by the codes.

It was concluded that DOSTOMAN uses a compartment modeling approach, with all other codes using a pathway dose conversion factor approach. Note that compartment modeling may sometimes be nonconservative since it assumes instantaneous dilution of the contaminant over some finite volume [Kozak *et al.*, 1989]. In principle, this problem may be overcome by making the number of compartments large, in which case the compartment model becomes equivalent to an assumption of local equilibrium. However, in practice one uses relatively few compartments, hence the results tend to be nonconservative.

Differences in the results from the various computer programs arise from differences in the way in which each incorporates exposure scenarios and pathways. PRESTO, PATHRAE, and DOSTOMAN were developed using only the few pathways believed to be the most important for the problem. Code modifications were made when a new problem was faced, and as a result there are many versions of these codes, each with slightly different capabilities. For instance, Rogers *et al.* [1985], Merrell *et al.* [1986], and Rogers and Hung [1987] all describe moderate perturbations to the base PATHRAE code. Of the codes evaluated, only IMPACTS-BRC is intended to include all pathways of likely significance in a single code.

IMPACTS-BRC was found to consider all of the exposure scenarios included in the other three codes except (1) postoperational, onsite exposure of an intruder to irrigated agricultural products and drinking water, (2) postoperational, onsite exposure of an intruder engaged in community agriculture, and (3) postoperational offsite exposure to an individual or population well. These scenarios were considered only by DOSTOMAN. Only IMPACTS-BRC considered population exposures to exposed waste. A comparison of the exposure scenarios considered in the codes is shown in Table 2.3

The list of operational period onsite pathways in IMPACTS-BRC is much more complete than the other codes, as is shown in Table 2.4. The only pathways not considered by IMPACTS-BRC relate to visitor exposures (which PRESTO considers); however, IMPACTS-BRC considers instead more chronic exposures to individuals and populations during this period (which PRESTO does not consider).

2"Evaluation of Capabilities and Limitations of IMPACTS-BRC," Task 1 Letter Report to NRC, FIN A1763, September 1, 1988.

3"IMPACTS-BRC Computer Code Verification," Task 2 Letter Report to NRC, FIN A1763, October 27, 1988.

4"IMPACTS-BRC Computer Code Benchmarking," Task 3 Letter Report to NRC, FIN A1763, February 10, 1989.

5Gilbert, T. L., M. J. Jusko, K. F. Eckerman, W. R. Hansen, W. E. Kennedy, B. A. Napier, and J. K. Soldat, A Manual for Implementing Residual Radioactive Material Guidelines, Argonne National Laboratory, Final Draft, January, 1988.

Table 2.3: Scenario Completeness Comparison for Several Codes*

Scenario	PRESTO	PATHRAE	DOSTOMAN	IMPACTS-BRC
Operational Period (onsite)				
disposal site worker/visitor	yes	yes	yes	yes
waste transportation worker	no	yes	yes	yes
waste process worker	no	no	no	yes
offsite impacts	no	no	no	yes
Postoperational (onsite)				
intruder discovery/construction	no	yes	yes	yes
intruder agriculture	no	yes	no	yes
intruder agriculture with irrigation and drinking water	no	no	yes	no
intruder community agriculture	no	no	yes	no
Postoperational (offsite)				
individual or population well	no	no	yes	no
individual or population well with irrigation and drinking water	yes	yes	yes	yes
population exposed waste	no	no	no	yes

* "IMPACTS-BRC Computer Code Verification," Task 2 Letter Report to NRC, FIN A1763, October 27, 1988.

Table 2.4: Operational Period Onsite Pathway: Completeness Comparison For Several Codes*

Scenario	PRESTO	PATHRAE	DOSTOMAN	IMPACTS-BRC
Surface Contamination or Waste				
disposal site worker	yes	yes	yes	yes
processing worker	no	no	no	yes
transportation worker	no	no	no	yes
population or individual	no	no	no	yes
visitor	yes	no	no	no
Air Immersion	no	no	no	yes
Resuspended Soil				
worker	yes	yes	yes	yes
visitor	yes	no	no	no
offsite individual or population	yes	no	no	yes
Incineration or Fire (particulates)				
offsite individual or population	yes	yes	no	yes
Ingestion				
vegetables	no	no	no	yes
animal products	no	no	no	yes

* "IMPACTS-BRC Computer Code Verification," Task 2 Letter Report to NRC, FIN A1763, October 27, 1988

The IMPACTS-BRC list of postoperational period pathways is also more complete than in the other codes, as shown in Table 2.5. IMPACTS-BRC only lacks onsite ingestion of water, aquatic foods, and soil, and these are included in the offsite exposure pathways. Among transport pathways, all of the codes are fairly complete, but PATHRAE includes the ability to model decay chains during transport, which the others do not (though IMPACTS-BRC does account for daughter production for intruder and exposed waste scenarios). Only DOSTOMAN includes transport through biological excretion.

Table 2.5: Postoperational Period Pathways: Completeness Comparison for Several Codes*

Scenario	PRESTO	PATHRAE	DOSTOMAN	IMPACTS-BRC
Onsite				
External Exposure				
air immersion	no	no	yes	yes
stored or buried waste	no	yes	no	yes
surface contamination	no	yes	yes	yes
Inhalation				
resuspended soil particulates	no	yes	yes	yes
Ingestion				
water	no	no	yes	no
vegetation	yes	yes	yes	yes
animal products	yes	yes	yes	yes
aquatic products	no	no	yes	no
soil	no	no	yes	no
Offsite				
External Exposure				
air immersion	yes	no	no	yes
surface contamination	yes	no	no	yes
Inhalation				
resuspended soil particulates	yes	yes	no	yes
Ingestion				
water	no	no	yes	no
vegetation	no	yes	yes	no
animal products	yes	yes	yes	yes
aquatic products	yes	yes	yes	yes

* "IMPACTS-BRC Computer Code Verification," Task 2 Letter Report to NRC, FIN A1763, October 27, 1988.

2.5.2 Verification of the Code

An extensive verification of the mathematical expressions in Version 1.0 of the code was also conducted by O'Neal and Lee and documented in a letter report.[6] A line-by-line verification was conducted on the main program and all subroutines using the sample problems. This line-by-line verification was used to determine logic paths, develop flow diagrams, and evaluate mathematical expressions.

The line-by-line comparison was conducted by adding write statements for each variable of interest before and after each line in the subroutine being tested. In each case, after the write statements were added, the full program was run, and the output compared to a baselined output file. In this way, assurance was generated that the addition of the write statements did not accidentally alter

[6] "IMPACTS-BRC Computer Code Benchmarking," Task 3 Letter Report to the NRC, FIN A1763, February 10, 1989.

the computer program. The intermediate output of the parameters from the verification calculations was then compared to hand calculations. These calculations were recorded and documented, and have been archived at SNL along with other verification results.

A few sections of IMPACTS-BRC were identified as having not been exercised by the original sample problems by O'Neal and Lee. Their findings are paraphrased below.

- Subroutine SPLICE: the waste processing option that includes size reduction and separation (IP=4) was not tested.
- Subroutine READ2: non-default facility and environmental parameters (IDAT=3) were not tested (Section of subroutine from RED2 620 to RED2 830).
- Subroutine READ5: the branches for hazardous waste incinerator/hazardous waste landfill (IQ=4 or 5) when the ratio of the total mass of the BRC waste stream to the number of transportation vehicles multiplied by the percentage of BRC waste in the vehicle (A4) is greater than 11.3 (line RED5 860 in subroutine) were not tested.
- Subroutine INCIMP: of the 5 DO loops in the subroutine, the first and fourth were only tested for the municipal incinerator (IQ=2) and not for the on-site or hazardous waste incinerators (IQ=1,5).
- Subroutine OVRFLO: Activated metal waste (IA=2) was not tested in this subroutine. The branch where the disposal facility life (ILFE) multiplied by one minus the exponential of the negative nuclide decay constant (A1 on lines OVRF 450 and OVRF 460) is zero was never tested. This branch is designed to avoid divide by zeros and should not be taken during normal code operation.
- Subroutine INTIMP: activated metal waste (IA=2) is not tested in this subroutine. The branch where the institutional control period (IINS) is zero causing A1 to equal A2 (INTI 600) was not tested.
- Subroutine OPSIMP: for a hazardous waste landfill (IQ=3 or 4), activated metal waste (IA=2) and very dispersible waste (ID=3) were not tested.
- Subroutine CHNS: The chains with parents Pu-236, Cf-252, Mo-99, and Ba-140 were not tested.
- Subroutine GWATER: Cases where the cumulative pumping volume (TVOL) was less than 110.0 were not tested. Also, the contaminant transport loop was not tested for cases where one or more of the 10 sources had not reached the well (TYM*B3 <1.0, line GWTR 680).

These portions of the code were not verified during the development of Version 2.0, and presumably have not been verified by any other investigators. Many of the untested "branches" are quite minor, consisting of a statement to change the value of a single parameter.

2.5.3 Transportation Model Benchmarking

Benchmarking analyses were performed by O'Neal and Lee on several portions of the code: the transportation model, the dose conversion factor table for a volume source used in the transportation model, the model for evaluating a finite volume source, the dose conversion factor tables for inhalation and ingestion, the dose conversion factor tables for ground surface and air immersion exposures, and the analysis of radionuclide decay chains.

The transportation model was chosen for the benchmarking analysis because it is believed that this exposure pathway will often dominate the exposure analysis. In addition, users have expressed concern that the transportation model produced overly conservative results by not using realistic shielding factors. Therefore, the benchmarking effort was directed toward determining the amount of conservatism in the IMPACTS-BRC model relative to other models.

The IMPACTS-BRC transportation model is described in detail by O'Neal and Lee [1990]. The model is used to evaluate exposures to the maximally exposed transportation worker, to all transportation workers, and to the population. The model is based on an exposure scenario that defines the source term, and exposure time and exposure distance factors for both individuals and population groups. The model uses dose conversion factors for exposures to an infinite volume source of uniform radionuclide concentration. Correction factors are applied to the dose conversion factors to represent a semi-infinite volume source of finite lateral dimensions. This source configuration is used to approximate a generic waste disposal vehicle, and to adjust for gamma radiation attenuation resulting from waste density variations.

Correction factors for source dimensions and distances used in IMPACTS-BRC are calculated as the parameter CF in the code. The values of this parameter were benchmarked against an analytical solution developed by Lee [1973]. The agreement between the analytical solution and the IMPACTS-BRC correction factors is excellent, as is shown in Table 2.6. The correction factors from the two approaches are identical to four significant figures; the maximum absolute error between the two methods is 6.4×10^{-7} (relative error 1.9×10^{-4}).

Table 2.6: Verification of Correction Factors for Source Dimension and Distance*

Source Radius (m)	Distance from Source (m)	Correction Factor	Absolute Error
2.0	1.0	1.949×10^{-1}	1.0×10^{-7}
2.0	5.0	2.826×10^{-2}	1.6×10^{-7}
2.0	10.0	9.608×10^{-3}	4.0×10^{-8}
2.0	20.0	3.283×10^{-3}	4.2×10^{-7}
2.0	30.0	1.785×10^{-3}	8.9×10^{-8}
2.0	40.0	1.171×10^{-3}	5.7×10^{-7}
2.0	50.0	8.508×10^{-4}	6.4×10^{-7}
4.0	1.0	3.409×10^{-1}	1.1×10^{-7}
4.0	5.0	9.376×10^{-2}	1.5×10^{-7}
4.0	10.0	3.626×10^{-2}	5.6×10^{-8}
4.0	20.0	1.292×10^{-2}	4.2×10^{-7}
4.0	30.0	7.085×10^{-3}	7.8×10^{-8}
4.0	40.0	4.664×10^{-3}	5.7×10^{-7}
4.0	50.0	3.393×10^{-3}	6.4×10^{-7}
10.0	1.0	5.462×10^{-1}	8.0×10^{-8}
10.0	5.0	2.992×10^{-1}	5.4×10^{-8}
10.0	10.0	1.668×10^{-1}	1.3×10^{-7}
10.0	20.0	7.283×10^{-2}	4.1×10^{-7}
10.0	30.0	4.209×10^{-2}	3.2×10^{-8}
10.0	40.0	2.828×10^{-2}	5.9×10^{-7}
10.0	50.0	2.078×10^{-2}	6.2×10^{-7}
20.0	1.0	6.936×10^{-1}	3.0×10^{-9}
20.0	5.0	5.103×10^{-1}	8.1×10^{-7}
20.0	10.0	3.749×10^{-1}	2.2×10^{-7}
20.0	20.0	2.204×10^{-1}	3.1×10^{-7}
20.0	30.0	1.439×10^{-1}	1.1×10^{-7}
20.0	40.0	1.024×10^{-1}	6.3×10^{-7}
20.0	50.0	7.756×10^{-2}	5.2×10^{-7}

* IMPACTS-BRC only accounts for daughter production for intruder and exposed waste scenarios.

Gamma radiation attenuation calculations in IMPACTS-BRC were benchmarked against MICROSHIELD [Grove Engineering, 1985]. The dose conversion factors for the transportation model tabulated in IMPACTS-BRC are based on a waste density of 1.6 g/cc. It is assumed in the code that the linear attenuation coefficients for the gamma energies are sufficiently linear over the range of interest. Hence, a ratio of the density of the waste of interest to the base case density is used to evaluate waste of another density. The user is required to supply the waste density as an input parameter, and the code calculates an effective density based on the percentage of BRC waste using a generic density of 0.27 g/cc for non-BRC waste. The results of this benchmark are shown in Table 2.7. As the waste density decreases, there is increasing divergence between the IMPACTS-BRC and the MICROSHIELD evaluation of the density effects, although the maximum deviation is about 65 percent. However, as indicated by the results, the IMPACTS-BRC approach will produce conservative results at reduced waste densities.

Table 2.7: Density Correction Factors Used in IMPACTS-BRC Compared to Values Calculated by MICROSHIELD*

Waste Density	IMPACTS-BRC Correction Factor	MICROSHIELD Correction Factor**	Ratio (IMPACTS-BRC/MICROSHIELD)
1.60	1.00	1.00	1.00
1.00	1.60	1.46	1.09
0.50	3.20	2.49	1.28
0.25	6.40	3.91	1.64

* Adapted from O'Neal and Lee [1990]

** Note, MICROSHIELD density effects are dependent on gamma energy and waste density. The tabulated values are the averages of the following gamma energies: 1.25 MeV, 0.836 MeV, 0.564 MeV, 0.361 MeV, and 1.22 MeV. Build up was accounted for in the calculations using the geometric progression method.

An intercomparison between IMPACTS-BRC and MICROSHIELD was conducted for a typical transportation scenario. The implementation in MICROSHIELD used the assumptions of a finite rectangular solid geometry. The truck was assumed to be filled with 100 percent BRC waste with a homogeneous nuclide concentration of 1 pCi/m^3. Waste density was assumed to be 1.6 g/cm^3, resulting in a specific activity of 0.63 μCi/g. The transportation worker was assumed to be 1 meter from the side of the truck for 0.5 hours and 1 meter from the front of the waste (in the cab) for 2 hours.

The problem was run for several radionuclides with varying gamma energies to evaluate the influence of shielding (Details of the thickness of the shielding and the size of the vehicle can be found in Table A of O'Neal and Lee [1990].). The results are given for both unshielded and hypothetical shielded conditions in Table 2.8. The IMPACTS-BRC analysis provided results that were about 40 percent lower than the unshielded doses calculated using MICROSHIELD, and were about the same as the MICROSHIELD doses that accounted for shielding. This is one case where IMPACTS-BRC does not produce conservative results in an intercomparison study.

Table 2.8: Comparison of Doses (mR) from IMPACTS-BRC and MICROSHIELD for a Sample Transportation Scenario*

Nuclide	MICROSHIELD Dose (Without Shielding)	MICROSHIELD Dose (With Shielding)	IMPACTS-BRC Dose
Co-60	1534	1140	1000
Mn-54	527	344	329
Cs-137	382	231	219
I-131	236	110	139
Co-57	16	24	36

* IMPACTS-BRC only accounts for daughter production for intruder and exposed waste scenarios.

2.5.4 Benchmarking Dose Conversion Factors for External Exposures

External doses must generally be calculated using the geometry of the source and orientation of the receptor to the source. However, in radiological assessments, such detailed information is often unavailable, or at best is generated by speculative judgment about the behavior of an individual in a radiation field. These problems have given rise to the use of simplified (and usually conservative) assumptions about the exposure geometries. For instance, the source may be assumed to be uniformly distributed over an infinite or semi-infinite domain. These assumptions are rarely, if ever, met in practice, but they serve to eliminate geometric considerations from the assessment, which makes the evaluation simple and generic. These generic assumptions lead to doses that are independent of the details of the exposure mode, and that can therefore be used to generate generic dose conversion factors for external exposure.

The external dose conversion factor approach to modeling external exposures is used in IMPACTS-BRC. The dose conversion factors used in the code are based on immersion in contaminated air, and irradiation at a height of 1 meter above a contaminated ground surface. These assumptions identify the dose conversion factor uniquely for a given radionuclide and exposed organ.

In most cases, the dose conversion factor approach can be expected to provide a conservative estimate of the external dose. The factors may be expected to provide reasonably realistic estimates for electron sources if the source concentration does not vary greatly over a distance about equal to the electron range. The range of energetic electrons is on the order of several meters in air. By contrast, for photon exposures the contamination must be approximately uniform over a few hundred meters before the dose conversion factor can be expected to provide a reasonably correct value. If the size of the source is smaller than the appropriate value the dose conversion factor will overestimate the dose. Similarly, the dose conversion factors do not account for shielding by building walls and ground irregularities, which also makes the factors provide conservative overestimates of the dose. The ground exposure dose conversion factors are calculated for a height of 1 meter, rather than averaging the dose over the person's height. This approach provides reasonable estimates for photon exposures unless the photon mean-free-path is less than 2 meters. For electron exposures the dose conversion factors provide reasonable estimates of the dose for electron energies greater than about 1 MeV, and may be considered conservative for lower energy electrons. Daughter radionuclides are not taken into account explicitly; rather, the dose conversion factors for some parents include the contributions from daughter radionuclides. These radionuclides are identified in the IMPACTS-BRC, Version 2.0 User's Manual [O'Neal and Lee, 1990].

O'Neal and Lee undertook a benchmark analysis to evaluate the external dose conversion factors used in IMPACTS-BRC, Version 1.0 against comparable results generated using MICROSHIELD. However, these dose conversion factors were updated during development of Version 2.0, and these updated factors were subsequently verified during this work (see Chapter 3). Hence the results of this benchmark analysis are no longer pertinent.

Another portion of the transportation model that was benchmarked against MICROSHIELD was the pathway dose conversion factor for external exposures (PDCF-5). The dose model in IMPACTS-BRC is based on direct gamma exposure emitted by radionuclides homogeneously distributed through soil of infinite depth and horizontal extent. The comparison between IMPACTS-BRC and MICROSHIELD is not included in this report, since the analysis was conducted using Version 1.0 dose conversion factors. Consequently the results of this benchmark analysis are no longer pertinent.

2.5.5 Benchmarking Radioactive Decay and Decay Chains

Ten of the 85 radionuclides in the code are parent radionuclides of decay chains. These radionuclides are Mo-99, Ba-140, Pu-236, Pu-241, Pu-242, Cm-242, Cm-243, Am-243, Cm-244, and Cf-252. For the intruder scenario, IMPACTS-BRC calculates decay and ingrowth of daughters for the length of time between facility closure and loss of institutional control. This time period must be input by the user. For the erosion scenario, decay calculations are performed for an erosion delay period of 1000 years.

The decay and ingrowth calculations are based on the well-established Bateman equations [Bateman, 1910]. A benchmark comparison was made of the Bateman equation implementation in IMPACTS-BRC with RADDECAY, which is a submodel of MICROSHIELD [Grove

Engineering, 1985] that performs decay and ingrowth calculations for a large number of radionuclides. The two codes showed excellent agreement, as is shown in Table 2.9; slight differences in the results were attributable to small differences in the decay constants for the radionuclides.

Table 2.9: Comparison of Fractional Amounts Remaining for Pu-238 Chain. IMPACTS-BRC and RADDECAY*

Nuclide	IMPACTS (30 Years)	RADDECAY (30 Years)	IMPACTS (1000 Years)	RADDECAY (1000 Years)
Pu-238	7.862×10^{-1}	7.890×10^{-1}	3.288x10[illegible]	3.711×10^{-4}
U-234	7.292×10^{-5}	7.572×10^{-5}	3.494×10^{-4}	3.578×10^{-4}
Th-230	1.012×10^{-8}	1.063×10^{-8}	2.642×10^{-6}	2.807×10^{-6}
Ra-226	4.455×10^{-11}	4.678×10^{-11}	4.510×10^{-7}	4.786×10^{-7}

* IMPACTS-BRC only accounts for daughter production for i[illegible]der and exposed waste scenarios.

2.5.6 Verification of Pathway Dose Conversion Factor Transfer and Uptake Parameters

IMPACTS-BRC uses the pathway dose conversion factor (PCDF) approach to calculate radiological doses, as has been documented in Oztunali and Roles [1984] and Forstom and Goode [1986]. Each PCDFs represents a specific set of a biotic access medium and an exposure pathway. They are generic, and parameter values are assumed based on typical environmental conditions and human actions. Some of the parameters are accessible to the user, and some are not.

Most of the parameters used in IMPACTS-BRC for transfer and uptake factors were chosen to be consistent with NRC Regulatory Guide 1.109 [NRC, 1977a]. The objective of the verification exercise conducted by O'Neal and Lee was to determine if the parameter values used in the code are within the range of values that appear in the literature. The literature values selected for comparison were found in the recommendations of the National Council on Radiation Protection [NCRP, 1984]. A more extensive literature search was not conducted for this verification exercise.

Soil-to-plant concentration ratios, shown in Table 2.10, commonly vary over several orders of magnitude depending on chemical and physical form of the radionuclide, plant species, physicochemical properties of the soil, plant part, and stage of growth. The concentration ratios may be measured in laboratory experiments in greenhouses, or from field plots. If experimental data are unavailable, these factors may be estimated from concentration ratios of stable isotopes in field-grown plants. Experimental conditions often do not reflect normal or average situations, and this introduces additional uncertainties into the values.

Table 2.10: Soil-to-Plant Concentration Ratios:
Comparison of IMPACTS-BRC to NCRP 76 Values*

Element	IMPACTS-BRC	NCRP 76 Range
Co	$1.5x10^{-2}$**	$1.0x10^{-3}$ - $9.4x10^{-3}$
Sr	$7.5x10^{-2}$	$1.7x10^{-2}$ - 1.0
Ru	$1.4x10^{-3}$**	$3.8x10^{-3}$ - $6.0x10^{-2}$
I	$4.5x10^{-3}$**	$2.0x10^{-2}$ - $5.5x10^{-2}$
Cs	$5.0x10^{-3}$	$6.4x10^{-4}$ - $7.8x10^{-2}$
Ra	$1.4x10^{-3}$	$3.1x10^{-4}$ - $6.2x10^{-2}$
U	$2.5x10^{-3}$	$2.9x10^{-4}$ - $2.5x10^{-3}$
Pu	$5.6x10^{-4}$**	$1.0x10^{-6}$ - $2.5x10^{-4}$

* IMPACTS-BRC only accounts for daughter production for intruder and exposed waste scenarios.

** Value is outside of recommended NCRP 76 range.

The feed and water-to-meat transfer factors recommended by NCRP vary somewhat less than the concentration ratios, as is shown in Table 2.11. Nevertheless, these values have considerable uncertainty associated with them, and will further vary according to chemical speciation of the radionuclide. These factors are estimated from radioisotope tracer studies, and from the concentrations of radioactive or stable elements in meat and feed.

Table 2.11: Feed and Water-to-Meat Transfer Factors:
Comparison of IMPACTS-BRC to NCRP 76 Values*

Element	IMPACTS-BRC	NCRP 76 Range
Co	$9.7x10^{-3}$	$1.0x10^{-3}$ - $1.7x10^{-2}$
Sr	$5.9x10^{-4}$	$3.0x10^{-4}$ - $2.0x10^{-3}$
Ru	$1.4x10^{-3}$**	$3.8x10^{-3}$ - $6.0x10^{-2}$
I	$4.5x10^{-3}$**	$2.0x10^{-2}$ - $5.5x10^{-2}$
Cs	$5.0x10^{-3}$	$6.4x10^{-4}$ - $7.8x10^{-2}$
Ra	$1.4x10^{-3}$	$3.1x10^{-4}$ - $6.2x10^{-2}$
U	$2.5x10^{-3}$	$2.9x10^{-4}$ - $2.5x10^{-3}$
Pu	$5.6x10^{-4}$**	$1.0x10^{-6}$ - $2.5x10^{-4}$

* IMPACTS-BRC only accounts for daughter production for intruder and exposed waste scenarios.

** Value is outside of recommended NCRP 76 range.

The feed and water-to-milk transfer factors in IMPACTS-BRC are compared to NCRP recommended values in Table 2.12. These factors depend on the physical and chemical form of the radionuclide in the animal's diet. They are typically measured by tracer experiments in which concentrations in milk are measured as a function of time after a single intake of radionuclide.

Table 2.12: Feed and Water-to-Milk Transfer Factors: Comparison of IMPACTS-BRC to NCRP 76 Values*

Element	IMPACTS-BRC	NCRP 76 Range
Co	$1.8x10^{-3}$	$5.0x10^{-4}$ - $2.0x10^{-3}$
Sr	$1.4x10^{-4}$	$8.0x10^{-4}$ - $2.4x10^{-3}$
Ru	$6.1x10^{-7}$	$5.0x10^{-7}$ - $1.0x10^{-6}$
I	$9.9x10^{-3}$	$6.0x10^{-3}$ - $1.0x10^{-2}$
Cs	$7.1x10^{-3}$	$5.0x10^{-3}$ - $1.2x10^{-2}$
Ra	$5.9x10^{-4}$	$2.0x10^{-4}$ - $8.0x10^{-3}$
U	$6.1x10^{-4}$**	$1.2x10^{-4}$ - $6.0x10^{-4}$
Pu	$1.0x10^{-7}$	$2.5x10^{-8}$ - $2.0x10^{-6}$

* IMPACTS-BRC only accounts for daughter production for intruder and exposed waste scenarios.

** Value is outside of recommended NCRP 76 range.

Water-to-seafood transfer factors are compared in Table 2.13. These factors represent the ratio of the concentration in the whole animal or tissue to the concentration in water. This assimilation process is particularly complex, since it may include direct absorption from the water in addition to uptake by consumption of other contaminated organisms. Furthermore, the transfer factor varies according to such diverse effects as chemical form of the radionuclide, species characteristics, chemical composition of water, and whether dry, wet, or ash weight was used in the analytical determination of mass. Consequently these parameter values may be expected to have large uncertainties in them.

Table 2.13: Water-to-Seafood Transfer Factors: Comparison of IMPACTS-BRC to NCRP 76 Values*

Element	IMPACTS-BRC	NCRP 76 Range
Co	50.0	5.0 - 280.0
Sr	30.0	1.3 - 130
Ru	10.0**	0.2 - 3.5
I	15.0	15.0 - 170.0
Cs	2000.0	400.0 - 14000.0
Ra	50.0	42.0 - 140.0
U	2.0	0.7 - 38.0
Pu	5.5	10.0 - 70.0

* IMPACTS-BRC only accounts for daughter production for intruder and exposed waste scenarios.

** Value is outside of recommended NCRP 76 range.

Radionuclide-independent parameters used in food chain analyses in IMPACTS-BRC are compared to recommended NCRP values in Table 2.14. These are intended to be conservative default parameter values to be used in the absence of site-specific data [Oztunali and Roles, 1984]. The dietary factors are based on the average daily uptake of adult males, and were determined from a 1965 survey. Consequently, these values are not necessarily appropriate today given the new health-conscious diets of many Americans; changes in dietary habits since 1965 have not yet been characterized [NCRP, 1984].

Table 2.14: Radionuclide-Independent Parameters*

Parameter Description	IMPACTS-BRC	NCRP 76
Consumption of Plants by Man	190 kg/yr	115 - 220 kg/yr
Consumption of Plants by Animals	50 kg/d	16 kg/d
Consumption of Animals by Man	95 kg/yr	90 - 120 kg/yr
Consumption of Milk by Man	0.3 ℓ/d	0.3 - 0.65 ℓ/d
Consumption of Water by Beef Cattle	50 ℓ/d	50 ℓ/d
Consumption of Water by Milk Cows	60 ℓ/d	60 ℓ/d
Consumption of Water by Man	370 ℓ/yr	192 - 411 ℓ/yr
Consumption of Fish by Man	6.9 kg/yr	3.9 - 65 kg/yr
Consumption of Seafood by Man	1.0 kg/yr **	1.31 - 44 kg/yr
Inhalation Rate of Man	8000 m^3/yr	8400 m^3/yr
Crop Yield per Unit Area	1.0 kg/m^2 **	0.3 - 0.7 kg/m^2
Soil Density	1600 kg/m^3 **	500 - 1300 kg/m^3
Resuspension Factor	8.5×10^{-9} 1/m	10^{-10} - 10^{-3} 1/m
Areal Mass Available for Resuspension (Top 1 cm of Soil)	16 kg/m^2 **	5 - 13 kg/m^2
Fraction of Initial Activity Deposited as Fallout or Contaminated Water Retained by Foliage	0.25	0.25
Fraction of Activity Deposited as Foliage Removed per Unit Time by Weathering Mechanism	0.0483 1/d	0.02 - 0.25 1/d
Fraction of Activity Deposited in the Root Zone Removed per Unit Time	0.00076 1/d	***
Settling Velocity for Elements Other than Iodine	8.0×10^{-4} m/s	1.0×10^{-3} m/s
Settling Velocity for Iodine	1.0×10^{-2} m/s	1.0×10^{-2} m/s
Mass of Soil in Root Zone	240 kg/m^2 **	75 - 195 kg/m^2

* IMPACTS-BRC only accounts for daughter production for intruder and exposed waste scenarios.

** Value is outside of recommended NCRP 76 range.

*** The effective removal rate from soil is considered radionuclide dependent, and is approximated by the nuclide's radioactive decay constant.

Several of the values in IMPACTS-BRC are not within the range recommended by NCRP. The outlier values were not changed during the development of Versions 2.0 or 2.1, so these differences exist in the current version of the code. However, we note that all of these parameter values contain large uncertainties. Furthermore, there is no general scientific consensus on the appropriate values for any of the parameters.

2.5.7 Summary of the Assessment by O'Neal and Lee

Extensive assessment of Version 1.0 of the code was performed prior to the development of Version 2.0. Most of this assessment was only documented informally in letter reports or briefly referred to by O'Neal and Lee [1990]. Consequently, we have summarized the work in detail here.

The code was examined for completeness and compared to several other codes that conduct comparable pathway and scenario analyses. It was found that, for the most part, IMPACTS-BRC is more general and complete in the scenarios and pathways considered than any of the other codes.

An extensive line-by line code verification exercise was conducted by O'Neal and Lee using the original sample problems. Consequently, portions of all of the subroutines in the program were verified. The logic paths in the program that were not exercised in the original sample problems were clearly identified. These were the only parts of the program not subjected to line-by-line verification. The results of this verification exercise are archived at SNL.

Benchmark analyses were performed on the transportation model, on external dose conversion factors, and on radioactive decay and ingrowth calculations. It was concluded that the transportation model provides good agreement with point kernel calculations conducted using MICROSHIELD [Grove Engineering, 1985]. Slight overestimates of exposures may be calculated if the waste stream contains radionuclides whose emissions are primarily photon with energies less than 200 keV. The external dose conversion factor benchmark is no longer pertinent, since the factors were updated for Version 2.0. It was also concluded that the decay and ingrowth calculations are correctly performed, following a benchmark against RADDECAY [Grove Engineering, 1985].

An examination was performed on pathway specific parameters used in IMPACTS-BRC, and these parameters were compared to values recommended by the NCRP [NCRP, 1984]. Some of the parameters are not consistent with the recommendations of the NCRP. However, there is so much uncertainty in these parameters, and there is so little consensus about the appropriate values, that this is not considered to be a major concern.

2.6 Evaluation of Version 2.0 by S. Cohen and Associates

An independent review was conducted by S. Cohen and Associates, and preliminary results of the review were documented in a letter to the NRC.[7] The review identified 15 potential issues associated with IMPACTS-BRC, Version 2.0. The issues can be broadly categorized into two groups: parameters that were inconsistent with the documentation or untraceable and limitations to the modeling capabilities of the code. Our present work addresses all of the former issues, hence they will not be discussed here. The remaining issues are mentioned here as a possible basis for future improvements to IMPACTS-BRC. No assessment is made here about the importance or accuracy of this evaluation.

- IMPACTS-BRC currently contains a library of 85 radionuclides. It was suggested that this library may not be sufficient and should be expanded.
- IMPACTS-BRC uses Gaussian plume models to calculate dispersion of airborne contaminants. These models are known to give good results over long distances, but their applicability for short distances was questioned by the reviewers.
- The review suggested that the analysis of bioaccumulation of C-14 used in IMPACTS-BRC should be altered to include uptake of $^{14}CO_2$ during photosynthesis.
- The review suggested that chronic gaseous emissions of H-3 and C-14 should be included in the code.
- The review suggested that increased flexibility should be incorporated in modeling sanitary landfill occupational exposures for large landfills.
- The review recommended evaluating the range of applicability of the ground-water pathway model through benchmarking and intercomparison studies.
- The review suggested that the list of accident scenarios may not be complete.
- The review noted that some retardation factors are calculated internally in the code, and suggested that the alternate use of the values in TAPE1.DAT will always make the retardation factor visible to the user.
- The review noted that IMPACTS-BRC does not truncate doses below 0.1 mrem/yr, and suggested that such truncation could be implemented in the code.
- The review suggested that greater flexibility is needed in dispersability and accessibility indices.
- The review suggested that all the "hard-wired" parameters in the code should read in through an input file.
- The review recommended development of a version of the code that treats parameter uncertainty.

[7] Letter from J.C. Dehmel, S. Cohen and Associates, Inc. to S. Klementowicz, NRC Office of Research, October 29, 1990.

2.7 Summary of Previous Assessments

Most sensitivity analyses conducted by the various reviewers of the code have indicated that the transportation worker dose will be the limiting exposure analysis for BRC wastes. Several assessments have been made of the transportation scenario model, with differing conclusions. All of these evaluations were performed on Version 1.0 of the code, so the results may be somewhat different for Version 2.1.

Kennedy *et al.* [1989] compared IMPACTS-BRC results to those from ISOSHLD, and found that they compared reasonably well, but that neither approach was clearly conservative. For the case of Tc-99 there was substantial deviation between the approaches. Kennedy *et al.* also criticized shielding and exposure duration assumptions used in IMPACTS-BRC, and suggested that the transportation worker dose was conservative by a factor of about 10 because of those assumptions.

Rogers and Murphy [1988] conducted an intercomparison of the transportation scenario model in IMPACTS-BRC to MICROSHIELD, which is the personal computer version of ISOSHLD. For 10 percent BRC waste in the load, the exposure calculations agreed well. For 100 percent BRC waste, the two codes still compared reasonably well, with MICROSHIELD producing moderately more conservative results

Hertel *et al.* [1988] compared the transportation worker exposure analysis to a Texas Low-Level Radioactive Waste Disposal Authority study, to MICROSHIELD and to QAD-CGGP. Following adjustments for differing assumptions in the analyses, it was concluded that the MICROSHIELD and QAD-CGGP results were in good agreement, with IMPACTS-BRC exposure results slightly low but in reasonable agreement, and the Texas study exposure results quite low.

O'Neal and Lee [1990] benchmarked the geometrical shape correction factors in IMPACTS-BRC to an analytical solution, and found excellent agreement. They also compared the effects of the density correction factor in IMPACTS-BRC to the correction factor in MICROSHIELD, and concluded that the approach used in IMPACTS-BRC was accurate near densities of 1.6 g/cc, and more conservative at reduced densities. O'Neal and Lee [1990] also reported an intercomparison between MICROSHIELD and IMPACTS-BRC for a sample transportation scenario, and concluded that the two codes agreed well for the shielded conditions of their problem.

Based on previous assessments of the code, we conclude that the transportation worker dose model in IMPACTS-BRC is reasonable compared to more elaborate analysis methods. However, the results from all of the methods are quite scattered, suggesting a significant amount of modeling uncertainty, which may arise from a number of different sources. In order to ensure that this and other uncertainties are bounded by the analysis, the analyst must be certain of using appropriately conservative parameter and exposure scenario assumptions. The updated dose conversion factors used in Version 2.1 should have little effect on the conclusions for the transportation model evaluations.

Kennedy *et al.* [1989] also compared doses calculated using IMPACTS-BRC to two independent methods: the IAEA approach and ONSITE/MAXI1. Kennedy *et al.* concluded that the methods agreed within modeling accuracy. However, we note that this modeling accuracy encompassed quite large deviations. Consequently, we again comment that in order to bound the modeling uncertainty, one must ensure that conservative model assumptions and parameter values are applied. The alternative is to apply formal uncertainty analysis (*e.g.*, Monte Carlo analysis) to attempt to ensure that conservative parameter values have been applied.

Several workers evaluated IMPACTS-BRC for completeness, and all agreed that the code was reasonably complete and general. O'Neal and Lee compared IMPACTS-BRC to other similar codes and found it to be the most complete. Furthermore, the exposure pathways and analyses unique to other codes were bounded by ones found in IMPACTS-BRC. Kennedy *et al.* [1989] noted that a possible improvement in the generality of IMPACTS-BRC could be an improved treatment of discrete sources.

3.0 Current Assessment and Verification of Version 2.0

The evaluation of Version 1.0 by O'Neal and Lee showed that the sample problems distributed with the code allowed for verification of most, but not all, of the code. The evaluation of Version 2.0 by S. Cohen and Associates, Inc. suggested the need for an additional verification of the data files used by the code. The current assessment of IMPACTS-BRC was undertaken to remedy the gaps in the verification of the code.

3.1 Quality Assurance Procedures

The basic goal of software quality assurance in the R&D process is to ensure that reliable software is developed, its application in analysis is appropriate, and the results are traceable, retrievable, reproducible, and defensible in the regulatory or scientific community. The purpose of quality assurance procedures is to identify controls that will help ensure the quality of work yet allow flexibility in the planning and execution of project activities [Brosseau *et al.*, 1991].

Prior to the initiation of the verification work conducted for this report, quality assurance procedures were established.[8] The complete quality assurance plan has been permanently archived in SNL's Central Technical Files, Organization 3140. This section will describe the salient aspects of that plan.

Project logbooks were used to record all technical work on this project. Separate areas were maintained for data verification and code verification activities by each person involved in these activities. Any corrections made to the logbooks were made by lining through the original text so that the original is readable. Any changes were dated and initialed.

All BRC project logbooks, letter and formal reports, and the configuration management notebook have been sent to SNL's Central Technical Files, Organization 3144, for permanent storage.

During the course of the project, a quality assurance surveillance was performed by the staff quality coordinator to verify that all quality requirements were satisfied. The results of this surveillance are included in Appendix H.

IMPACTS-BRC, Version 2.0 was obtained from the National Energy Software Center (NESC) at Argonne National Laboratory. To verify that SNL had received the correct version of the program, and that it was running correctly on SNL's computers, the example problems were run and compared with the output in the user's manual [O'Neal and Lee, 1990]. The results obtained from running the code on our computers were identical to the results given in the user's manual. This formed the Version 2.0 baseline for SNL's verification effort..

A manual configuration management system using diskettes was established to centralize and control Version 2.0 and subsequent versions of the code and data developed under this project. Analysts were required to create a directory structure on their personal computers to ensure that each version of the program and each version of the data were maintained in different subdirectories. The initial version 2.0 of the data and code used by each analyst was obtained from the controlled version of the code. Prior to beginning the verification work, Version 2.0 of the data and code were installed on each machine, and the three existing sample problems were run to test the baseline against the results presented in the user's guide [O'Neal and Lee, 1990].

An independent check and assessment of all findings was made by an independent reviewer from the project team (*i.e.*, a team member who was not involved in the initial audit). For findings involving dose conversion factors, the independent assessment was performed by the project team health physicist. Each corrective action was also documented by the reviewer. No changes were made to the data or code until all findings were reviewed and approved. All changes were then made simultaneously to generate Version 2.1.

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[8] C.P. Harlan and S. Bensonhaver, "Quality Control Plan", FIN L1925 Task 1.0 Letter Report, June 26, 1991.

3.2 Data Verification

A review of data in the IMPACTS-BRC, Version 2.0 code was conducted. Data that could be compared to specific, accepted references (*e.g.*, fundamental dose conversion factors) were reviewed for correctness. However, many of the parameters used in IMPACTS-BRC do not have generic "correct" values (*e.g.*, retardation factors, transfer factors). For these parameters the data set was evaluated for traceability: the historical development of the code [Oztunali and Roles, 1984; Forstom and Goode, 1986; O'Neal and Lee, 1990] was examined to identify when and by whom the parameter value was justified. An evaluation was also made to ensure that the most recent parameter recommendations were incorporated in the code. However, SNL did not compare this set of parameters to any other references to attempt to establish their conservatism.

The following parameter values for each radionuclide were traced historically through the development of the code [Oztunali and Roles, 1984; Forstom and Goode, 1986; O'Neal and Lee, 1990]:

- Radionuclides included in IMPACTS-BRC, Version 2.0
- Number of solubility classes included
- Solubility classes
- Soil-to-plant transfer factors
- Feed and water-to-meat transfer factors
- Feed and water-to-milk transfer factors
- Water-to-fish transfer factors
- Water-to-freshwater seafood transfer factors
- Waste-to-leachate partition ratio
- 1st and 4th set of retardation coefficients

The nuclide decay constants used in the code are consistent throughout all versions of the code; however, they were not referenced anywhere during the code's history. Consequently, they were recalculated using the half-lives given in Kocher and Eckerman [1988] to produce compatibility with the dose conversion factors used in the code, which are based on those half-lives, and to ensure traceability. A listing of the worksheet used to calculate the decay constants can be found in Appendix I. The dose conversion factors for a volume source (DCF3(N)), were compared to the results obtained from the MICROSHIELD computer code, which are listed in Table 7-6, pages 7-19 to 7-20 of O'Neal and Lee [1990]. The decay chains included in calculating DCF3(N) values are indicated in Table 7-6, page 7-9 of the IMPACTS-BRC user's guide [O'Neal and Lee, 1990].

The dose conversion factors for ingestion (DCF1(N)) and inhalation (DCF2(N)) were compared to the electronic tapes, DFINGEST.DAT and DFINHALE.DAT, received from Dr. Keith Eckerman at Oak Ridge National Laboratory. The tapes were taken from the ICRP/ORNL Dosimetry files assembled during the course of the calculations for ICRP-30 [ICRP, 1982], Parts I-IV in preparation for the Federal Guidance Report 11 [Eckerman *et al.*, 1988]. The tapes include organ dose conversion factors needed for IMPACTS-BRC that were not included in the organ list published in Eckerman *et al.* [1988]. The tape values refer to a unit intake of the stated radionuclide, but include committed dose equivalent contributed by any daughter radionuclide produced from radioactive decay of the parent nuclide in the body. The dose conversion factors for inhalation are based on 1 micron activity median aerodynamic diameter size particles.

The dose conversion factors Ag-108m and Ag-110m were omitted from the Eckerman diskette. The ingestion and inhalation dose conversion factors for those radionuclides were compared to the dose conversion factor document by Eckerman *et al.* [1988] (page 132 and page 163) for the organs included therein. These organs were lung, red marrow, bone surface, thyroid, and the effective dose equivalent. For the organs not included in the Eckerman document (*i.e.*, stomach wall, lower large intestine (LLI) wall, kidney, and liver) the dose conversion factors were compared with the values cited in the sample TAPE1.DAT in Volume II of the de Minimis documentation [Forstom and Goode, 1986] and were found to be in agreement. Therefore, they were left unchanged.

The fundamental dose conversion factors for external exposure to an area source, DCF4, and for air immersion, DCF5, were compared to Tables A.1 and A.3 in the DOE dose-rate conversion document [Kocher and Eckerman, 1988]. For some nuclides, to obtain a dose conversion factor for the parent in a decay chain the dose conversion factor of the first daughter is added to that of the parent. These values are included in TAPE1.DAT. The worksheets for the calculation of the dose conversion factors for these decay chains can be found in Appendix J. A summary of the historical tracing of TAPE1.DAT parameters is given in Appendix E.

All TAPE2.DAT parameter values have been traced historically from Volume 1 of the de Minimis documentation [Oztunali and Roles, 1984]. A summary of this process can be found in Appendix F.

3.2.1 Additional Noted Items

Several items were identified during the data review for which action was not taken because they were not within the scope of this work. Correction of these items would lead to improved clarity and usefulness of the code's input files.

The current format of the TAPE1.D   put file for the IMPACTS-BRC computer code allows for a field of six alphanumeric characters for the identification of the radionuclides. Several of the radionuclides are considered in their metastable state and these are noted with a small letter "m" following the isotope identifier. When the isotope identifier itself is composed of six characters the "m" is currently dropped from the field in the TAPE1.DAT input file for those isotopes while it is retained for those isotopes for which the identifier is composed of less than six characters. This inconsistency could potentially lead to confusion on the part of the user and should be considered for possible future action. It has not been done at this time because such a change would require concurrent changes to the IMPACTS-BRC computer code and preprocessor.

Only one solubility class (Y) is currently being used for the radionuclide Nb-95 even though the documentation indicates that two solubility classes (Y and W) will be used. These two solubility classes are currently used for Nb-94. It would be desirable to include the solubility class, W, for Nb-95, but such a change in the TAPE1.DAT input file for the IMPACTS-BRC computer code would require modifying the preprocessor. Since a solubility class of a year is more conservative than a solubility class of a week, it is not imperative that this change be made.

The current version of the code allows for only 85 radionuclides, and it is recognized that this list is inadequate for certain facilities. To incorporate an additional radionuclide involves replacing one of the nuclides in the standard list of radionuclides and all of the associated nuclide specific parameters. At the present time, this process is not trivial with many considerations necessary to ensure the substitution will allow the code to function as expected. Modifications also would have to be made to the data input preprocessor. It would be desirable to modify the current version of the IMPACTS-BRC code to allow for more flexibility on the part of the user to add radionuclides appropriate for their analysis, or conversely, to make the library large enough that all nuclides of interest are included.

3.3 Code Verification

In this section we describe the methods and results of the code verification work. The current verification effort was conducted according to the quality assurance procedures previously mentioned for this work.[6] This involved production of an interim baseline version of the code using the updated (Version 2.1) input data, dev   ed under the data verification component of the current project. All code verification efforts were conducted using the baselined 2.0 Version of the code with the updated Version 2.1 input data. The baseline Version 2.1 TAPE1.DAT and TAPE2.DAT data files are attached to this report as Appendix B.

Write statements were added to the previously unverified sections of the baselined Version 2.0 of the code, which allowed for a line-by-line examination of the pertinent parts of the code. The modified code was then compiled with the Lahey FORTRAN F77L-EM/32, Version 4.0 compiler. The existing sample problems were rerun to ensure that addition of the write statements did not cause any spurious changes. This version of the code was then used for verification activities.

3.3.1 Development of Verification Test Problems

The intent of the test problems is to verify all previously untested mathematical models given in the reference documents [Oztunali and Roles, 1984; O'Neal and Lee, 1990] and ensure that they are implemented correctly. It is therefore unimportant for the problem to be completely meaningful, since the physics behind the mathematical model is not being tested under the current scope of work. Therefore, some unlikely combinations are included, such as Pu-236 present in an activated-metal BRC waste stream. This was done so that the unverified sections of the code could be tested in the most efficient manner. Three test problems were developed, which are described below.

- This test problem exercised subroutines SPLICE, READ2, CHNS, and half of INCIMP. This first test problem has the following properties. Non-default environmental facility and environmental parameters (IDAT=3) are used. This was achieved by using the default parameters as non-default ones; in this case, we used the Northeast region parameters. The waste stream is separated and reduced in size, using sorting option 2 (IP=4). An activated-metal stream (IA=2) is used that contains Pu-236 (.0001 mCi/g), Cf-252 (.0002 mCi/g), Mo-99 (.0003 mCi/g), and Ba-140 (.0004 mCi/g). The waste stream is considered very dispersible (ID=3). The on-site incinerator/sanitary landfill (IQ=1) disposal option was used. The input file for this test problem is attached to this report in Appendix C.

- The second test problem exercises subroutines OVRFLO, and half of INTIMP and OPSIMP. In this problem, the waste stream is disposed of (IP=1) at a hazardous waste incinerator/hazardous waste landfill (I) (IQ=4). All other parameters are the same as test problem 1. The input file for this test problem is in Appendix C.

- The third test problem exercises subroutines READ5, and half of INCIMP and OPSIMP. In this test problem, the waste stream (Ra-226, .0001 mCi/g) is incinerated and disposed of (IP=2) at a hazardous waste incinerator/hazardous waste landfill (II) (IQ=5). A4, defined as the ratio of the total mass of the BRC waste stream to the number of transportation vehicles multiplied by the percentage of BRC waste in the vehicle, will be set greater than 11.3. The institutional control period is zero (IINS=0). The input file for this test problem is in Appendix C.

3.3.2 Verification with Test Problems

This section details the results of testing the necessary portions of the subroutines with the test problems. Each verified subroutine is discussed separately. The discussion begins with a statement of the part of the subroutine that needs to be tested and goes on to detail the results of the verification work.

- Subroutine SPLICE: Test sorting option 2 (IP=4).

  In subroutine SPLICE, there are two discrepancies between the model described in NUREG/CR-3585 and its implementation in the code. Table 5-10 of the NUREG identifies

$$V_{res} = 0.036\ V_{BRC} \tag{1}$$

where V_{res} = volume residue
V_{BRC} = volume BRC waste

but the IMPACTS-BRC, Version 2.0 uses

$$V_{res} = \frac{m_{res}}{\rho_{res}} \tag{2}$$

where m_{res} = mass residue
ρ_{res} = density residue

The change between these approaches is not traceable in subsequent documentation of the code. However, the approach used in the code is logical because volume, mass, and density will be consistent, and should be retained. The approach in the original reference is not consistent. Table 5-10 in NUREG/CR-3585 also reports that

$$m_{discard} = 0.37\ m_{BRC} \tag{3}$$

where $m_{discard}$ = mass discarded waste
m_{BRC} = mass BRC waste

in contrast, IMPACTS-BRC, Version 2.0 uses

$$m_{discard} = m_{BRC}\ (1\text{-}A1) \tag{4}$$

where A1 = fraction waste incinerated

Again, it has not been documented when this change was made, but the current approach used by the code, where the mass discarded is the amount remaining after incineration, is more appropriate and should be retained.

- Subroutine READ2: Test non-default facility and environmental parameters (IDAT=3).

  The sections that had been untested relate to calculation of impacts to individuals and populations from airborne contaminants for non-default parameters. This is the only part of the code that uses the function XOQFC. Consequently, SNL verified that XOQFC was appropriate for its purpose by comparison with Equation (3) in NRC Regulatory Guide 1.111 [NRC, 1977b]. The approach described in Oztunali and Roles [1984] for estimating parameters in the model was reviewed, and this procedure was verified to be correctly implemented in the code. The function was verified against hand calculations using the appropriate model [NRC, 1977b]. The algorithm for evaluating population exposures was verified by inspection. It was noted that the ASCII file normally distributed with IMPACTS-BRC, Version 2.0 contains a typographical error in XOQFC, such that the conversion factor for s/m^3 to yr/m^3 was in the numerator rather than the denominator. This error was only in the ASCII file; the source code and executable files contained the correct equation. No changes to the code were necessary.

- Subroutine READ5: Test branches for hazardous waste incinerator /hazardous waste landfill (IQ=4 or 5) when A4 is greater than 11.3.

  The sections of the subroutine affected when A4 is greater 11.3 are implemented and working correctly.

- Subroutine INCIMP: Test the first and fourth DO loops for the on-site and hazardous waste incinerators (IQ=1,5).

  The only part of the first loop that depended on IQ was what fraction A1 was set to. This was determined to be working correctly. IQ did not affect the mathematical models in the rest of the DO loop, only the choice of parameters. Therefore, subroutine INCIMP for IQ=1,5 was verified to be implemented and working correctly.

- Subroutine OVRFLO: Test activated metal waste option (IA=2).

  The activated-metal waste section of the subroutine was verified to be implemented and working correctly. The branch where the disposal facility life (ILFE) multiplied by one minus the exponential of the negative nuclide decay constant is zero has been verified to be correctly implemented by hand calculations.

- Subroutine INTIMP: Test activated metal waste option (IA=2).

  The activated metal waste section and the branch where IINS is zero were verified to be implemented and working correctly.

- Subroutine CPSIMP: For a hazardous waste landfill (IQ=3 or 4, since they are both hazardous waste landfills and the mathematical models are identical, only the parameters are different) test activated metal waste (IA=2) and very dispersible waste (ID=3).

  The activated metal and the dispersible waste sections were verified to be implemented and working correctly.

- Subroutine CHNS: Test the entire subroutine for the following chains: Mo-99, Ba-140, Pu-236, and Cf-252.

  Verification of the decay chain analyses in subroutine CHNS was run for Mo-99, Ba-140, Pu-236, and Cf-252 at 50 and 1000 years. The results of these analyses were compared to results from RADDECAY Version 3.01 [Grove Engineering, 1985]. The Mo-99 and Ba-140 chains in IMPACTS-BRC are complete: all daughters are included. IMPACTS-BRC and RADDECAY agreed to three significant figures for both times with these two chains. The Pu-236 and Cf-252 chains in IMPACTS-BRC are simplified chains, in which only radionuclides with half lives greater than a year are retained. The Pu-236 chain calculations agreed to three significant figures for the three nuclides included in the IMPACTS-BRC chain. The agreement was not as good for the Cf-252 chain. The results of this comparison are shown in Tables

3.1 and 3.2. The Cf-252 chain is also a simplified chain, and the short-lived radionuclides are omitted in the tables. The differences are comparatively minor, and do not require more attention.

Table 3.1: Comparison Between IMPACTS-BRC, Version 2.1 and RADDECAY for Calculation of Cf-252 Chain at 50 years

Radionuclide	Fractional Activity (IMPACTS-BRC)	Fractional Activity (RADDECAY)
Cf-252	$1.59x10^{-6}$	$1.98x10^{-6}$
Cm-248	$7.68x10^{-6}$	$7.54x10^{-6}$
Pu-244	$2.98x10^{-12}$	$2.68x10^{-12}$
Pu-240	$7.27x10^{-15}$	$6.59x10^{-15}$
U-236	$3.36x10^{-21}$	$2.08x10^{-20}$
Th-232	0	$5.84x10^{-26}$
Ra-228	0	$9.86x10^{-26}$
Th-228	0	$8.16x10^{-26}$

Table 3.2: Comparison Between IMPACTS-BRC, Version 2.1 and RADDECAY for Calculation of Cf-252 Chain at 1000 years

Radionuclide	Fractional Activity (IMPACTS-BRC)	Fractional Activity (RADDECAY)
Cf-252	0	0
Cm-248	$7.66x10^{-6}$	$7.53x10^{-6}$
Pu-244	$6.41x10^{-11}$	$5.77x10^{-11}$
Pu-240	$3.24x10^{-12}$	$2.94x10^{-12}$
U-236	$3.21x10^{-17}$	$2.00x10^{-16}$
Th-232	$4.07x10^{-25}$	$2.51x10^{-24}$
Ra-228	$3.72x10^{-25}$	$2.49x10^{-24}$
Th-228	$3.49x10^{-25}$	$2.45x10^{-24}$

- Subroutine GWATER: Test to see that if the cumulative pumping volume (TVOL) is less than the minimum value of 110.0, it is set to 110.0.

  The correct implementation of this was verified by inspection. The contaminant transport loop was also verified by inspection.

3.3.3 Summary of Code Verification

All previously untested portions of the code were exercised in this verification work. Deviations were discovered between the description of subroutine SPLICE in Oztunali and Roles [1984] and its implementation in the code. We verified that the algorithm in the code is correct and that no changes should be made. An error was found in function XOQFC in the ASCII file normally distributed with the code. The error was not found in the code itself, and no changes to the code were necessary. Minor deviations were found between radionuclide concentrations calculated using subroutine CHNS and independent calculations for the Cf-252 chain. The differences are believed to be the result of slightly different half lives used in the two codes. No alterations to IMPACTS-BRC are recommended to address this issue. All other portions of the code were verified to be working correctly. No algorithm or coding changes to IMPACTS-BRC were necessary as a result of this verification effort.

3.4 IMPACTS-BRC, Version 2.1

Version 2.1 of IMPACTS-BRC was produced from Version 2.0 of the code with very minor revisions. These revisions include modifying the banner to print out the new version number and adding comments to detail our verification activities. No changes were made to the models in the code to produce Version 2.1. The source code listing for IMPACTS-BRC, Version 2.1 is given in Appendix A. The most significant change to Version 2.1 is that it uses the 2.1 input data, which was produced during this project. Differences between TAPE1.DAT and TAPE2.DAT from Version 2.0 to 2.1 of the data are summarized in Appendix G.

The results of running the original sample problems (given in Appendix C) [O'Neal and Lee, 1990] with IMPACTS-BRC, Version 2.1 are given in Appendix D. Any user of the code should compare the results from running the program on their computer to the results in Appendix D to verify that the code is working properly on their system.

4.0 General Comments About IMPACTS-BRC

In conducting our review of IMPACTS-BRC, we have several general comments about using the code for site-specific applications. Our primary comments pertain to possibly non-conservative models used in IMPACTS-BRC and the way uncertainties are addressed.

4.1 Comments on Models in IMPACTS-BRC

IMPACTS-BRC was derived from the Impacts Analysis Methodology for low-level radioactive waste [Oztunali *et al.*, 1981]. The Impacts Analysis Methodology [Oztunali *et al.*, 1981] and its BRC update [Oztunali and Roles, 1986] were generated to support the Environmental Impact Statement for 10 CFR Part 61. They were developed to allow NRC to assess qualitatively the effects of various variables on the overall impacts of low-level waste disposal. The approach was clearly acknowledged to be used for scoping analyses, and it was not believed to be appropriate for site-specific applications. Similarly, the EPA developed the PRESTO family of codes to conduct generic assessments for their 40 CFR Part 193 rulemaking on low-level waste (which has not yet been promulgated).

Both PRESTO and the Impacts Analysis Methodology were eliminated very early on in the development of the current NRC low-level waste performance assessment methodology, since they were specifically developed only for generic use in rule making, and they are considered inappropriate for site-specific applications.

Many of the models in IMPACTS-BRC are the same as those in the Impacts Analysis low-level waste methodology, and the models retain many of the same drawbacks. These drawbacks are:

- The Impacts Analysis Methodology is demonstrably nonconservative compared to models in the current NRC low-level waste performance assessment methodology for the ground water pathways [Kozak *et al.*, 1990].
- Geosphere modeling cannot be done on a generic basis except through the use of very conservative (scoping) models [IAEA, 1989] that bound the conceptual model uncertainty.
- IMPACTS relies heavily on nonmechanistic "index" factors that reduce impacts by orders of magnitude; these factors cannot be justified for specific sites.
- Use of nonphysical models and parameters in IMPACTS.

Some of the models in IMPACTS-BRC have dubious physicochemical bases. One example is the model for calculating the impact from bathtubbing of the disposal facility, which leads to overland flow that contaminates a nearby stream. The impact, H_2, is calculated using the equation

$$H_2 = \sum_i \sum_n \frac{f_0 \, C_{ni} \, f_i \, V_L \, M_0 \, t_c \, 10^{(1-IA)} \, f_{2n} \, PDCF\text{-}7}{Q} \tag{5}$$

where f_0 = decay correction factor

C_{ni} = concentration of the n^{th} radionuclide in the i^{th} waste stream (Ci/m^3)

f_i = fraction of the total waste volume that is composed of the i^{th} waste stream

V_L = volume of leachate released annually (m^3)

M_0 = radionuclide-specific leach fraction

t_c = fraction of a year that the leachate contacts the waste

IA = accessibility index

f_{2n} = radionuclide retention in soil during overland flow

PDCF-7 = pathway dose conversion factor (mrem m^3/yr Ci)

Q = flow rate of the surface stream (m^3/yr)

Equation (5) is used to calculate concentration of radionuclide in surface water, which can then be multiplied by the PDCF, and summed over all radionuclides to calculate an impact from this pathway. The assumptions necessary in using this equation are not discussed by Oztunali and Roles [1984], therefore, a discussion is presented here.

One general problem with the IMPACTS-BRC code is the use of generic pathway dose conversion factors for site-specific applications. This approach is only appropriate as long as the pathways and usage factors in the model correspond to the conditions at the site. Hence, this approach cannot always be conservative, and there may clearly be cases for which the assumed pathways are inadequate. The conservatism of each pathway dose conversion factor must be evaluated for each specific site. The generic parameters and the unjustified assumptions used by the code should also be questioned. For Equation (5), as an example, the assumptions made and the parameters used to calculate surface-water concentrations are doubtful.

The purpose of the numerator in the equation is to calculate the release rate of radionuclides into the stream. This release is then diluted by the stream flow rate to produce a surface-water concentration. This analysis assumes complete lateral mixing in the stream. While this approach may be appropriate for small streams, it is inappropriate for larger streams [Kozak *et al.*, 1989], since it will lead to calculation of nonconservative surface-water concentrations. Previously this limitation has not been acknowledged . We also note that the code cannot model lake concentrations, and that lakes have the potential to be net accumulators of radionuclides. Neglecting this potential accumulation is also not conservative.

Next, examine the parameters used in the numerator of equation (5) to calculate the radionuclide release rate to the stream. The combination $f_i C_{ni} M_0$ is used to calculate radionuclide concentrations in water in the disposal trench from concentrations in the waste stream. It assumes (1) complete dilution of the i^{th} waste stream by other wastes, and (2) some generic "leach fraction," M_0, that relates ground-water concentrations to solid concentrations. The complete dilution assumption is not conservative, but probably cannot be avoided because of the uncertainty about the distribution of waste in the disposal facility.

The leach fraction is another matter. Values for the leach fractions in the code were developed from data from the Maxey Flats' low-level waste disposal site. It is often argued that these values for leach fractions are conservative, *but there is absolutely no experimental or theoretical basis for this argument.* The leaching process depends heavily on the chemical and physical form of the waste, the geochemistry of the waste, soil, and ground water, and on the hydrological flow regime of the site. Leaching results from Maxey Flats depend in a complicated way on conditions at Maxey Flats, and other sites may bear no resemblance to these conditions. For example, at Maxey Flats, uranium moves very slowly. Consequently, it is assigned a low leach fraction in the IMPACTS approach. However, it is well known that uranium compounds are quite mobile at a number of existing DOE sites [Sheppard and Thibault, 1990]. This is a clear and demonstrable case in which the Maxey Flats' data are not conservative when used for a different site. In addition, chelating compounds cannot be excluded from consideration in BRC waste assessment, and the presence of chelating agents may increase leach rates even further. Furthermore, in developing the leach fractions, a number of dubious assumptions were required, so the Maxey Flats "data" are not as straightforward as they first appear.[9] One of the most important pieces of missing information needed to generate the leach fractions is the inventory at the site. The quantities and forms of the inventory are not known with confidence at Maxey Flats, so the leach fractions are based on dubious estimates of the inventory [Pescatore and Sullivan, 1991].

Current low-level waste leaching models assume that leaching from trash occurs through a "surface-wash" mechanism [Sullivan and Suen, 1989; Kozak *et al.*, 1989], which suggests that much higher release rates can be expected. The uncertainties in leaching from very heterogeneous waste are believed to be bounded by this approach.

The leachate concentration is multiplied by the parameters V_L, t_c, $10^{(1-IA)}$, and f_{2n}. V_L was defined in Oztunali and Roles [1984] in units of m^3, but it should be m^3/yr for dimensional consistency of the overall equation. More importantly, we note that the parameter t_c, as originally defined, has no basis in hydrological principles. The variable t_c is defined as $p/(nv)$, where p is the infiltration

[9] Dr. Terry Sullivan, Brookhaven National Laboratory, personal communication, 1991.

rate (m/yr), n is the effective porosity, and v is the ground-water velocity (m/yr). The stated intention is for this fraction to be a correction factor for "transient and partially saturated conditions" [Oztunali and Roles, 1984]; it is also identified with "the fraction of a year that ... water is in contact with waste" [Oztunali and Roles, 1984]. In fact, t_c is the fractional saturation for unsaturated flow, and is equal to unity for saturated flow; it has nothing to do with transient effects. It is not entirely clear why the fractional saturation should multiply the other factors in equation (5), particularly since the leach fractions are supposed to be based on "real" data that would include the effects of partial saturation. We conclude that t_c appears to be nothing more than a "fudge" factor that can be used to decrease impacts. The parameter was set to 1.0 for all cases by Forstom and Goode [1986], and consequently does not affect the results of current code analyses. However, future users may wish to use other values for the parameter, so it is important to recognize that it does not have a physical basis. We also suggest that the inclusion of this parameter in this model is suggestive of the level of empiricism that exists in many of the models in the code.

The effect of the accessibility index, IA, in the code is to reduce release rates of activated metals by a factor of 10 for all situations. There is no experimental evidence for this ten-fold reduction in the release rate. Actual releases may be either more or less than those calculated using IMPACTS-BRC, and will depend on site-specific conditions. Sullivan and Suen [1989] have suggested an alternate model for releases from activated metals. This model is a semiempirical approach that combines an established phenomenological analytical structure for corrosion rate with field data for underground corrosion as a function of soil properties. Limitations to the model are documented [Sullivan and Suen, 1989; Kozak *et al.*, 1989] and consist primarily of narrow empirical bases for parameters in the model. Nevertheless, the model is considerably more defensible than an arbitrary ten-fold reduction in release rates.

The factor f_{2n} is the fractional amount of radionuclides retained by soils during overland flow. Two issues should be raised in regards to this parameter: (1) it is conventional to model sorption as a delay mechanism rather than a removal mechanism (the current approach in the code is not conservative), and (2) soil-radionuclide interactions cannot be quantified on a generic basis.

The examination of overland transport from the disposal trench in IMPACTS-BRC indicates that

- Parameters in the model have no physical or experimental basis.
- The model takes excessive credit for dilution and removal mechanisms at each step in the process.

The model cannot therefore be considered to be conservative on a generic basis, nor can it be considered either conservative or realistic for site-specific analyses.

These issues have been raised by examining only one of the many models in IMPACTS-BRC. It is expected that there are similar problems in other models in the code. Note that SNL's primary concerns are for the models for transport in the geosphere. These models have not been considered the most important for BRC waste disposal petitions. It has been more common for doses to the transportation worker to dominate the disposal scenario doses [Kennedy *et al.*, 1989]. It is therefore possible that addressing our concerns about these models will not substantially change previously calculated overall BRC doses.

On the other hand, doses for the ground water-to-well pathway almost always dominate postclosure doses in low-level waste disposal assessments. The system here is similar, except that inventories in BRC waste have lower concentrations, and the doses are compared against lower regulatory performance objectives. The ground water transport analysis in IMPACTS-BRC is believed to suffer from the same defects as the overland transport analysis. Furthermore, many of the assessments of the relative importance of pathways have been carried out using IMPACTS-BRC. Given the probable nonconservatism of the geosphere models, these pathways may have been incorrectly identified as being insignificant. Consequently, these issues are of uncertain importance in relationship to the overall assessment of BRC wastes. In SNL's opinion, they should be investigated in order to produce a more defensible BRC analysis.

4.2 Comments on Uncertainty Analysis

Another concern about IMPACTS-BRC relates to the approach to uncertainty in current applications of the code. Refer to section 1.5 for a background discussion on treatment of uncertainty. In SNL's opinion, IMPACTS-BRC does not adequately address either conceptual model or parameter uncertainty.

In assessing a BRC petition, the analyst must develop a conceptual model that includes information about the geosphere (for offsite exposure analyses) in addition to making hypotheses about the future behavior of people at the site (for input into operational and intrusion analyses). The process of developing a conceptual model of the geosphere is complicated and site specific. When using IMPACTS-BRC, the analyst is confined to a small set of conceptual models of the site. Consequently, the analyst is unable to examine possible alternative conceptual models. In addition, some of the models are clearly not conservative compared to other comparable models currently in use (see section 4.1).

To bound both conceptual model and parameter uncertainties, a combination of conservative models and conservative parameters must be used. Unless formal parameter uncertainty methods, such as Monte Carlo methods, are used, it is difficult to provide evidence that the parameter uncertainty has been bounded. Unless site-specific validation is performed, anything less than a very conservative model is not justified [Davis *et al.*, 1991]. If either the parameters or the models are nonconservative, it is likely that the radiological impacts will be underpredicted [NCRP, 1984].

Previous evaluations of conservatism in IMPACTS-BRC have suggested that portions of the code, *i.e.* the transportation analysis, are overly conservative for specific applications [Rogers and Murphy, 1988; Kennedy *et al.*, 1989]. However, these results are not general and generic models and parameters must be very conservative to bound the uncertainties associated with their use at heterogeneous sites.

We conclude that in using IMPACTS-BRC, an analyst can neither span the conceptual model uncertainties, nor bound them. In addition, using generic data as a surrogate for site-specific data is not necessarily conservative. This problem is further aggravated since some of the parameters in the code are "hard wired," and inaccessible to the user. This means that a user could not use more conservative values for these parameters even if he were so inclined. If the code is used to produce only a single realization of the data set, this approach does not allow the analyst to acknowledge data uncertainties.

Allowing for greater flexibility in the models used in IMPACTS-BRC would address concerns about the quality of models used in the code as well as concerns about the way the program handles conceptual model uncertainty. The code also needs greater flexibility for handling parameter uncertainty, since many of the parameters are hard-wired into the code.

4.3 Summary of General Comments

Two areas of concern are identified in this report. The first is concern about the lack of conservatism and the lack of physical bases for many models and parameters used in the code. The second area of concern is the approach taken toward uncertainty. The code appears to be intended to be used as a bounding analysis, but neither the models nor the parameters appear to bound the uncertainties. If, alternatively, an accurate estimate of impacts is desired, site-specific models must be used. Hence, IMPACTS-BRC, with its generic models and data sets, does not appear to produce either accurate site-specific results or conservative generic results.

Possibly, the areas of concern will not affect calculated doses from projected BRC waste disposal. However, we recommend that the models in the code and the overall approach to uncertainty analysis be reevaluated to ensure that conservative and defensible analyses are used.

Evaluation of BRC petitions would be better conducted by identifying a suite of codes to conduct individual parts of the assessment. Several codes should be identified for each module of the methodology. This approach was used in the recently developed NRC/SNL low-level waste performance assessment methodology [Kozak *et al.*, 1990; Deering and Kozak, 1990]. One important advantage is that different models can be substituted into the analysis when they are appropriate. When greater uncertainties exist, more conservative models may be used.

The primary disadvantage to this approach is that a greater burden is placed on the applicant to justify the models and parameters used in the analysis. In other words, it is more work for the applicant since he must understand the site better. Again, the NRC's low-level waste performance assessment philosophy is to require a conservative analysis to be used, unless the applicant can demonstrate that less conservative approaches are appropriate [Starmer *et al.*, 1988]. We believe that forcing the applicant to justify assumptions will result in better radiological assessments.

5.0 Summary of IMPACTS-BRC, Version 2.1

All the data in the input files (TAPE1.DAT and TAPE2.DAT) to IMPACTS-BRC have been verified. The verification was carried out by comparison of the data files with independent sources [Eckerman et al., 1988 or Kocher and Eckerman, 1988], tracing the data to earlier documentation of the code [Oztunali and Roles, 1984, Forstom and Goode, 1986, or O'Neal and Lee, 1990], changing the data to be consistent with the documentation, or identifying the data as untraceable. The new data, Version 2.1, has been produced under strict quality assurance procedures. The new data set have been included in this report as Appendix B.

In addition to the data verification, SNL has conducted code verification on previously untested parts of IMPACTS-BRC. SNL has determined that the code implements the models correctly as documented in Oztunali and Roles [1984], and that it performs as described in the code documentation [O'Neal and Lee, 1990]. No changes were recommended to the code as a result of the code verification efforts.

We have produced IMPACTS-BRC, Version 2.1, which uses Version 2.1 of the data. Version 2.1 of the code differs from Version 2.0 only in the version number on the banner it prints in the output files and in some of the comment lines. The updated code is appended to this report as Appendix A. IMPACTS-BRC, Version 2.1 was produced under quality assurance guidelines.

The purpose of the verification work was to produce a more defensible version of IMPACTS-BRC by ensuring that the data and the code were checked carefully for consistency with the literature. However, in SNL's opinion, the defensibility of the code is even more closely related to the defensibility of the underlying models than to its being produced under strict quality assurance guidelines.

Some of these models have been called into question; primarily the models for geosphere transport. These models and their associated parameters are intended to bound possible offsite impacts, but it is quite clear that they do not. SNL has suggested an alternative to evaluating BRC petitions that is comparable to the NRC's technical position on low-level radioactive waste disposal assessments.

6.0 Distribution of IMPACTS-BRC, Version 2.1

IMPACTS-BRC, Version 2.1 is available from the Energy Science and Technology Software Center (ESTSC), P.O. Box 1020, Oak Ridge, Tennessee 37831-1020 on floppy disk. This disk contains the following files:

Name.ext	Size	Date
IMPACTS.EXE	242576	10-11-91
IMPSHELL.EXE	113920	12-17-89
BROWSE.EXE	42240	12-15-89
INSTALL.EXE	67520	12-15-89
PRINTER.DTA	7752	12-15-89
IMPSHELL.OVR	111037	12-15-89
IMPSHEL2.PCS	57328	12-19-89
TAPE1.DAT	59350	8-27-91
TAPE1.DTA	59350	8-27-91
TAPE1BAK.DTA	59350	8-27-91
TAPE2.DAT	3848	8-27-91
TAPE2.DTA	3848	8-27-91
TAPE2BAK.DTA	3848	8-27-91
TAPE5.DAT	2758	12-15-89
TAPE5BAK.DTA	2758	12-15-89
IMPACTS.ASC	69929	10-03-91

IMPACTS.EXE is the executable of IMPACTS-BRC, Version 2.1. IMPSHELL.EXE is the data preprocessor that can be used to modify the input data sets. The preprocessor uses BROWSE.EXE, INSTALL.EXE, PRINTER.DTA, IMPSHELL.OVR, IMPSHEL2.PCS, TAPE1.DTA, and TAPE2.DTA. TAPE1.DAT, TAPE2.DAT, and TAPE5.DAT are the data input files, while TAPE1BAK.DTA, TAPE2BAK.DTA, and TAPE5BAK.DTA are their backups. IMPACTS.ASC is an ASCII listing of the IMPACTS-BRC, Version 2.1 source code. Note that the common blocks required for compiling the program are not included in the ASCII file.

Details of how to use the preprocessor, and the hardware and software requirements for running the code can be found in the IMPACTS-BRC, Version 2.0 user's manual [O'Neal and Lee, 1990]. Note, during the creation of Version 2.1 of the code, no changes were made to the preprocessing software.

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APPENDIX A: IMPACTS-BRC Version 2.1 Source Code

```
      PROGRAM IMPACTS_BRC
C
C  PROGRAM TITLE:  IMPACTS-BRC                         VERSION 2.1
C
C  DEVELOPED FOR:  U.S. NUCLEAR REGULATORY COMMISSION
C                  OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
C                  DIVISION OF WASTE MANAGEMENT
C
C+  VERSION 1.0 Developed on
C  DATE:  MAY 1986
C
C  NRC CONTACT:  CHIEF, GEOTECHNICAL BRANCH    PHONE: (301) 492-7000
C                DIVISION OF WASTE MANAGEMENT
C
C  CODE DEVELOPER:  DR. O.I. OZTUNALI, EBASCO SERVICES INC.
C                   WITH MODIFICATIONS BY DANIEL J. GOODE, NRC
C
C  TITLES OF ASSOCIATED DOCUMENTATION AND NUREG NUMBERS:
C
C   OZTUNALI, O.I., AND G.W. ROLES. DE MINIMIS WASTE IMPACTS ANALYSIS
C     METHODOLOGY, VOL 1, NUREG/CR-3585, 1984.
C
C   FORSTROM, J.M., AND D.J. GOODE, DE MINIMIS WASTE IMPACTS ANALYSIS
C     METHODOLOGY, VOL 2, IMPACTS-BRC USER'S GUIDE AND METHODOLOGY FOR
C     RADIOACTIVE WASTE BELOW REGULATORY CONCERN, NUREG/CR-3585, 1986.
C+
C+ --------------------------------------------------------
C+
C+ Version 2.0 developed on
C+ Date : October 1, 1989
C+
C+ By
C+      Safety and Reliability Analysis Division 6415
C+      Sandia National Laboratories
C+      Albuquerque, NM 87185
C+
C+ Code Revisions by :
C+
C+      Dr. Clarence E. Lee               Mr. Bill O'Neal
C+      Applied Physics, Inc              Division 6415
C+      5353 Wyoming Blvd. NE, Suite 3    Sandia National Laboratory
C+      Albuquerque, NM 87109             Albuquerque, NM 87185
C+
C+ Version 2 modifications include:
C+  o  Addition of Tape11 containing ICRP summary information
C+  o  Modification of the Tape2 format to include all possible card
C+      configurations automatically, e.g., site specific information
C+      so that the IMPACTS preprocessor shell, IMPSHELL.EXE, could be
C+      used to efficiently input modify data and then run IMPACTS.EXE.
C+  o  Allowing the user to name input and output files from the
C+      command line (see format below) in free standing or shell modes.
C+  o  Implemention of onscreen waste stream batch run monitoring.
C+  o  Auto detection of file status precluding a run and aborting.
C+  o  Addition of clock and timing information on runs.
C+  o  Correction of a few programming and computational errors.
C+  o  Limited model changes were implemented by SNLA
C+      (these are documented separately - in the user's manual).
C+
C+ --------------------------------------------------------
CSNL+ + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + + +
CSNL
CSNL    Version 2.1 developed on October 1, 1991
CSNL
CSNL       By Sandia National Laboratories, Division 6416
CSNL
CSNL    Following code and data verification activities, Version 2.1 of
```

```
CSNL    IMPACTS-BRC was produced.
CSNL
CSNL    Version 2.1 modifications include:
CSNL
CSNL    o  The input data files, TAPE1.DAT and TAPE2.DAT, were modified
CSNL       as described in NUREG/CR-5797.
CSNL
CSNL    o  The only change required for the code was to update the banner to
CSNL       print out Version 2.1.
CSNL
CSNL  ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
C
C   THIS PROGRAM WAS PREPARED FOR AN AGENCY OF THE UNITED STATES
C   GOVERNMENT.  NEITHER THE UNITED STATES GOVERNMENT NOR ANY AGENCY
C   THEREOF, NOR ANY OF THEIR EMPLOYEES, MAKES ANY WARRANTY, EXPRESSED
C   OR IMPLIED, OR ASSUMES ANY LEGAL LIABILITY OR RESPONSIBILITY FOR
C   ANY THIRD PARTY'S USE, OR THE RESULTS OF SUCH USE, OF ANY PORTION
C   OF THIS PROGRAM OR REPRESENTS THAT ITS USE BY SUCH THIRD PARTY
C   WOULD NOT INFRINGE PRIVATELY OWNED RIGHTS.
C
C+--------------------------------------------------------------
C
C   THIS CODE REPRESENTS AN ANALYSIS METHODOLOGY FOR DETERMINING THE
C   RADIOLOGICAL IMPACTS ASSOCIATED WITH THE DISPOSAL OF BELOW REGULATORY
C   CONCERN (BRC) WASTE.  IT CALCULATES THE IMPACTS UNDER A NUMBER OF
C   SCENARIOS, INCLUDING THOSE INVOLVED WITH TRANSPORTATION OF THE WASTE,
C   SORTING/INCINERATION/RECYCLE OF THE WASTE AND FINAL DISPOSAL AND
C   POST-DISPOSAL CONSIDERATIONS.
C
C   THE INPUT/OUTPUT FILES ARE IDENTIFIED AS FOLLOWS:
C
C     TAPE1= INPUT FILE CONTAINS NUCLIDE SPECIFICATION DATA, SUCH AS:
C            THE BASIC DOSE CONVERSION FACTORS, NUCLIDE NAMES,
C            SOLUBILITY CLASSES, GROUNDWATER RETARDATION COEFFICIENTS,
C            UPTAKE FACTORS, ETC.
C
C     TAPE2= INPUT FILE CONTAINING THE DEFAULT ENVIRONMENTAL,
C            TREATMENT, AND DISPOSAL PARAMETERS USED IN THIS ANALYSIS.
C            ALSO CONTAINS NON-DEFAULT FACILITY AND ENVIRONMENT DATA.
C
C     TAPE5= INPUT FILE CONTAINING TREATMENT/DISPOSAL OPTIONS, AND
C            WASTE STREAM CHARACTERISTICS.  THIS FILE WILL MOST LIKELY
C            CHANGE WITH EACH CASE UNDER CONSIDERATION.
C
C     TAPE6= OUTPUT FILE CONTAINING THE MAIN RESULTS OF THE ANALYSIS
C
C     TAPE10= OUTPUT FILE CONTAINING ICRP DOSES FOR EACH NUCLIDE
C             (MOST PATHWAYS)
C+
C+    TAPE11 = OUTPUT FILE CONTAINING ONLY THE EFFECTIVE DOSE
C              EQUIVALENTS FO THE ANALYSIS
C+
C+    THE OVERALL CODE HIERARCHY IS AS FOLLOWS:
C+
C+ ------------- IMPACTS-BRC CODE HIEARCHY ----------------
C+ Subroutines:
C+
C+        |-- Zero
C+        |
C+        |-- Blockd
C+        |
C+        |-- Read1 --- Read
C+        |
C+        |-- Read2 |--- Read
C+        |         |--- Write
C+        |
```

```
C+       |-- Read5 |---  Zero
C+       |         |---  Read
C+       |         |---  Write
C+       |         |---  Uptake ----  Write
C+       |
C+         Splice |---  Recycl --|-- Write
C+       |        |---  Incimp   |-- Zero
C+       |        |---  Write
C+ MAIN--|
C+       |-- Intimp|---  Chns   ---  Zero
C+       |         |---  Write
C+       |         |---  Calc
C+       |
C+       |-- Expwas|---  Chns  ----  Zero
C+       |         |---  Write
C+       |         |---  Calc
C+       |
C+       |-- Opsimp
C+       |
C+       |-- Ovrflo ----  Write
C+       |
C+       |-- Gwater ----  Write
C+       |                Zero
C+       |
C+       |-- Divvy  ----  Write
C+       |
C+       |-- Prntc  ----  Write
C+
C+
C+ Functions:
C+
C+        E1   --|--  Alog
C+               |--  Exp
C+
C+        ERFS --|--  Exm  --  Exp
C+               |--  Poly
C+
C+        POLY
C+
C+        COFF  -----  Sqrt
C+
C+        DOFF  -----  Exm  --  Exp
C+
C+        XOQFC -----  Exp
C+
C+
C+   The subroutines and functions are each ordered alphabetically
C+   in the source file.
C+
C+   This source code is compilable with
C+     LAHEY F77L into *.EXE   (runs free standing / under IMPSHELL.EXE)
C+   and/or
C+     LAHEY F77L/32EMS into *.EXP ( runs only free standing : UP impacts)
C+   executable files.
C+
C+   Modifications are required to use the Microsoft FORTRAN:
C+    Changes required would involve the
C+    include, GetCL, Under0, len, index, charnb, timer, time and
C+    date subroutines and functions used here.
C+
C+   Compiler specific functions and procedures are called out in the
C+     source listing. Except as noted, the source code satisfies the
C+     FORTRAN 77 standard.
C+
C+   The file IMPCOMM.FOR contains common block definitions.
C+   It must be available for successful compilation.
```

```
C+
      INCLUDE IMPCOMM.FOR
      CHARACTER TimeStart*11
      INTEGER*4 TStart,TStop
      CHARACTER tline*220,Cmdline*220,
     - InputName*50,Tape6Name*50,Tape10Name*50,Tape11Name*50,
     + DateName*8
      LOGICAL SUCCESS,EXIST5,EXIST6,EXIST10,EXIST11
      CHARACTER ORG(10)*9,SCN(36)*6,FAS(5)*20,NUCT*6,SOLT*1
      COMMON/CHYN/NXUC(85),ICH(8,10),LCH(10),ACT(8),BCT(8,2)/UPTK/FK(21)
      COMMON/DCFS/FF(85,5),DCF1(159,10),DCF2(159,10),DCF3(85),
     + DCF4(85,10),DCF5(85,10),NUCT(159),SOLT(159)
      DIMENSION TYMD(16),BIMPT(10,65)
      DATA ORG/'  LUNGS  ',' S.WALL  ',' LLI WALL ',' T. BODY ',
     + ' KIDNEYS ','  LIVER  ',' RED MAR ','   BONE  ',
     + ' THYROID ','   ICRP  '/
      DATA SCN/'INT-CO','INT-AG','IN-AIR','ER-AIR','IN-WAT','ER-WAT',
     + 'IC-POP','IC-IND','IC-WOR','IC-MWR','OP-POP','OP-IND',
     + 'OP-WOR','OP-MWR','  20YR','  40YR','  60YR','  80YR',
     + ' 100YR',' 120YR',' 160YR',' 200YR',' 400YR',' 600YR',
     + ' 800YR',' 1K YR',' 2K YR',' 5K YR','10K YR','20K YR',
     + 'TR-MAX','TR-OCC','TR-POP','LA-OPS','LA-OVF','LA-AIR'/
C+ FACILITY NAMES
      DATA FAS/'ONSITE INC, S. LANDF','SANITARY LANDFILL   ',
     + 'ONSITE INC, H. LANDF','HAZARDOUS WASTE I   ',
     + 'HAZARDOUS WASTE II  '/
      DATA TYMD/20.,40.,60.,80.,100.,120.,160.,200.,400.,600.,
     + 800.,1000.,2000.,5000.,10000.,20000./
      DATA NTYM/16/
  101 FORMAT(8I3)
  102 FORMAT(//2X,A20//2X'LIFE = 'I3,2X'OVFL = 'I3,2X'NSTR = 'I3/
     + 2X'REGN = 'I3,2X'DATA = 'I3/2X'IPOP = 'I3,2X'INST = 'I3)
  103 FORMAT(1H1)
  104 FORMAT(/,2X,'TRANSPORTATION IMPACTS',10X,A6,
     +' =',1PE9.2,' MREM/YR',
     +/,34X,A6,' =',E9.2,' PERSON-MREM/YR',/,34X,A6,' =',E9.2,
     +' PERSON-MREM/YR')
  106 FORMAT(1H1/2X'CUMULATIVE IMPACTS'/)
C+ Setup for automatic set-to-zero on underflow in Lahey FORTRAN
      LOGICAL*4 LFLAG                        ! SNLA modification
      LFLAG = .TRUE.
      CALL UNDER0(LFLAG)
C+  Set all underflows = 0 on storage to memory
C+
C+ --------------- COMMAND LINE FORMAT ------------------
C+ Read Command Line for Input & Output File Names   ! SNLA modification
C+ Format assumed = impact: InputName + Tape6Name,Tape10Name,Tape11Name
C+ Input and Tape names support paths and directories in the format
C+        [d:]\[path]\[filename.ext]
C+  with the length of complete drive,path,and filename <= 50 characters.
C+ If only the code name supplied, default line input names are supplied.
C+ If '>' is supplied at end, screen output is piped to a named file.ext.
C+ ---------------------------------------------------
C+
       InputName = 'Tape5.dat'             ! Default line input
       Tape6Name = 'Tape6.out'
       Tape10Name = 'Tape10.out'
       Tape11Name = 'Tape11.out'
       Call GetCL(cmdline)                 ! Command Line input
       tline = charnb(cmdline)             ! Strip trailing blanks
       i1 = index(tline,'+')               ! input:output delimiter
       i2 = index(tline,',')               ! tape6,tape10,tape11 delim
       i3 = len(tline(1:nblank(tline)))
       if ((i1.GT.0).and.(i2.GT.0).and.(i3.GT.0)) then
        InputName = ' '
        InputName(1:i1-1) = tline(2:i1-1)
```

```
      if (i1.LE.2) InputName = 'Tape5.dat'
      Tape6Name = ' '
      Tape6Name(1:i2-i1-1) = tline(i1+1:i2-1)
      If ((i1+1).EQ.i2) Tape6Name = 'Tape6.out'
      Tape10Name = ' '
      Tape10Name(1:i3-i2+1) = tline(i2+1:i3+1)
      tline = Tape10Name
      Tape10Name = ' '
      i2 = index(tline,',')
      i3 = len(tline(1:nblank(tline)))
      Tape10Name(1:i2-1) = tline(1:i2-1)
      If (i2.LE.1) Tape10Name = 'Tape10.out'
      Tape11Name = ' '
      Tape11Name(1:i3-i2+1) = tline(i2+1:i3)
      If ((i2+1).GE.i3) Tape11Name = 'Tape11.out'
     endif
     write(*,1..)
 107 format(' IMPACTS-BRC - VERSION 2.1: Documented in NUREG/CR-5797')
     write(*,108) InputName
 108 format(' Tape 5  Input  Name = ',a)
     write(*,109) Tape6Name
 109 format(' Tape 6  Output Name = ',a)
     write(*,110) Tape10Name
 110 format(' Tape 10 Output Name = ',a)
     write(*,911) Tape11Name
 911 format(' Tape 11 Output Name = ',a)
C+ Test and OPEN THE FILES FOR NAMING TAPE5 & CREATING TAPE6,10, & 11
C      Note : Tape6 is UNIT 7
C+ Test for existence of files, query status, decide on running
     INQUIRE(FILE=InputName,EXIST=exist5)      ! Test InputName
     INQUIRE(FILE=Tape6Name,EXIST=exist6)      ! Test Tape6Name
     INQUIRE(FILE=Tape10Name,EXIST=exist10)    ! Test Tape10Name
     INQUIRE(FILE=Tape11Name,EXIST=exist11)    ! Test Tape11Name
     success = .true.
     if (exist5) then
      OPEN(5,FILE=InputName,STATUS='OLD')
     else
           success = .false.
      write(*,112) InputName
 112  format(' ',a,
    + ' does not exist!'/ ' It is required for running.')
     endif
     if (.not.exist6) then
      OPEN(7,FILE=Tape6Name,STATUS='NEW')
     else
      success = .false.
      write(*,113) Tape6Name
 113  format(' ',a,
    + ' already exists!.'/ ' It must be renamed/erased.')
     endif
     if (.not.exist10) then
      OPEN(10,FILE=Tape10Name,STATUS='NEW')
     else
      success = .false.
      write(*,113) Tape10Name
     endif
     if (.not.exist11) then
      OPEN(11,FILE=Tape11Name,STATUS='NEW')
     else
      success = .false.
      write(*,113) Tape11Name
     endif
     if (.not.success) then
      write(*,114)
 114 format(' Errors detected in the input/output file status.')
      STOP ' Further running is not possible at this time.'
```

```
      endif
C+ Read TStart clock (ticks in hundreths of second)
C+ & TimeStart HH:MM:SS:hh  DateName in format MM/DD/YY

      CALL TIMER(TStart)                ! Lahey System Subroutine
      CALL TIME(TimeStart)              ! Lahey System Subroutine
      CALL DATE(DateName)               ! Lahey System Subroutine
      write(*,111) TimeStart,DateName   ! Monitor Line Header output
  111 format('   Time       Waste Stream           Started -
     +a11,' on ',a8)
      DO 10 I=1,3
   10 FRACT(7,I)=FRACT(29,I)
      CALL BLOCKD
      CALL READ1
C+ START OF A GIVEN CASE - ONE FACILITY AND ANY NUMBER OF
C+ WASTE STREAMS WITH GIVEN CHARACTERISTICS
C+ WRITE HEADER ON TAPES 6, 10, and 11 append with DateName & TimeStart
      WRITE(7,1000)  DateName,TimeStart
      WRITE(10,1000) DateName,TimeStart
      WRITE(11,1000) DateName,TimeStart
 1000 FORMAT('  IMPACTS-BRC - VERSION 2.1: Run on ',a8,' at ',a11)
   20 READ(5,101,END=50) IR,IDAT,IQ,NSTRD,IPOP,ILFE,IINS,IOFL
      WRITE(7,102)  FAS(IQ),ILFE,IOFL,NSTRD,IR,IDAT,IPOP,IINS
      WRITE(11,102) FAS(IQ),ILFE,IOFL,NSTRD,IR,IDAT,IPOP,IINS
C+ WRITE SCENARIO HEADER ON TAPE10.OUT
      WRITE(10,1002) FAS(IQ)
 1002 FORMAT(//2X,A20)
      CALL READ2
      CALL ZERO(BIMPT,650)
      DO 40 ISTRD=1,NSTRD
        CALL ZERO(BIMP,650)
        IF(ISTRD.NE.1)WRITE(7,103)
        IF(ISTRD.NE.1)WRITE(11,103)
C+ CALCULATE IMPACTS
        CALL READ5
C+ SAVE DISPOSAL/INCINERATION/SORTING OPTION
        INCIN=ISPC(1,5)
        CALL SPLICE
        CALL INTIMP
        CALL EXPWAS
        CALL OPSIMP
        IF(IOFL.NE.0)CALL OVRFLO
        CALL GWATER(NTYM,TYMD,SCN)
C+ NORMALIZE INDIVIDUAL IMPACTS WITH NUMBER OF FACILITIES
        CALL DIVVY(1,1,2)
        CALL DIVVY(1,5,6)
C+ NORMALIZE INCINERATOR IMPACTS IF INCINERATION OCCURS
        IF(INCIN.NE.1) CALL DIVVY(2,8,8)
        IF(INCIN.NE.1) CALL DIVVY(2,10,10)
        CALL DIVVY(1,12,12)
        CALL DIVVY(1,14,14)
        CALL DIVVY(1,15,64)
        WRITE(7,104)  (SCN(I+26),BAS(1,I),I=5,7)
        WRITE(11,104) (SCN(I+26),BAS(1,I),I=5,7)
        CALL PRNTE(ORG,SCN,BIMP)
        DO 30 I=1,10
          DO 30 J=1,65
   30       BIMPT(I,J)=BIMPT(I,J)+BIMP(I,J)
   40 CONTINUE
      IF(NSTRD.EQ.1)GO TO 20
      WRITE(7,106)
      WRITE(11,106)
      CALL PRNTE(ORG,SCN,BIMPT)
      GO TO 20
C+ THE END OF A GIVEN CASE, GO TO 20 FOR NEW CASE OR
C+ CLOSE FILES IF END-OF-FILE IS ENCOUNTERED ON TAPE5 INPUT
```

```
   50 CONTINUE
C+ Print Total Run time.                              ! SNLA modification
      CALL TIMER(TStop)                                ! Lahey System Subroutine
      If (TStop .LT. TStart) TStop = TStop + 86400  ! Adjust for midnight
      TRun = (TStop-TStart)/6000.0                     ! Convert to minutes
      Write(*,100) TRun                               ! Run time in minutes
      Write(7,100) TRun
      Write(10,100) TRun
      Write(11,100) TRun
  100 Format(50('-'),/,' Total Run Time = ',G12.6,' Minute(s)')
      CLOSE (5)                                        ! Close all output files
      CLOSE (7)
      CLOSE(10)
      CLOSE(11)
      STOP 'NORMAL TERMINATION OF IMPACTS-BRC, Version 2.1'
      END
C+ ------------ END OF MAIN ---------------------------------
      SUBROUTINE BLOCKD
      COMMON/CHYN/NXUC(85),ICH(8,10),LCH(10),ACT(8),BCT(8,2)
     + /NUCS/ALFP(595),FRACT(85,3),NUX(85)/UPTK/FK(21)
      DIMENSION NXUC2(85),ICH2(8,10),LCH2(10),FK2(21),FRACT2(85,3)
      DATA NXUC2/27*0,1,0,1,16*0,1,6*0,1,0,5*1,3*0,24*1/
      DATA ICH2/85,84,78,75,69,63,58,60,83,75,69,63,58,60, 0, 0,
     + 82,74,68,64,59, 0, 0, 0,81,73,67,62,57,56,54,55,
     + 80,74,68,64,59, 0, 0, 0,76,79,71,66,61, 0, 0, 0,
     + 77,70,67,62,57,56,54,55,72,65,60, 0, 0, 0, 0, 0,
     + 28,30,29, 0, 0, 0, 0, 0,47,48, 0, 0, 0, 0, 0, 0/
      DATA LCH2/8,6,5,8,5,5,8,?,3,2/
      DATA FK2/8.0E-4,0.01,0.0483,7.65E-4,240.0,0.0037,0.25,1.0,1600.0,
     + 190.0,50.0,95.0,0.3,50.0,60.0,370.0,6.9,1.0,8.5E-9,8000.0,16.0/
      DATA FRACT2/0.9,0.75,26*2.5E-3,4*0.01,7*2.5E-3,3*0.01,43*2.5E-3,
     +0.9,0.75,26*5.0E-3,4*0.01,7*5.0E-3,3*0.01,43*5.0E-3,
     +0.9,0.75,26*2.5E-3,4*0.01,7*2.5E-3,3*0.01,43*2.5E-3/
      DO 10 I=1,85
        NXUC(I)=NXUC2(I)
        DO 10 J=1,3
          FRACT(I,J)=FRACT2(I,J)
   10 CONTINUE
      DO 20 I=1,10
        LCH(I)=LCH2(I)
        DO 20 J=1,8
          ICH(J,I)=ICH2(J,I)
   20 CONTINUE
      DO 30 I=1,21
        FK(I)=FK2(I)
   30 CONTINUE
      RETURN
      END
C+ ---------------------------------------------------------
      SUBROUTINE CALE(INUC,IP,C1,C2,C3,C4,IEN,IBG,NCH)
C+ CALE PERFORMS THE SAME FUNCTION AS SUBROUTINE "CALI",
C+ ONLY FOR SUBROUTINE "EXPWAS" RATHER THAN "INTIMP".
C+
C+ CHAIN EFFECTS FOR INTRUDER- AND EROSION-INITIATED EXPOSED
C+ WASTE SCENARIOS ARE CALCULATED.
      COMMON/BAST/E[illegible]COM(834),ISPC(2,15),PDCF(85,10,7)
     + /CHYN/NXUC(85),ICH(8,10),LCH(10),ACT(8),BCT(8,2)
      IF(NXUC(INUC).NE.0)GO TO 15
C+ INUC not a member of a chain
      C1=BCT(1,1)*PDCF(INUC,IP,3)
      C2=BCT(1,2)*PDCF(INUC,IP,3)
      C3=BCT(1,1)*PDCF(INUC,IP,7)
      C4=BCT(1,2)*PDCF(INUC,IP,7)
      RETURN
C+ INUC a member of a chain
   15 IEND=IEN-IBG+1
```

```
      C1=0.0
      C2=0.0
      C3=0.0
      C4=0.0
      DO 20 I=1,IEND
        NN=ICH(IBG+I-1,NCH)
        C1=C1+BCT(I,1)*PDCF(NN,IP,3)
        C2=C2+BCT(I,2)*PDCF(NN,IP,3)
        C3=C3+BCT(I,1)*PDCF(NN,IP,7)
   20 C4=C4+BCT(I,2)*PDCF(NN,IP,7)
      RETURN
      END
C+-----------------------------------------------------------
      SUBROUTINE CALI(INUC,IP,C1,C2,C3,C4,IEN,IBG,NCH)
C+    CALI PERFORMS THE SAME FUNCTIONS AS "CALE" ONLY FOR
C+    SUBROUTINE "INTIMP" RATHER THAN "EXPVAS". CHAIN EFFECT FOR
C+    THE INTRUDER AGRICULTURAL AND CONSTRUCTION SCENARIOS ARE
C+    CALCULATED.
C+
      COMMON/BAST/BASCOM(834),ISPC(2,15),PDCF(85,10,7)
     + /CHYN/NXUC(85),ICH(8,10),LCH(10),ACT(8),BCT(8,2)
     + /NUCS/AL(85),FMF(85),RET(85,5),FRACT(85,3),NUX(85)
      IF(NXUC(INUC).NE.0)GO TO 15
C+ INUC not a member of a chain
   10 A1=ACT(1)
      C1=A1*PDCF(INUC,IP,5)
      C2=A1*PDCF(INUC,IP,2)
      C3=A1*PDCF(INUC,IP,3)
      C4=A1*PDCF(INUC,IP,4)*FMF(INUC)
      RETURN
C+ INUC a member of a chain.
   15 IEND=IEN-IBG+1
      C1=0.0
      C2=0.0
      C3=0.0
      C4=0.0
      DO 20 I=1,IEND
        NN=ICH(IBG+I-1,NCH)
        C1=C1+ACT(I)*PDCF(NN,IP,5)
        C2=C2+ACT(I)*PDCF(NN,IP,2)
        C3=C3+ACT(I)*PDCF(NN,IP,3)
        C4=C4+ACT(I)*PDCF(NN,IP,4)*FMF(NN)
   20 CONTINUE
      RETURN
      END
C+-----------------------------------------------------------
      SUBROUTINE CHNS(INUC,GDEL,IEN,IBG,NCH)
C+    The logic of CHNS is identical with the ACTDR subroutine of
C+    the MILDOS code. First, the chain members are determined,
C+    then the ACTDR calculation is applied. Double precision is
C+    is used to reduce significance loss in the arithmatic.
      COMMON/CHYN/NXUC(85),ICH(8,10),LCH(10),ACT(8),BCT(8,2)
     + /NUCS/AL(85),FMF(85),RET(85,5),FRACT(85,3),NUX(85)
      DOUBLE PRECISION Y,Z,DACT(8),HLM(8),EHLM(8)
      CALL ZERO(ACT,8)
      IF(NXUC(INUC).NE.0)GO TO 12
   10 ACT(1)=EXM(AL(INUC)*GDEL)
      RETURN
   12 DO 16 NCH=1,10
        IEN=LCH(NCH)
        DO 14 IBG=1,IEN
          IF(INUC.EQ.ICH(IBG,NCH))GO TO 18
   14   CONTINUE
   16 CONTINUE
      STOP 'CANT FIND NUCLIDE IN CHAINS'
   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) = 0.0
   60 CONTINUE
      DO 70 I = 1,IEND
   70 ACT(I) = DACT(I)
      RETURN
      END
C+-----------------------------------------------------------
      SUBROUTINE DIVVY(MODE,N1,N2)
C+      DIVVY divides selected impacts by either the number
C+      of disposal facilities or processing facilities, depending
C+      on the value of the parameter MODE.
      COMMON/BAST/BAS(2,92),BIMP(10,65),ISPC(2,15),PDCF(85,10,7)
      IF(MODE.EQ.2)GO TO 20
      IF(ISPC(1,11).EQ.0)WRITE(7,100)
      IF(ISPC(1,11).EQ.0)WRITE(11,100)
      ADIV = ISPC(1,11)
      IF(ADIV.EQ.0.) ADIV = 1.0
      DO 10 I = 1,10
        DO 10 J = N1,N2
   10     BIMP(I,J) = BIMP(I,J)/ADIV
      RETURN
   20 IF(ISPC(1,10).EQ.0)WRITE(7,101)
      IF(ISPC(1,10).EQ.0)WRITE(11,101)
      ADIV = ISPC(1,10)
      IF(ADIV.EQ.0.) ADIV = 1.0
      DO 30 I = 1,10
        DO 30 J = N1,N2
   30     BIMP(I,J) = BIMP(I,J)/ADIV
  100 FORMAT(//2X'**** NUMBER OF DISPOSAL FACILITIES   = 1 ****'//)
  101 FORMAT(//2X'**** NUMBER OF PROCESSING FACILITIES = 1 ****'//)
      RETURN
      END
C+-----------------------------------------------------------
      SUBROUTINE EXPWAS
C+     EXPWAS calculates impacts from the intruder initiated and
C+     erosion initiated exposed waste scenarios. Subroutine also
C+     calls "CHNS" and "CALE".
      INCLUDE IMPCOMM.FOR
      COMMON/CHYN/NXUC(85),ICH(8,10),LCH(10),ACT(8),BCT(?,2)
C+     BIMP(3) - INTRUDER-AIR IMPACTS
C+     BIMP(4) - EROSION-AIR IMPACTS
C+     BIMP(5) - INTRUDER-WATER IMPACTS
C+     BIMP(6) - EROSION-WATER IMPACTS
      GREC = IINS
```

```
      GERDD = GERO(IQ)
      AREC = 1.8E+3*RMIX(IQ)*EMP(IQ)
      AERO = ILPE*VANN(IQ)/(EMP(IQ)*EFF(IQ))
      FRA = 19.75*EREC(IR)*POP(IR)*AREC
      FEA = 19.75*EERO(IR)*POPE(IR)*AERO
      FRW = 1.15E-4*POPW(IR)*AR..C
      FEW = 1.15E-4*POPW(IR)*AERO
C+ EACH STREAM HANDLED SEPARATELY
   10 ISTR = 1
      I9 = ISPC(ISTR,2)
      A9 = 1.0
      IF(I9.GT.1) A9 = 10.0**(1-I9)
      A2 = BAS(ISTR,1)/VANN(IQ)
C+ PRINT HEADER FOR TAPE10 OUTPUT
      WRITE(10,7000)
 7000 FORMAT(//2X,'EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)'//
     + 2X,'****  IMPACTS ARE NOT NORMALIZED BY NUMBER ',
     + 'OF DISPOSAL FACILITIES  ****'//
     + 2X,'NUC      INTRUDER-AIR EROSION-AIR INTRUDER-WATER',
     + ' EROSION-WATER'/)
      ARITOT = 0.0
      ARETOT = 0.0
      WTITOT = 0.0
      WTETOT = 0.0
      DO 30 INUC = 1,85
        IF(NUX(INUC).EQ.0)GO TO 30
        CALL CHNS(INUC,GREC,IEN,IBG,NCH)
        DO 12 I = 1,8
   12   BCT(I,1) = ACT(I)
        CALL CHNS(INUC,GEROD,IEN,IBG,NCH)
        DO 14 I = 1,8
   14   BCT(I,2) = ACT(I)
        A8 = BAS(ISTR,INUC+7)
        B1 = FRA*A2*A8*A9
        B2 = FEA*A2*A8
        B3 = FRW*A2*A8*A9
        B4 = FEW*A2*A8
        DO 25 IORG = 1,10
          CALL CALE(INUC,IORG,C1,C2,C3,C4,IEN,IBG,NCH)
          BIMP(IORG,3) = BIMP(IORG,3) + B1*C1
          BIMP(IORG,4) = BIMP(IORG,4) + B2*C2
          BIMP(IORG,5) = BIMP(IORG,5) + B3*C3
          BIMP(IORG,6) = BIMP(IORG,6) + B4*C4
   25   CONTINUE
C+ PRINT ICRP (IORG = 10) IMPACTS FOR EACH NUCLIDE
        AIRINT = B1*C1
        AIRERO = B2*C2
        WATINT = B3*C3
        WATERO = B4*C4
        WRITE(10,7010) NUC(INUC),AIRINT,AIRERO,WATINT,WATERO
 7010   FORMAT(2X,A6,3X,1P4E12.3)
        ARITOT = ARITOT + AIRINT
        ARETOT = ARETOT + AIRERO
        WTITOT = WTITOT + WATINT
        WTETOT = WTETOT + WATERO
   30 CONTINUE
C+ TOTAL IMPACT
      WRITE(10,7015) ARITOT,ARETOT,WTITOT,WTETOT
 7015 FORMAT(/2X,'TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS'/
     + 11X,1P4E12.3)
   40 CONTINUE
      RETURN
      END
C+-----------------------------------------------------------------
      SUBROUTINE GWATER(NTYM,TYMD,SCN)
C+    GWATER calculates impacts resulting from groundwater migration
```

```
C+     of radioactivity to three biota access locations :
C+     intruder-well, population-well and surface water.
      INCLUDE IMPCOMM.FOR
C+ DIMENSIONED ARRAYS FOR TIMES AND NUCLIDE-SPECIFIC DOSES
      DIMENSION TYMD(16),RES(16,3)
      CHARACTER SCN(36)*6
      DIMENSION DOSNUC(16),DOSSUM(16,3)
C+ GWATER TRANSPORT AT END OF FACILITY LIFE
      GDEL=0.0
      NSEC=10
      PERC=PRC(IR,IQ)*TSC(IR,IQ)
      TVOL=ILFE*VANN(IQ)*PRC(IR,IQ)/(EMP(IQ)*EFF(IQ))
C+ LOWER MINIMUM INDIVIDUAL WATER PUMPAGE
      IF(TVOL.LT.110.) TVOL=110.0
      NPTH=3
      IF(IR.EQ.3)NPTH=2
C+ HEADER FOR GWATER OUTPUT ON TAPE10
      WRITE(10,7000) (SCN(IT),IT=15,30)
 7000 FORMAT(//2X,'GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT ',
     + 'EACH TIME'/2X,'****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF ',
     + 'DISPOSAL FACILITIES  ****'//
     + 2X,'FIRST ROW IS INTRUDER WELL'/
     + 2X,'SECOND ROW IS POPULATION WELL'/
     + 2X,'THIRD ROW IS SURFACE WATER'//
     + 16(2X,A6)/)
C+ EACH STREAM HANDLED SEPARATELY
      ISTR=1
      A9=1.0
      IF(ISPC(ISTR,2).GT.1)A9=0.1
      I1=NRET(IR)                              ! SNLA modification
      TDUM=EMP(IQ)*EFF(IQ)*SEFF(IQ)/(PERC*A9)
      IF(I1.LE.0)I1=1
C+ ZERO DOSSUM
      CALL ZERO(DOSSUM,48)
      DO 80 INUC=1,85
        IF(NUX(INUC).EQ.0)GO TO 80
        IF(BAS(ISTR,INUC+7).LT.1.0E-14)GO TO 80
        TDUR=TDUM/FMF(INUC)
C+ NUCLIDE NAME
        WRITE(10,7010) NUC(INUC)
 7010   FORMAT(2X,A6)
        CALL ZERO(RES,3*16)
        DO 30 IPTH=1,3
          A1=RET(INUC,I1)*TTM(IR,IPTH,IQ)+GDEL
          DO 20 ITYM=1,NTYM
            TYM=TYMD(ITYM)
C+            A2 = TYMD(ITYM - TDUR          ! SNLA modification
            DO 10 ISEC=1,10
              B3=1.0/(A1+RET(INUC,I1)*(ISEC-1)*DTTM(IR,IQ))
C+ DISPERSION CALCULATION WITH SQUARE WAVE
              IF(TYM*B3.LT.1.0) GOTO 20
C+                BRKTHU=1.0/B3                  ! SNLA modification
C+                IF(TYM.GT.TDUR+BRKTHU) GO TO 20  ! SNLA modification
              A3=1.0
   10       RES(ITYM,IPTH)=RES(ITYM,IPTH)+A3
   20     CONTINUE
   30   CONTINUE
        B1=BAS(ISTR,1)*BAS(ISTR,INUC+7)/TDUR
        DO 70 IPTH=1,NPTH
          K=14+(IPTH-1)*16
          B2=B1/(QFC(IR,IPTH)*NSEC)
          IF(TVOL.GT.QFC(IR,IPTH))B2=B2*QFC(IR,IPTH)/TVOL
          I2=6
          IF(IPTH.EQ.3)I2=7
          DO 60 ITYM=1,NTYM
c+            A3=EXM(AL(INUC*TYMD(ITYM)
```

```
            A3 = EXM((AL(INUC) + 1.0/TDUR)*TYMD(ITYM)) ! SNLA modification
            DO 50 I = 1,10
              A4 = A3*RES(ITYM,IPTH)*B2*PDCF(INUC,I,I2)
 50         BIMP(I,K + ITYM) = BIMP(I,K + ITYM) + A4
C+ SAVE ICRP DOSE, I = 10
            DOSNUC(ITYM) = A4
            DOSSUM(ITYM,IPTH) = DOSSUM(ITYM,IPTH) + A4
 60       CONTINUE
C+ ICRP DOSE FOR THIS NUCLIDE AT EACH TIME
         WRITE(10,7020) (DOSNUC(IT),IT = 1,16)
 7020     FORMAT(1P16E8.1)
  70   CONTINUE
  80 CONTINUE
C+ TOTAL IMPACTS
      WRITE(10,7025) ((DOSSUM(IDS,JDS),IDS = 1,16),JDS = 1,3)
 7025 FORMAT(/2X,'TOTAL NON-NORMALIZED GROUNDWATER IMPACTS'
     + 3(/1P16E8.1))
  90 CONTINUE
      RETURN
      END
C+ -------------------------------------------------------
      SUBROUTINE INCIMP(I1,I2,ISTR)
C+      INCIMP calculates impacts associated with incineration of waste
C+      streams including contributions to facility workers and members
C+      of the surrounding population.
      INCLUDE IMPCOMM.FOR
      DIMENSION QT1(10),QT3(10),QT5(10)
C+ DOSNUC ARRAY FOR NUCLIDE CALCULATIONS
      DIMENSION DOSNUC(3,85)
C+     BIMP(7)  - OFFSITE POPULATION - INCINERATION IMPACTS
C+     BIMP(8)  - MAXIMUM INDIVIDUAL - INCINERATION IMPACTS
C+     BIMP(9)  - ALL WORKERS        - INCINERATION IMPACTS
C+     BIMP(10) - MAXIMUM WORKER     - INCINERATION IMPACTS
      IF(I2.EQ.1)RETURN
      I4 = ISPC(ISTR,1)
      FDS = 1.0
      IF(I4.LT.3)FDS = 10.0**(I4-3)
      I4 = ISPC(ISTR,2)
      FAC = 1.0
      IF(I4.GT.1)FAC = 10.0**(1-I4)
C+ ZERO THE GENERIC IMPACT CONSTANTS
      CALL ZERO(QT1,10)
      CALL ZERO(QT3,10)
      CALL ZERO(QT5,10)
C+ CLEAR NUCLIDE-SPECIFIC DOSE ARRAYS
      CALL ZERO(DOSNUC,255)
      DO 14 J = 1,85
        IF(NUX(J).EQ.0)GO TO 14
        A1 = FRACT(J,2)
        IF(I1.EQ.1.OR.I1.EQ.3) A1 = FRACT(J,1)
        IF(I1.GT.3) A1 = FRACT(J,3)
  10    DO 12 I = 1,10
          QT1(I) = QT1(I) + BAS(ISTR,J + 7)*PDCF(J,I,1)
          QT3(I) = QT3(I) + BAS(ISTR,J + 7)*PDCF(J,I,3)*A1
  12    QT5(I) = QT5(I) + BAS(ISTR,J + 7)*PDCF(J,I,5)
C+ ICRP IMPACT FOR EACH NUCLIDE
        BASNUC = BAS(ISTR,J + 7)
        DOSNUC(1,J) = BASNUC*PDCF(J,10,1)
        DOSNUC(2,J) = BASNUC*PDCF(J,10,3)*A1
        DOSNUC(3,J) = BASNUC*PDCF(J,10,5)
C+ SUBTRACT AIRBORNE RELEASE FRACTION
        BAS(ISTR,J + 7) = BAS(ISTR,J + 7)*(1.0-A1)
  14 CONTINUE
C+ HEADER ON TAPEK
      WRITE(10,7000)
 7000 FORMAT(//2X,'INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)'//
```

```
     + 2X,'****  IMPACTS NOT NORMALIZED BY NUMBER OF ',
     + 'PROCESSING FACILITIES  ****'//2X,
     + 'NUC      MAXIMUM OFF-SITE INDIVIDUAL '/)
C+ OFF-SITE IMPACT CALCULATIONS
      DO 20 I=1,10
        A1=QT3(I)*BAS(ISTR,1)
        BIMP(I,7)=BIMP(I,7)+A1*POP(IR)
   20 BIMP(I,8)=BIMP(I,8)+A1*XOQI(I1)*EDFI(I1)
C+ ICRP IMPACTS BY NUCLIDE
      FACMAS=BAS(ISTR,1)*XOQI(I1)*EDFI(I1)
      DOST=0.0
      DO 21 J=1,85
        IF(NUX(J).EQ.0) GOTO 21
        DOS8=DOSNUC(2,J)*FACMAS
        WRITE(10,7010) NUC(J),DOS8
 7010   FORMAT(2X,A6,4X,1PE10.3)
        DOST=DOST+DOS8
   21 CONTINUE
      WRITE(10,7015) DOST
 7015 FORMAT(/2X,'TOTAL NON-NORMALIZED INCINERATOR IMPACT =',1P1E12.3)
C+ WORKER IMPACTS FOR ONSITE INCINERATION
      A1=0.237*BAS(ISTR,1)/VINC(I1)
      ADSL=A1*TWI(I1,1)*FDS
      ADSM=A1*TWI(I1,2)*FDS
      ADSHRH=A1*TWI(I1,3)
      ADSHML=A1*TWI(I1,3)*0.5*(1.0+FDS)
      A1=A1*FAC*1.6/T[illegible]I(I1)
      ADGL=A1*DOFF(30.0)*COFF(30.0,4.0)          ! SNLA modification
      ADGM=A1*DOFF(10.0)*COFF(10.0,4.0)          ! SNLA modification
      ADGH=A1*DOFF(1.0) *COFF(1.0, 4.0) * 0.33   ! SNLA modification
      DO 30 I=1,10
        A1=QT1(I)*ADSL+QT5(I)*ADGL
        A2=QT1(I)*ADSL+QT5(I)*ADGM
        A3=QT1(I)*ADSM+QT5(I)*ADGM
        A4=QT1(I)*ADSM+QT5(I)*ADGH
        A5=QT1(I)*ADSHRH+QT5(I)*ADGH
        A6=QT1(I)*ADSHML+QT5(I)*ADGH
C+ MAXIMUM WORKER CONTRIBUTIONS
        A7=AMAX1(A1,A2,A3,A4,A5,A6)
        IF(A7.GT.BIMP(I,10))BIMP(I,10)=A7
        GO TO (22,22,24,24,24),I1
   22   DUM=2.0*A1+2.0*A2+8.0*A3+6.0*A4+4.0*A5+8.0*A6
        IF(I2.EQ.3)DUM=DUM+2.0*A3+A4
        IF(I2.EQ.4)DUM=DUM+3.0*A3+A4+A6
        IF(I2.EQ.5)DUM=DUM+2.0*A2+4.0*A3+2.0*A4+2.0*A6
        GO TO 26
   24   DUM=6.0*A1+2.0*A2+4.0*A3+2.0*A4+2.0*A5+2.0*A6
   26   BIMP(I,9)=BIMP(I,9)+DUM
   30 CONTINUE
C+ ICRP IMPACTS BY NUCLIDE FOR WORKERS
      WRITE(10,7020)
 7020 FORMAT(//2X,'WORKER INCINERATION ICRP IMPACTS BY NUCLIDE ',
     + '(MREM/YR)'//2X,'****  IMPACTS ARE NOT NORMALIZED BY ',
     + 'NUMBER OF PROCESSING FACILITIES  ****'//
     + 2X,'NUC  RESIDUE HANDLERS  MAINTENANCE'/)
      A5T=0.0
      A6T=0.0
      DO 40 J=1,85
        IF(NUX(J).EQ.0) GOTO 40
        D1=DOSNUC(1,J)
        D3=DOSNUC(3,J)
        A5=D1*ADSHRH+D3*ADGH
        A6=D1*ADSHML+D3*ADGH
        WRITE(10,7030) NUC(J),A5,A6
 7030   FORMAT(2X,A6,3X,1P2E12.3)
        A5T=A5T+A5
```

```
      A6T = A6T + A6
   40 CONTINUE
      WRITE(10,7035) A5T,A6T
 7035 FORMAT(/2X,'TOTAL NON-NORMALIZED WORKER IMPACTS'/11X,1P2E12.3)
      RETURN
      END
C+ ---------------------------------------------------------------
      SUBROUTINE INTIMP
C+    INTIMP calculates inadvertant intruder impacts for construction
C+    and agricultural scenarios.
      INCLUDE IMPCOMM.FOR
      DATA CONST/2.51E-5/
C+ BIMP(1) - INTRUDER-CONSTRUCTION IMPACTS
C+ BIMP(2) - INTRUDER-AGRICULTURE IMPACTS
C+ EACH STREAM HANDLED SEPARATELY
      ISTR = 1
      I12 = ISPC(ISTR,12)                        ! SNLA modification
      I13 = ISPC(ISTR,13)                        ! SNLA modification
      I14 = ISPC(ISTR,14)                        ! SNLA modification
      I15 = ISPC(ISTR,15)                        ! SNLA modification
      A21 = (0.95*I12 + 0.05*I13 + 0.05*I14 + 0.10*I15)/100.0   ! SNLA modification
      FDS = EMP(IQ)*BAS(ISTR,1)/VANN(IQ)
      A9 = 1.0
      IF(ISPC(ISTR,2).GT.1) A9 = 0.1
      GDEL = IINS
C+ HEADER FOR TAPE10 FOR NUCLIDE IMPACT OUTPUT
      WRITE(10,7000)
 7000 FORMAT(//2X,'INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)'//
     + 2X,'****  IMPACTS ARE NOT NORMALIZED BY NUMBER ',
     + 'OF DISPOSAL FACILITIES  ****'//
     + 2X,'NUC      CONSTRUCTION  AGRICULTURE'/)
      CONTOT = 0.0
      AGRTOT = 0.0
      DO 50 INUC = 1,85
        IF(NUX(INUC).EQ.0)GO TO 50               ! SNLA modification
        IF(ISPC(ISTR,5).GT.3) BAS(ISTR,INUC + 7) = BAS(ISTR,INUC + 7)/A21
        A1 = FDS*A9*BAS(ISTR,INUC + 7)
        CALL CHNS(INUC,GDEL,IEN,IBG,NCH)
        DO 40 I = 1,10
          CALL CALI(INUC,I,C1,C2,C3,C4,IEN,IBG,NCH)
          A2 = C1
          B5 = RMIX(IQ)*A1*A2*0.27
          B2 = A1*A2*0.057*RMIX(IQ)              ! SNLA modification
          B1 = A1*FSC(IR)*C2*RMIX(IQ)            ! SNLA modification
          B3 = RMIX(IQ)*A1*FSA(IR)*C3
          B4 = RMIX(IQ)*0.5*A1*C4
          BIMP(I,1) = BIMP(I,1) + B1 + B2
   40   BIMP(I,2) = BIMP(I,2) + B3 + B4 + B5
C+ ICRP (I = 10) IMPACT FOR EACH NUCLIDE
        CONINT = B1 + B2
        AGRINT = B3 + B4 + B5
        WRITE(10,7010) NUC(INUC),CONINT,AGRINT
 7010   FORMAT(2X,A6,3X,1P2E12.3)
        CONTOT = CONTOT + CONINT
        AGRTOT = AGRTOT + AGRINT
   50 CONTINUE
      A1 = AL(57)*IINS
      A2 = AL(62)*IINS
      RAD = BAS(ISTR,64)*EXM(A1)
      IF(A1.NE.A2)RAD = RAD + BAS(ISTR,69)*A1*(EXM(A1)-EXM(A2))/(A2-A1)
      RAD = RAD*FDS*CONST
      DO 55 I = 1,10
   55 BIMP(I,2) = BIMP(I,2) + RAD*PDCF(56,I,2)
C+ ICRP (I = 10) IMPACT FOR RADON
      AGRINT = RAD*PDCF(56,10,2)
      WRITE(10,7020) AGRINT
```

```
7020 FORMAT(2X,'RADON',16X,1PE12.3)
     AGRTOT=AGRTOT+AGRINT
     WRITE(10,7025) CONTOT,AGRTOT
7025 FORMAT(/2X,'TOTAL NON-NORMALIZED INTRUDER IMPACTS'/
    + 11X,1P2E12.3)
  60 CONTINUE
     RETURN
     END
C+-----------------------------------------------------------
     SUBROUTINE OPSIMP
C+     OPSIMP calulates on-site and off-site impacts for
C+     disposal operations.
     INCLUDE IMPCOMM.FOR
C+ BIMP(11) - OFFSITE POPULATION          - OPERATIONAL IMPACTS
C+ BIMP(12) - MAXIMUM OFFSITE INDIVIDUAL - OPERATIONAL IMPACTS
C+ BIMP(13) - ALL WORKERS                - OPERATIONAL IMPACTS
C+ BIMP(14) - MAXIMUM WORKER             - OPERATIONAL IMPACTS
     GO TO (20,20,30,30,30),IQ
C+ CALCULATION OF OFF-SITE RELEASES FROM ON-SITE FACILITY
C+ MUNICIPAL WASTE FACILITY IMPACTS
  20 DPOP=SQRT(ADAY(IQ,1)/3.1415927)
     DEQP=SQRT(ADAY(IQ,2)/3.1415927)
     DOTH=SQRT(ADAY(IQ,3)/3.1415927)
C+ STREAM HANDLED SEPARATELY
     ISTR=1
     I5=ISPC(ISTR,1)
     FDS=1.0
     IF(I5.LT.3)FDS=10.0**(I5-3)
     I9=ISPC(ISTR,2)
     FAC=1.0
     IF(I9.GT.1)FAC=10.0**(1-I9)
     AS1=FDS*EMP(IQ)*0.237*BAS(ISTR,1)/VANN(IQ)
     AS2=AS1*TWO(IQ,3)*WVEL(IR)*2.0*DPOP*9.45E+7
     AG1=AS1*(FAC/FDS)*1.6/DEN2(IQ)
     DO 24 I=1,10
       A1=0.0
       A2=0.0
       A3=0.0
       A5=0.0
       DO 22 J=1,85
         IF(NUX(J).EQ.0)GO TO 22
         A1=A1+BAS(ISTR,J+7)*PDCF(J,I,1)
         A2=A2+BAS(ISTR,J+7)*PDCF(J,I,3)*FRACT(J,3)
         A3=A3+BAS(ISTR,J+7)*PDCF(J,I,3)
         A5=A5+BAS(ISTR,J+7)*PDCF(J,I,5)
  22   CONTINUE
C+ OFF-SITE RELEASES
       BIMP(I,11)=BIMP(I,11)+AS2*A3*POP(IR)
       BIMP(I,12)=BIMP(I,12)+AS2*A3*XOQO(IQ)*EDFO(IQ)
C+ WORKER EXPOSURES
       ADSL=AS1*TWO(IQ,1)
       ADSM=AS1*TWO(IQ,2)
       ADSH=AS1*TWO(IQ,3)
       ADGL=AG1*DOFF(50.0)*COFF(50.0,DOTH)
       ADGM=AG1*DOFF(30.0)*COFF(30.0,DOTH)
       ADGH=AG1*DOFF( 1.0)*COFF( 1.0,DEQP)
       ACOV=6.26E-2*AG1
       B2=A1*ADSL+A5*(ADGL+ACOV)              ! SNLA modification
       B4=A1*ADSM+A5*(ADGM+ACOV)
       B6=A1*ADSH+A5*(ADGH+ACOV)
c+     B7=2.0*B2+4.0*B4+2.0*B6                 ! SNLA modification
C+ DISPOSAL WORKERS FOR SANITARY LANDFILL (IQ=1 OR 2)
       IF(IQ.EQ.1.OR.IQ.EQ.2) B7=2.0*B2+5.0*B4+3.0*B6
       BIMP(I,13)=BIMP(I,13)+B7/10.0
       BIMP(I,14)=BIMP(I,14)+B7/10.0
  24 CONTINUE
```

```
   26 CONTINUE
      RETURN
C+ HAZARDOUS WASTE FACILITY IMPACTS
   30 DPOP=SQRT(ADAY(IQ,1)/3.1415927)
      DEQP=SQRT(ADAY(IQ,2)/3.1415927)
      DOTH=SQRT(ADAY(IQ,3)/3.1415927)
C+ EACH STREAM HANDLED SEPARATELY
      ISTR=1
      I5=ISPC(ISTR,1)
      FDS=1.0
      IF(I5.LT.3)FDS=10.0**(I5-3)
      I9=ISPC(ISTR,2)
      FAC=1.0
      IF(I9.GT.1)FAC=10.0**(1-I9)
      AS1=FDS*EMP(IQ)*0.237*BAS(ISTR,1)/VANN(IQ)
      AS2=AS1*EFAC(IR)*ADAY(IQ,2)*3.15E+1
      AS3=AS1*EFAC(IR)*ADAY(IQ,2)/(2.0*DPOP*3.0E+6*WVEL(IR)*DEN2(IQ))
      AG1=AS1*(FAC/FDS)*1.6/DEN2(IQ)
      AX1=BAS(ISTR,2)*2.6E-11*FDS*ISPC(ISTR,11)
      AX2=AX1*1.248*AXOQ(IR)
      DO 36 I=1,10
        A1=0.0
        A2=0.0
        A3=0.0
        A5=0.0
        DO 32 J=1,85
          IF(NUX(J).EQ.0)GO TO 32
          A1=A1+BAS(ISTR,J+7)*PDCF(J,I,1)
          A2=A2+BAS(ISTR,J+7)*PDCF(J,I,2)
          A3=A3+BAS(ISTR,J+7)*PDCF(J,I,3)
          A5=A5+BAS(ISTR,J+7)*PDCF(J,I,5)
   32   CONTINUE
        DIAM=DEQP
        IF(ISPC(ISTR,3).NE.0)DIAM=DOTH
        ADGL=AG1*DOFF(50.0)*COFF(50.0,DIAM)
        ADGM=AG1*DOFF(30.0)*COFF(30.0,DIAM)
        ADGH=AG1*DOFF( 1.0)*COFF( 1.0,DIAM)
        ACOV=2.49E-2*AG1
        IF(ISPC(ISTR,3).NE.0)GO TO 34
C+ UNPACKAGED WASTE
        BIMP(I,11)=BIMP(I,11)+AS2*A3*POF(IR)
        BIMP(I,12)=BIMP(I,12)+AS2*A3*XOQO(IQ)*EDFO(IQ)
        ADSL=AS3
        B1=A1*ADSL+A5*(ADGL+ACOV)
        B2=A1*ADSL+A5*(ADGM+ACOV)
        B3=A1*ADSL+A5*(ADGH+ACOV)
        B4=AMAX1(B1,B2,B3)
        BIMP(I,13)=BIMP(I,13)+14.0*B1+15.0*B2+29.0*B3
        BIMP(I,14)=BIMP(I,14)+B4
        GO TO 36
C+ PACKAGED WASTE
   34   BIMP(I,12)=BIMP(I,12)+AX2*A2
        ADSL=AX1
        B1=A2*ADSL+A5*(ADGL+ACOV)
        B2=A2*ADSL+A5*(ADGM+ACOV)
        B3=A2*ADSL+A5*(ADGH+ACOV)
        B4=AMAX1(B1,B2,B3)
        BIMP(I,13)=BIMP(I,13)+14.0*B1+15.0*B2+29.0*B3
        BIMP(I,14)=BIMP(I,14)+B4
   36 CONTINUE
   38 CONTINUE
      RETURN
      END
C+-----------------------------------------------------------
      SUBROUTINE OVRFLO
C+    OVRFLO calculates radiological impacts for three scenarios which
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C+     may result from leachate accumulation at a disposal facility:
C+     1) During facility operation, accumulating leachate is removed,
C+        treated, and released to a nearby stream.
C+     2) After facility closure, accumulating leachate is allowed to
C+        fill up disposal cells, overflow and reach a nearby stream.
C+     3) After facility closure, accumulating leachate is removed and
C+        processed through an evaporator, thus impacting the local
C+        population.
      INCLUDE IMPCOMM.FOR
c+    double precision added to avoid intermediate underflow errors
      DOUBLE PRECISION A1,A2,A3,A4,A5,A6,A7,A8,A9
      DIMENSION F1N(85),F2N(85)
      DATA F1N/85*1.0/,F2N/85*1.0/
      GDEL=IINS
      VTOT=ILFE*VANN(IQ)
      VL=PRC(IR,IQ)*VTOT/(EMP(IQ)*EFF(IQ))
      A8=ISPC(1,11)*4.5E6
C+ EACH STREAM HANDLED SEPARATELY
      ISTR=1
      I9=ISPC(ISTR,2)
      A9=1.0
      IF(I9.GT.1) A9=0.1
      A4=A9*BAS(ISTR,1)*VL/VANN(IQ)
C+ HEADER FOR TAPE10 FOR NUCLIDE IMPACT OUTPUT
      WRITE(10,7000)
 7000 FORMAT(//2X,'OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)'//
     + 2X,'****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF ',
     + 'DISPOSAL FACILITIES  ****'//
     + 2X,'NUC          TREATMENT     OVERFLOW   EVAPORATOR'/)
      TRTOT=0.0
      OVRTOT=0.0
      EVPTOT=0.0
      DO 20 INUC=1,85
        IF(NUX(INUC).EQ.0)GO TO 20
        A7=1.0
        A1=ILFE*(1.0-EXM(AL(INUC)))
        IF(A1.GT.0.)A7=(1.0-EXM(AL(INUC)*ILFE))/A1
        A5=A4*A7*BAS(ISTR,INUC+7)*FMF(INUC)
        A6=A5*EXM(AL(INUC)*GDEL)
        A1=A5*F1N(INUC)*TSC(IR,IQ)/A8
        A2=A6*F2N(INUC)/A8
        A3=A6*FRACT(INUC,2)*POP(IR)
        DO 10 I=1,10
          BIMP(I,63)=BIMP(I,63)+A1*PDCF(INUC,I,7)
          BIMP(I,64)=BIMP(I,64)+A2*PDCF(INUC,I,7)
   10   BIMP(I,65)=BIMP(I,65)+A3*PDCF(INUC,I,3)
C+ ICRP (I=10) IMPACTS FOR EACH NUCLIDE
        TREAT=A1*PDCF(INUC,10,7)
        OVERF=A2*PDCF(INUC,10,7)
        EVAPO=A3*PDCF(INUC,10,3)
        WRITE(10,7010) NUC(INUC),TREAT,OVERF,EVAPO
 7010   FORMAT(1X,A6,3X,1P3E12.3)
        TRTOT=TRTOT+TREAT
        OVRTOT=OVRTOT+OVERF
        EVPTOT=EVPTOT+EVAPO
   20 CONTINUE
C+ TOTAL IMPACTS
      WRITE(10,7015) TRTOT,OVRTOT,EVPTOT
 7015 FORMAT(/2X,'TOTAL NON-NORMALIZED OVERFLOW IMPACTS'/11X,1P3E12.3)
   30 CONTINUE
C+      write(*,220)
C+ 220  format(' finished gwater')
      RETURN
      END
C+-----------------------------------------------------------
      SUBROUTINE PRNTE(ORG,SCN,BI)
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C+     PRNTE prints most of the final impact results to TAPE6.
C+     Addition of ORG1 for tape 11 output
      CHARACTER ORG(10)*9,SCN(36)*6,ORG1(1)*9
      DATA ORG1/'  ICRP    '/
      DIMENSION BI(10,65)
      WRITE(7,107)
      WRITE(7,105) ORG
      WRITE(7,103) (SCN(J),(BI(I,J),I = 1,10),J = 1,2)
      WRITE(7,108)
      WRITE(7,105) ORG
      WRITE(7,103) (SCN(J),(BI(I,J),I = 1,10),J = 3,6)
      WRITE(7,109)
      WRITE(7,105) ORG
      WRITE(7,103) (SCN(J),(BI(I,J),I = 1,10),J = 7,14)
      WRITE(7,114)
      WRITE(7,105) ORG
      WRITE(7,103) (SCN(J-29),(BI(I,J),I = 1,10),J = 63,65)
      WRITE(7,110)
      WRITE(7,111)
      WRITE(7,104) ORG
      WRITE(7,103) (SCN(J),(BI(I,J),I = 1,10),J = 15,30)
      WRITE(7,112)
      WRITE(7,104) ORG
      WRITE(7,103) (SCN(J-16),(BI(I,J),I = 1,10),J = 31,46)
      WRITE(7,113)
      WRITE(7,104) ORG
      WRITE(7,103) (SCN(J-32),(BI(I,J),I = 1,10),J = 47,62)
C+ Tape 11 output summary of IMPACTS-BRC with only ICRP output
      WRITE(11,107)
      WRITE(11,125) ORG1
      WRITE(11,123) (SCN(J),BI(10,J),J = 1,2)
      WRITE(11,108)
      WRITE(11,125) ORG1
      WRITE(11,123) (SCN(J),BI(10,J),J = 3,6)
      WRITE(11,129)
      WRITE(11,125) ORG1
      WRITE(11,123) (SCN(J),BI(10,J),J = 7,14)
      WRITE(11,114)
      WRITE(11,125) ORG1
      WRITE(11,123) (SCN(J-29),BI(10,J),J = 63,65)
      WRITE(11,110)
      WRITE(11,111)
      WRITE(11,124) ORG1
      WRITE(11,123) (SCN(J),BI(10,J),J = 15,30)
      WRITE(11,112)
      WRITE(11,124) ORG1
      WRITE(11,123) (SCN(J-16),BI(10,J),J = 31,46)
      WRITE(11,113)
      WRITE(11,124) ORG1
      WRITE(11,123) (SCN(J-32),BI(10,J),J = 47,62)
C+ Tape 6 (Unit 7) formats:
  103 FORMAT(2X,A6,1P,10E9.2)
  104 FORMAT(4X,'TIME',10A9)
  105 FORMAT(4X,'SCN ',10A9)
  107 FORMAT(/2X'INTRUDER IMPACTS (MREM/YR):'/)
  108 FORMAT(/2X'EXPOSED WASTE IMPACTS (MREM/YR):'/)
  109 FORMAT(/2X'INCINERATION AND OPERATIONAL IMPACTS:',
     + '   UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)'/
     + 49X,'IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)'/)
  110 FORMAT(1H1/2X'GROUND WATER IMPACTS (MREM/YR):')
  111 FORMAT(/2X'INTRUDER-WELL')
  112 FORMAT(/2X'POPULATION-WELL')
  113 FORMAT(/2X'POPULATION-SURFACE WATER')
  114 FORMAT(/2X'LEACHATE ACCUMULATION IMPACTS ',
     +' UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)'/)
C+ Tape 11 formats:
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```
  123 FORMAT(2X,A6,1P,E9.2)
  124 FORMAT(4X,'TIME',A9)
  125 FORMAT(4X,'SCN ',A9)
  129 FORMAT(/2X'INCINERATION AND OPERATIONAL IMPACTS:',
     +/ '   UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)'/
     +          10X,'IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)'/)
      RETURN
      END
C+-----------------------------------------------------------------
      SUBROUTINE READ1
C+      READ1 reads fundamental DCFs from TAPE1. UPTAKE uses these values
C+      in READ5 to compute PDCFs, as needed.
      CHARACTER BASN*10,NUC*6,NUCT*6,SOL*1,SOLB*1,SOLT*1
      COMMON/CHRC/BASN(2),NUC(85),SOL(85),SOLB(85)
     + /NUCS/AL(85),FMF(85),RET(85,5),FRACT(85,3),NUX(85)
      COMMON/DCFS/FF(85,5),DCF1(159,10),DCF2(159,10),DCF3(85),
     + DCF4(85,10),DCF5(85,10),NUCT(159),SOLT(159)
  101 FORMAT(A6,1X,I1,A1,10E9.2)
  102 FORMAT(9X,10E9.2)
  103 FORMAT(8X,A1,10E9.2/9X,10E9.2)
      OPEN(1,FILE='TAPE1.DAT')
      INCT=0
      DO 30 INUC=1,85
        READ(1,101) NUC(INUC),JJ,SOLB(INUC),DCF3(INUC),
     +              (FF(INUC,I),I=1,5),AL(INUC),FMF(INUC),
     +              RET(INUC,1),RET(INUC,4)
        A2=RET(INUC,4)
        A1=(A2/RET(INUC,1))**0.334
        RET(INUC,5)=A2*A1
        RET(INUC,3)=A2/A1
        RET(INUC,2)=RET(INUC,1)*A1
        READ(1,102) (DCF4(INUC,I),I=1,10),(DCF5(INUC,I),I=1,10)
        INCT=INCT+1
        NUCT(INCT)=NUC(INUC)
        READ(1,103) SOLT(INCT),(DCF1(INCT,I),I=1,10),
     +              (DCF2(INCT,I),I=1,10)
        IF(JJ.EQ.1)GO TO 30
        DO 20 IJ=2,JJ
          INCT=INCT+1
          NUCT(INCT)=NUC(INUC)
          READ(1,103) SOLT(INCT),(DCF1(INCT,I),I=1,10),
     +                (DCF2(INCT,I),I=1,10)
   20   CONTINUE
   30 CONTINUE
      CLOSE (1)
      RETURN
      END
C+-----------------------------------------------------------------
      SUBROUTINE READ2
C+      READ2 reads in treatment/disposal site environmental
C+      characteristics and treatment/disposal technology characteristics
C+      from TAPE2.
      INCLUDE IMPCOMM.FOR
      DIMENSION PDS(6),WSP(6),STB(6),DSP(6)
C+    arrays added to read tape2 in consistent manner
      DIMENSION TTTM(3),TTPC(3),QQFC(3)
  102 FORMAT(10E10.3)
  104 FORMAT(15I5)
  202 FORMAT(/2X'OPTIONAL XOQ PARAMS'/(2X,1P,4E10.3))
  203 FORMAT(2X,1P,6E10.3)
  204 FORMAT(/2X'OPTIONAL ENVIRONMENTAL PARAMETERS'/2X'PRC ='1PE9.2,
     + 2X'TXC ='E9.2,2X'QFC ='3E9.2/2X'FSC ='E9.2,2X'DTTM='E9.2,
     + 2X'TTM ='3E9.2/2X'FSA ='E9.2,2X'DTPC='E9.2,2X'TPC ='3E9.2/
     + 2X'WVEL='E9.2,2X'AXOQ='E9.2,2X'EFAC='E9.2)   ! SNLA modification
C+ DEFAULT SITE ENVIRONMENTAL PARAMETER VALUES
      OPEN(2,FILE='TAPE2.DAT')
```

```
      DO 10 I=1,3
        READ(2,102) (PRC(I,J),TSC(I,J),DTTM(I,J),(TTM(I,K,J),K=1,3),
     +    DTPC(I,J),(TPC(I,K,J),K=1,3),J=1,5)
        READ(2,102) FSC(I),FSA(I),(QFC(I,J),J=1,3),POP(I),POPE(I),
     +    POPW(I),TPOP(I),TDOZ(I),WVEL(I),AXOQ(I),EFAC(I),
     +    EERO(I),EREC(I)
        READ(2,104) NRET(I)
   10 CONTINUE
C+ DEFAULT FACILITY PARAMETER VALUES
      DO 12 I=1,5
        READ(2,102) TDIS(I),TVEL(I),VINC(I),XOQI(I),EDFI(I),DEN1(I),
     +    VANN(I),XOQO(I),EDFO(I),DEN2(I),(TWI(I,J),J=1,3),
     +    (TWO(I,J),J=1,3),(ADAY(I,J),J=1,3),RMIX(I),
     +    EMP(I),EFF(I),SEFF(I),GERO(I),OSWR,OSDL
        IF(OSDL.GT.0.0) TWO(I,3)=OSDL*1.0E-6/DEN2(I)
   12 CONTINUE
C+ OPTIONAL PARAMETER VALUES
      IF(IDAT.EQ.0)GO TO 22            ! IF IDAT = 0 NO MORE INFORMATION NEEDED
C+    IF(IDAT.EQ.2)GO TO 20
C+ SITE-SPECIFIC POP AND XOQ OPTION
      DO 14 I=1,6
       READ(2,102) DSP(I),PDS(I),WSP(I),STB(I)
   14 CONTINUE
      READ(2,102) HYTI,HYTO,DISTI,DISTO,EDFID,EDFOD
      IF(IDAT.EQ.2) GO TO 20           ! THIS INFORMATION NOT USED IF IDAT = 2
C+    OUTPUT TO TAPE6, 11 IF IDAT = 1,3 AND LOAD SITE-SPECIFIC VALUES
      WRITE(7,202)  (DSP(I),PDS(I),WSP(I),STB(I),I=1,6)
      WRITE(11,202) (DSP(I),PDS(I),WSP(I),STB(I),I=1,6)
      WRITE(7,203)  HYTI,HYTO,DISTI,DISTO,EDFID,EDFOD
      WRITE(11,203) HYTI,HYTO,DISTI,DISTO,EDFID,EDFOD
      A1=0.0
      A2=0.0
      DO 16 I1=1,6
        A1=A1+STB(I1)*XOQFC(HYTI,DISTI,WSP(I1),I1)
        A2=A2+STB(I1)*XOQFC(HYTO,DISTO,WSP(I1),I1)
   16 CONTINUE
      XOQI(IQ)=A1
      XOQO(IQ)=A2
      EDFI(IQ)=EDFID
      EDFO(IQ)=EDFOD
      A1=0.0
      DO 18 I1=1,6
        DO 18 I2=1,6
          A1=A1+PDS(I1)*STB(I2)*XOQFC(HYTI,DSP(I1),WSP(I2),I2)
   18 CONTINUE
      POP(IR)=A1
      POPE(IR)=3.0*A1
C+ '\20 IF(IDAT.EQ.1)GO TO 22
   20 CONTINUE                          ! IDAT = 2 COMES TO HERE
C+ SITE-SPECIFIC ENVIRONMENTAL PARAMETERS
C+      READ(2,102) PRC(IR,IQ),TSC(IR,IQ),DTTM(IR,IQ),
C+      + (TTM(IR,J,IQ),J=1,3),DTPC(IR,IQ),(TPC(IR,J,IQ),J=1,3),
C+      + FSC(IR),FSA(IR),(QFC(IR,J),J=1,3),WVEL(IR),AXOQ(IR),EFAC(IR)
C+      READ(2,104) NRET(IR)
C+     READ PARAMETERS INTO DUMMY STORAGE
      READ(2,102) PPRC,TTSC,DDTM,
     + (TTTM(J),J=1,3),DDTPC,(TTPC(J),J=1,3),
     + FFSC,FFSA,(QQFC(J),J=1,3),WWVEL,AAXOQ,EEFAC
      READ(2,104) NNRET
      IF (IDAT.EQ.1) GO TO 22    ! DON'T NEED THIS INFORMATION FOR IDAT = 1
C+    MAP THE DUMMY PARAMETERS BACK INTO THE SITE-SPECIFIC PARAMETERS
C+    ONLY FOR IDAT = 2,3 AND WRITE RESULTS TO TAPE6,11
      PRC(IR,IQ) = PPRC
      TSC(IR,IQ) = TTSC
      DTTM(IR,IQ) = DDTM
      DTPC(IR,IQ) = DDTPC
```

```
      FSC(IR) = FFSC
      FSA(IR) = FFSA
      WVEL(IR) = WWVEL
      AXOQ(IR) = AAXOQ
      EFAC(IR) = EEFAC
      NRET(IR) = NNRET
      DO 50 J = 1,3
       TTM(IR,J,IQ) = TTTM(J)
       TPC(IR,J,IQ) = TTPC(J)
       QFC(IR,J) = QQFC(J)
   50 CONTINUE
      WRITE(7,204) PRC(IR,IQ),TSC(IR,IQ),(QFC(IR,J),J=1,3),
     + FSC(IR),DTTM(IR,IQ),(TTM(IR,J,IQ),J=1,3),FSA(IR),DTPC(IR,IQ),
     + (TPC(IR,J,IQ),J=1,3),WVEL(IR),AXOQ(IR),EFAC(IR)
      WRITE(11,204) PRC(IR,IQ),TSC(IR,IQ),(QFC(IR,J),J=1,3),
     + FSC(IR),DTTM(IR,IQ),(TTM(IR,J,IQ),J=1,3),FSA(IR),DTPC(IR,IQ),
     + (TPC(IR,J,IQ),J=1,3),WVEL(IR),AXOQ(IR),EFAC(IR)
   22 CONTINUE                          ! IDAT = 0,1 COME TO HERE
C+ SITE-SPECIFIC TREATMENT/DISPOSAL PARAMETERS
   24 IF(IPOP.EQ.1.OR.IDAT.EQ.1.OR.IDAT.EQ.3)GO TO 28
C+ MODIFY POP FOR URBAN ENVIRONMENT IF IDAT = 0,2
      DO 26 I=1,3
        POPE(I)=POPE(I)*10.0
   26 POP(I)=POP(I)*10.0
   28 CLOSE (2)
      RETURN
      END
C+-----------------------------------------------------------

      SUBROUTINE READ5
C+     READ5 reads in treatment/disposal options and waste stream
C+     characteristics from TAPE5.
C+     UPTAKE is called to calculate the pathway dose conversion factors
C+     and transportation exposures.
      CHARACTER NUCD*6,SOLD*1,BLANK*6,EOFR*6,MTIME*11
      INCLUDE IMPCOMM.FOR
      DIMENSION NUCD(5),SOLD(5),COND(5)
      DATA BLANK/'      '/
      DATA EOFR/'$     '/
  101 FORMAT(A10,3E10.3)
  102 FORMAT(15I5)
  103 FORMAT(5(A6,1X,A1,E10.3,2X))
  104 FORMAT(/2X,'WASTE: ',A10,2X,'WEIGHT: ',1PE9.2,' MT  DENSITY ',
     +E9.2,' MT/M3',//2X,'ID = ',I2,2X,'IA = ',I2,2X,'IK1 = ',I2,2X,
     +'IK2 = ',I3,2X,'PROCESS = 'I2/2X,'IXS = ',4I4,/,2X,'ICS = ',4I4)
      NSTR=1
      CALL ZERO(BAS,184)
      DO 10 I=1,85
        SOL(I)=SOLB(I)
   10 NUX(I)=0
C+ WASTE STREAM CHARACTERISTICS
      READ(5,101) BASN(1),BAS(1,1),BAS(1,2),BAS(1,3)
      READ(5,102) (ISPC(1,J),J=1,15)
      WRITE(7,104) BASN(1),BAS(1,1),BAS(1,2),(ISPC(1,J),J=1,5),
     + (ISPC(1,J),J=8,15)
      WRITE(11,104) BASN(1),BAS(1,1),BAS(1,2),(ISPC(1,J),J=1,5),
     + (ISPC(1,J),J=8,15)
C+ WASTE STREAM HEADER ON TAPE10
      WRITE(10,1004) BASN(1)
 1004 FORMAT(//2X,A10)
C+ Monitor line to screen indicating the time, waste stream name
      CALL TIME(MTIME)               ! Lahey System Subroutine
c     MTIME = '0'                    ! SNLA modification
     write(*,2004) MTIME,BASN(1)
 2004 format(' ',a11,' ',A10)
C+
```

```
  12 READ(5,103,END=20) (NUCD(I),SOLD(I),COND(I),I=1,5)
     IF(NUCD(1).EQ.BLANK)GO TO 20
     DO 18 J=1,5
       IF (NUCD(J).EQ.BLANK) GO TO 20
       DO 14 I=1,85
         IF(NUCD(J).EQ.NUC(I))GO TO 16
  14   CONTINUE
       IF((NUCD(J).EQ.BLANK).OR.(NUCD(J).EQ.EOFR))GO TO 20
       STOP 'CANT FIND NUCLIDE NAME READ5'
  16   NUX(I)=1
       SOL(I)=SOLD(J)
       BAS(1,I+7)=COND(J)
  18 CONTINUE
C+ Loop back to 12 until an End-of-File on Unit 5 is encountered.
     GO TO 12
C+ Entry point after End-of-RECORD on Unit 5 is encountered.
  20 CALL UPTAKE
C+ TRANSPORTATION SECTION
C+    BAS(5) - MAXIMUM DRIVER IMPACTS
C+    BAS(6) - TOTAL DRIVERS IMPACTS
C+    BAS(7) - POPULATION IMPACTS
      A1=ISPC(1,9)/100.0
      DGA=0.0
      DO 22 I=1,85
        IF(NUX(I).EQ.1)DGA=DGA+PDCF(I,4,5)*BAS(1,I+7)
  22  CONTINUE
      DGA=DGA*BAS(1,2)/(A1*BAS(1,2)+DEN1(IQ)*(1.0-A1))
C+ NUCLIDE SPECIFIC ACCOUNTING FACTORS
      FAC=BAS(1,2)/(A1*BAS(1,2)+DEN1(IQ)*(1.0-A1))
      FAC3=A1
      A3=BAS(1,1)/4.534
      IF(ISPC(1,3).NE.0)A3=A3/0.75
      A4=A3/(ISPC(1,8)*A1)
      IF(IQ.GT.3)GO TO 24
      A2=(COFF(1.0,2.0)*2.+COFF(1.0,4.0)*0.5)/8760.0
      IF(A4.GT.750.0)BAS(1,5)=DGA*A1*A2*1.6*750.0
      IF(A4.LE.750.0)BAS(1,5)=DGA*A1*A2*1.6*A4
C+ FACTOR FOR NUCLIDE-SPECIFIC CALCULATIONS
      FAC2=750.0
      IF(A4.LE.750.0) FAC2=A4
      GO TO 26
  24  A2=(COFF(1.0,2.0)*5.0+COFF(1.0,4.0)*0.5)/8760.0
      IF(A4.GT.250.0)BAS(1,5)=DGA*A1*A2*1.6*250.0
      IF(A4.LE.250.0)BAS(1,5)=DGA*A1*A2*1.6*A4
C+ FACTOR FOR NUCLIDE-SPECIFIC CALCULATIONS
      FAC2=250.0
      IF(A4.LE.250.0) FAC2=A4
  26  BAS(1,6)=2.0*DGA*A2*1.6*A3
      A1=TPOP(IR)*TDIS(IQ)*TDOZ(IR)/TVEL(IQ)
      BAS(1,7)=A1*100.0*DGA*A3*1.6*COFF(1.0,4.0)/8760.0
C+ TRANSPORTATION IMPACTS BY NUCLIDE
      WRITE(10,7010)
 7010 FORMAT(//2X,'TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)'//
     + 2X,'NUC     MAX INDIVIDUAL'/)
      FAC4=FAC*FAC2*FAC3*A2*1.6
      TRNTOT=0.0
      DO 30 I=1,85
        IF(NUX(I).NE.1) GOTO 30
        DOST=FAC4*PDCF(I,4,5)*BAS(1,I+7)
        WRITE(10,7020) NUC(I),DOST
 7020   FORMAT(2X,A6,4X,1PE12.3)
        TRNTOT=TRNTOT+DOST
  30  CONTINUE
      WRITE(10,7030) TRNTOT
 7030 FORMAT(/2X,'TOTAL TRANSPORTATION IMPACTS =',1PE12.3)
      RETURN
```

```
      END
C+- ----------------------------------------------------------------
      SUBROUTINE RECYCL(ISTR,WT1,WT2,WTOT,NX)
C+     RECYCL calculates impacts from recycling contaminated materials.
C+     Three recycle scenarios are considered:
C+     1) recycle of metal containers;
C+     2) recycle of metal fraction of waste stream composition; and,
C+     3) recycle of glass fraction.
      INCLUDE IMPCOMM.FOR
      DIMENSION RI(85),RP(85)
C+ ARRAY TO SAVE METAL RECYCLE IMPACTS
      DIMENSION BRC3(85)
      DATA RI/
     + 2.13E-05,3.41E-07,7.15E-02,1.96E-03,2.85E-04,1.92E-04,
     + 8.17E-04,2.95E-04,6.57E-02,1.07E-01,2.20E-02,7.30E-07,
     + 2.60E-02,3.95E-03,1.80E-02,8.20E-02,1.53E-06,3.80E-06,
     + 1.40E-02,1.22E-02,2.03E-03,1.71E-02,1.15E-04,6.25E-04,
     + 5.60E-02,5.10E-02,1.83E-04,1.26E-03,4.63E-07,4.08E-02,
     + 8.50E-03,6.10E-03,4.80E-02,8.89E-02,8.98E-04,8.36E-03,
     + 6.50E-02,5.91E-02,3.51E-04,1.40E-03,9.80E-05,6.56E-04,
     + 4.60E-02,2.40E-04,7.02E-02,1.90E-02,8.81E-04,7.38E-02,
     + 5.47E-04,1.54E-03,1.91E-03,3.72E-02,1.01E-02,8.24E-03,
     + 1.13E-01,6.56E+00,2.59E-02,2.99E+00,1.34E+00,5.89E+00,
     + 8.92E-01,9.97E-02,8.54E-02,1.57E-01,1.13E-01,1.03E-01,
     + 8.80E-04,2.71E-03,9.57E-02,1.62E-03,9.17E-01,1.23E-01,
     + 1.17E-01,1.10E-01,1.10E-01,1.19E-06,1.04E-01,1.09E+00,
     + 9.00E-02,9.21E-01,1.30E-01,4.92E-01,1.24E-01,1.09E-01,
     + 4.58E-03/
      DATA RP/
     + 2.95E+00,7.80E-01,1.23E+03,1.83E+01,2.66E+00,1.89E+00,
     + 2.26E+02,3.52E+00,2.77E+02,4.27E+00,1.31E+02,5.69E-01,
     + 6.93E+00,2.61E+01,1.00E+01,2.61E+03,4.66E+00,1.04E-01,
     + 6.52E+01,5.59E+01,1.89E+01,6.98E+01,6.39E-02,1.25E+02,
     + 2.48E+01,6.13E+03,1.71E+00,1.18E+01,1.87E+00,1.64E+01,
     + 2.22E+00,4.38E+01,1.46E+03,5.67E+02,8.42E+00,3.77E+01,
     + 7.81E+03,2.41E+02,1.45E+01,5.71E+00,1.18E+01,6.11E+00,
     + 6.01E+02,6.50E+01,2.82E+02,2.10E+03,8.21E+00,2.96E+02,
     + 5.08E+00,1.11E+01,2.70E+02,2.57E+03,4.05E+01,8.15E+00,
     + 4.21E-01,3.38E+02,3.97E+01,1.50E+03,1.35E+03,9.96E+02,
     + 1.38E+03,9.35E+00,8.00E+00,2.42E+02,9.25E+00,9.59E+00,
     + 6.24E+00,9.44E+02,8.95E+00,2.32E+02,1.54E+03,1.77E+00,
     + 9.81E+00,1.03E+01,1.03E+01,9.51E-04,9.68E+00,1.68E+03,
     + 1.36E+02,1.42E+03,3.67E-01,5.65E+02,6.94E+00,9.96E+00,
     + 1.02E+00/
      DATA PAKF,FIND,FPOP,DISF/1.E-3,0.33,0.46,0.9738/
     + WMET,WGLS/857.0,90.0/
  101 FORMAT(/2X,'METAL PACKAGE RECYCLE IMPACTS',3X,'MAXIND =',
     +1PE9.2,' MREM/YR',/34X,'POPULN =',E9.2,' PERSON-MREM/30YRS')
  102 FORMAT(/2X,'METAL MATERIAL RECYCLE IMPACTS',2X,'MAXIND =',
     +1PE9.2,' MREM/YR',/34X,'POPULN ='E9.2,' PERSON-MREM/30YRS')
  103 FORMAT(/2X,'GLASS MATERIAL RECYCLE IMPACTS',2X,'MAXIND =',
     +1PE9.2,' MREM/YR',/34X,'POPULN ='E9.2,' PERSON-MREM/30YRS')
C+ Dummy WTOT to resolve non-usage compile error
      WTOT = WMET
       IF(NX.NE.1)GO TO 20
C+ METAL PACKAGE RECYCLE
      IP=ISPC(ISTR,5)
      IF(IP.NE.1)FCORR=1.0/ISPC(ISTR,10)
      IF(IP.EQ.1)FCORR=1.0/ISPC(ISTR,11)
      A1=0.0
      A2=0.0
C+ HEADER FOR TAPE10 OUTPUT
      WRITE(10,7000)
 7000 FORMAT(//2X,'METAL PACKAGE RECYCLE ICRP IMPACTS BY ',
     + 'NUCLIDE (MREM/YR)'//
     + 2X,'NUC          DOSIND'/)
```

```
      BRC1=0.01*ISPC(ISTR,4)*PAKF*BAS(ISTR,1)/0.0009*FIND*FCORR
      BRCTOT=0.0
      DO 10 I=1,85
        IF(NUX(I).EQ.0)GO TO 10
        A1=A1+BAS(ISTR,I+7)*RI(I)
        A2=A2+BAS(ISTR,I+7)*RP(I)
C+ IMPACT FOR EACH NUCLIDE
        BRC2=BRC1*BAS(ISTR,I+7)*RI(I)
        WRITE(10,7010) NUC(I),BRC2
 7010   FORMAT(2X,A6,3X,1PE12.3)
        BRCTOT=BRCTOT+BRC2
   10 CONTINUE
C+ TOTAL IMPACT
      WRITE(10,7015) BRCTOT
 7015 FORMAT(/2X,'TOTAL RECYCLE IMPACT =',1PE12.3)
      A3=0.01*ISPC(ISTR,4)*PAKF*BAS(ISTR,1)/0.0009
      A1=FIND*FCORR*A3*A1
      A2=FPOP*A3*A2
      WRITE(7,101)  A1,A2
      WRITE(11,101) A1,A2
      RETURN
C+ METAL FRACTION RECYCLE
   20 A1=0.0
      A2=0.0
C+ HEADER FOR TAPE10 OUTPUT
      WRITE(10,7020)
 7020 FORMAT(//2X,'METAL AND GLASS RECYCLE ICRP IMPACTS BY NUCLIDE'//
     + 2X,'**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF ',
     + 'FACILITIES ****'//
     + 2X,'  NUC      METAL IND      GLASS IND'/)
      BRC1=FIND*WT1/(0.0009*ISPC(1,10))
      DO 30 I=1,85
        IF(NUX(I).EQ.0)GO TO 30
        A1=A1+BAS(NSTR,I+7)*RI(I)
        A2=A2+BAS(NSTR,I+7)*RP(I)
C+ SAVE METAL RECYCLE IMPACT FOR THIS NUCLIDE
        BRC3(I)=BRC1*BAS(NSTR,I+7)*RI(I)
   30 CONTINUE
      A1=FIND*WT1*A1/(0.0009*ISPC(1,10))
      A2=FPOP*WT1*A2/0.0009
      WRITE(7,102)  A1,A2
      WRITE(11,102) A1,A2
C+ GLASS FRACTION RECYCLE
      FCORR=WT2/(ISPC(1,10)*WGLS)
      A1=0.0
      A3=0.0
C+ FACTOR FOR GLASS IMPACTS
      BRC1=FCORR*0.3*DISF*1.6*0.6936*0.0228
      DO 40 I=1,85
        IF(NUX(I).EQ.0)GO TO 40
        A1=A1+BAS(NSTR,I+7)*PDCF(I,4,5)
        Y=EXM(AL(I))
        X=EXM(AL(I)*30.0)
        Z=1.0
        IF(Y.NE.1.0) Z=(1.0-X)/(30.0*(1.0-Y))
        A3=A3+Z*BAS(NSTR,I+7)*PDCF(I,4,5)
C+ METAL AND GLASS IMPACTS BY NUCLIDE
        BRC2=BRC1*BAS(NSTR,I+7)*PDCF(I,4,5)
        WRITE(10,7030) NUC(I),BRC3(I),BRC2
 7030   FORMAT(2X,A6,3X,1P2E12.3)
   40 CONTINUE
      A2=0.3*DISF*1.6*0.6936
      A1=FCORR*A2*A1*0.0228
      A3=FCORR*A2*A3*ISPC(1,10)*52.0
      WRITE(7,103)  A1,A3
      WRITE(11,103) A1,A3
```

```
      RETURN
      END
C+ -------------------------------------------------------
      SUBROUTINE SPLICE
C+      SPLICE accounts for the division of a waste stream into sub-
C+      streams (maximum = 3) based on selected sorting options at a
C+      municipal waste incinerator. INCIMP and RECYCLE and INCIMP are
C+      called to calculate incineration and sorting/recovery impacts and
C+      recycle impacts.
      INCLUDE IMPCOMM.FOR
      ISTR=1
C+ METAL PACKAGE RECYCLING
      IF(ISPC(ISTR,3).NE.1.OR.ISPC(ISTR,4).EQ.0)GO TO 20
      CALL RECYCL(ISTR,0.0,0.0,0.0,1)
   20 I1=IQ
      I2=ISPC(ISTR,5)
      IF(I2.EQ.1)RETURN
      I6=ISPC(ISTR,12)
      I7=ISPC(ISTR,13)
      I8=ISPC(ISTR,14)
      I9=ISPC(ISTR,15)
      IF(I2.GT.3)GO TO 30
C+ INCINERATE/DISPOSE AND SORTING OPTION 1
      CALL INCIMP(I1,I2,ISTR)
      WRF=2.0
C+ OSWR FOR VOLUME REDUCTION IF INPUT (ORIGINALLY IQ=1)
      IF(OSWR.GT.0.0) WRF=OSWR
      BAS(ISTR,1)=BAS(ISTR,1)/WRF
      BAS(ISTR,2)=0.89
      BAS(ISTR,3)=BAS(ISTR,1)/BAS(ISTR,2)
      DO 24 J=8,92
   24 BAS(ISTR,J)=BAS(ISTR,J)*WRF
      ISPC(ISTR,1)=3
      ISPC(ISTR,2)=1
      ISPC(ISTR,3)=0
c+    ISPC(ISTR,5)=1                    ! SNLA modification
      RETURN
C+ SORTING OPTION 2
   30 A1=(0.95*I6+0.05*I7+0.05*I8+0.10*I9)/100.0
      A2=(0.05*I6+0.05*I7+0.10*I8+0.90*I9)/100.0
      A3=BAS(ISTR,1)
      NSTR=NSTR+1
      DO 32 J=1,92
   32 BAS(NSTR,J)=BAS(ISTR,J)
      DO 34 J=1,15
   34 ISPC(NSTR,J)=ISPC(ISTR,J)
      BASN(NSTR)=BASN(ISTR)
C+ RESIDUE SECTION
      BAS(ISTR,1)=BAS(ISTR,1)/9.4
      BAS(ISTR,2)=0.89
      BAS(ISTR,3)=BAS(ISTR,1)/BAS(ISTR,2)
      DO 36 J=8,92
   36 BAS(ISTR,J)=BAS(ISTR,J)*A1*9.40
      CALL INCIMP(I1,I2,ISTR)
      ISPC(ISTR,1)=3
      ISPC(ISTR,2)=1
      ISPC(ISTR,3)=0
C+    ISPC(ISTR,5)=1                    ! SNLA modification
      IF(I2.EQ.5) GO TO 40
C+ DISCARD MATERIAL SECTION
      BAS(NSTR,1)=BAS(NSTR,1)*(1.0-A1)
      BAS(NSTR,2)=0.62
      BAS(NSTR,3)=BAS(NSTR,1)/BAS(NSTR,2)
      BAS(NSTR,6)=0.0
      BAS(NSTR,7)=0.0
      ISPC(NSTR,1)=1
```

```
      ISPC(NSTR,2) = 2
      ISPC(NSTR,3) = 0
C+    ISPC(NSTR,5) = 1                     ! SNLA modification
      RETURN
C+ SORTING OPTION 3
   40 BAS(NSTR,1) = BAS(NSTR,1)*A2
      BAS(NSTR,2) = 0.84
      BAS(NSTR,3) = BAS(NSTR,1)/BAS(NSTR,2)
      BAS(NSTR,6) = 0.0
      BAS(NSTR,7) = 0.0
      ISPC(NSTR,1) = 1
      ISPC(NSTR,2) = 2
      ISPC(NSTR,3) = 0
C+    ISPC(NSTR,5) = 1                     ! SNLA modification
C+ RECYCLE OF SCRAP METAL AND GLASS
      IF(I7.EQ.0.AND.I8.EQ.0)RETURN
      A4 = A3*(1.0-A1-A2)
      A5 = 0.9*I7 + 0.85*I8
      WT1 = 0.9*A4*I7/A5
      WT2 = A4-WT1
      CALL RECYCL(ISTR,WT1,WT2,A3,2)
      RETURN
      END

C+---------------------------------------------------------------
      SUBROUTINE UPTAKE
C+    UPTAKE reads TAPE1 fundamental dose conversion factors, related
C+    nuclide-specific parameters and uptake factors. The pathway dose
C+    conversion factors are calculated for determining impacts in the
C+    main code: 85 radionuclides, 10 body organs, and 7 major pathways
C+    are included, as detailed in NUREG-3585, Vol. 1, Appendix D.
      CHARACTER BASN*10,NUC*6,SOL*1,SOLB*1,IPA9*6,IPA1*6,IPA5*6,
     + NUCT*6,SOLT*1
      COMMON/BAST/BASCOM(834),ISPC(2,15),PDCF(85,10,7)
     + /CHRC/BASN(2),NUC(85),SOL(85),SOLB(85)
     + /NUCS/AL(85),FMF(85),RET(85,5),FRACT(85,3),NUX(85)
      COMMON/DCFS/FF(85,5),DCF1(159,10),DCF2(159,10),DCF3(85),
     + DCF4(85,10),DCF5(85,10),NUCT(159),SOLT(159)
      COMMON/UPTK/V1,V2,S1,S2,Z,RI,R,CY,D,F2,F3,F5,F7,
     + F8,F8P,F11,F13,F13P,F14,F15,F18
      DATA IPA9,IPA1,IPA5/'I-129 ','I-131 ','I-125 '/
      DO 80 INUC = 1,85
        DO 10 IJ = 1,159
          INCT = IJ
          IF(NUCT(INCT).EQ.NUC(INUC))GO TO 20
   10   CONTINUE
        STOP 'CANT FIND NUCLIDE NAME IN NUCT'
   20   IF(SOLT(INCT).EQ.SOL(INUC)) GO TO 50
        INCT = INCT + 1
        IF(NUCT(INCT).NE.NUC(INUC))GO TO 40
        GO TO 20
   40   WRITE(7,101) NUC(INUC),SOL(INUC),NUCT(INCT),SOLT(INCT)
        WRITE(11,101) NUC(INUC),SOL(INUC),NUCT(INCT),SOLT(INCT)
  101   FORMAT(//2X,2(A6,2X,A1,2X))
        STOP 'CANT FIND SOLUBILITIES FOR NUCT'
   50   PTP = F2 + F3*(FF(INUC,2)*F5 + FF(INUC,3)*F7*365.0)
        PT = PTP*FF(INUC,1)
        FT = F8*FF(INUC,2)*F5 + F8P*FF(INUC,3)*F7*365.0 + F11
        F12N = FF(INUC,4)*F13 + FF(INUC,5)*F13P
        V = V1
        IF(NUC(INUC).EQ.IPA9) V = V2
        IF(NUC(INUC).EQ.IPA1) V = V2
        IF(NUC(INUC).EQ.IPA5) V = V2
        D1 = 86400.0*V/(S2*Z)
        D2 = 86400.0*R*V/S1
        W1 = RI/(S2*Z)
```

```
      W2=R*R1/S1
      DO 70 IO=1 10
        A1=F18*(F14*(F15*DCF2(INCT,IO)+DCF5(INUC,IO))
     +        +DCF4(INUC,IO))
        PDCF(INUC,IO,1)=F15*DCF2(INCT,IO)+DCF5(INUC,IO)+A1*D1
        PDCF(INUC,IO,2)=F15*DCF2(INCT,IO)+DCF5(INUC,IO)+0.242*A1*D1
        PDCF(INUC,IO,3)=PDCF(INUC,IO,1)+(D1*PT
     +                  +(D2/CY)*PTP)*DCF1(INCT,IO)
        PDCF(INUC,IO,4)=(PT/D)*DCF1(INCT,IO)
        PDCF(INUC,IO,5)=DCF3(INUC)
        PDCF(INUC,IO,6)=(W1*PT+(W2/CY)*PTP+FT/1000.0)
     +                  *DCF1(INCT,IO)+W1*A1
        PDCF(INUC,IO,7)=PDCF(INUC,IO,6)+(F12N/1000.0)*DCF1(INCT,IO)

        DO 60 J=1,7
 60      PDCF(INUC,IO,J)=PDCF(INUC,IO,J)*1.0E+12
 70   CONTINUE
 80 CONTINUE
     RETURN
     END
C+----------------------------------------------------------
     SUBROUTINE ZERO(A,N)
C+ Zero the array A having N elements
     DIMENSION A(N)
     DO 10 I=1,N
  10 A(I)=0.0
     RETURN
     END
C+----------------------------------------------------------
     FUNCTION EXM(A1)
     Double precision a2
     A2=0.0
C+    IF(A1.LT.85.0)A2=EXP(-A1)    ! Doesn't work on all machines
     IF(A1.LT.50.0)A2=EXP(-A1)     ! Required limit for some clones
     EXM=A2                        ! SNLA modification
     RETURN
     END
C+----------------------------------------------------------
     FUNCTION COFF(X,R)
     DATA U/0.0097/
     A1=E1(U*X)
     R1=SQRT(R*R+X*X)
     COFF=(A1-E1(U*R1))/A1
     RETURN
     END
C+----------------------------------------------------------
     FUNCTION DOFF(X)
     DATA U/0.0097/
     A1=1.0+0.95*U+0.35*U*U
     A2=EXM(U)*(1.0-U*EXP(U)*E1(U))
     Y=U*X
     DOFF=(1.0+0.95*Y+0.35*Y*Y)*EXM(Y)*(1.0-Y*EXP(Y)*E1(Y))/(A1*A2)
     RETURN
     END
C+----------------------------------------------------------
     FUNCTION XOQFC(H,R,V,IS)
     DIMENSION A(6),B(6),C(6)
     DATA A/0.2,0.12,0.08,0.06,0.03,0.016/,
    + B/2*0.0,0.0002,0.0015,2*0.0003/,
    + C/2*0.0,2*0.5,2*1.0/
C+    SPYEAR = SECONDS PER YEAR
     DATA SPYear/3.15E07/                ! SNLA modification
     SIGZ=A(IS)*R/((1.0+B(IS)*R)**C(IS))
     XOQFC=2.032*EXP(-0.5*(H/SIGZ)*(H/SIGZ))/(V*R*SIGZ*SPYear)
     RETURN
     END
```

```
C+ --------------------------------------------------------------------
      FUNCTION E1(X)
      DIMENSION A(5),AT(4),BT(4)
      DATA A0/-0.57721566/
      DATA SMALL/1.0E-30/                    ! SNLA modification
      DATA A/0.99999193,-0.24991055,0.05519968,-0.00976004,0.00107857/
      DATA AT/8.5733287401,18.0590169730,8.6347608925,0.2677737343/
      DATA BT/9.5733223454,25.6329561486,21.0996530827,3.9584969228/
      IF(X.GT.SMALL .AND. X.LE.1.0) GO TO 10    ! SNLA modification
      IF(X.GT.1.0) GO TO 30
      WRITE (*,99) X
   99 FORMAT(' Argument X = ',G16.10)
      STOP 'E1(X) ARGUMENT BECAME NEGATIVE OR ESSENTIALLY ZERO'
   10 E=0.0
      XP=1.0
      DO 20 I=1,5
        XP=XP*X
        E=E+A(I)*XP
   20 CONTINUE
      E1 = (E+A0)-dLOG(X)
      RETURN
   30 ET=0.0
      EB=0.0
      XP=1.0
      DO 40 I=1,4
        XP=XP*X
        IF(I.EQ.4) GO TO 50
        J=4-I
        ET=ET+AT(J)*XP
        EB=EB+BT(J)*XP
   40 CONTINUE
   50 E=(XP+ET+AT(4))/(XP+EB+BT(4))
      E1=E*EXP(-X)/X
      RETURN
      END
C+ ------------------END OF IMPACTS_BRC ---------------------
```

APPENDIX B: IMPACTS-BRC STANDARD INPUT FILES

IMPACTS-BRC INPUT FILE: TAPE1.DAT

```
H-3    1*  .00E+00 4.80E+00 1.20E-02 1.40E-02 9.00E-01 9.00E-01 5.64E-02 1.15E+00 1.00E+00 1.00E+00
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
         * 6.40E-00 6.40E-08 6.40E-08  .00E+00 6.40E-08 6.40E-08 6.40E-08 6.40E-08 6.40E-08 6.40E-08
           6.40E-08 6.40E-08 6.40E-08  .00E+00 6.40E-08 6.40E-08 6.40E-08 6.40E-08 6.40E-08 6.40E-08
C-14   1*  .00E+00 5.50E+00 3.10E-02 1.50E-02 4.60E+03 9.10E+03 1.21E-04    0.103      1.0 1.00E+01
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
         * 2.09E-06 2.09E-06 2.09E-06  .00E+00 2.09E-06 2.09E-06 2.09E-06 2.09E-06 2.09E-06 2.09E-06
           2.09E-06 2.09E-06 2.09E-06  .00E+00 2.09E-06 2.09E-06 2.09E-06 2.09E-06 2.09E-06 2.09E-06
NA-22  1D 1.59E-05 4.60E-03 8.30E-02 3.50E-02 1.00E+02 2.00E+02 2.65E-01 1.62E-04      1.0 7.20E+02
           1.85E-04 1.70E-04 1.68E-04  .00E+00 1.82E-04 1.73E-04 1.67E-04 2.06E-04 2.30E-04 2.10E-04
           9.86E-03 9.09E-03 8.97E-03  .00E+00 9.72E-03 9.26E-03 1.00E-02 1.09E-02 1.23E-02 1.12E-02
         D 9.29E-06 1.06E-05 1.14E-05  .00E+00 1.05E-05 9.99E-06 1.59E-05 2.05E-05 9.25E-06 1.15E-05
           9.14E-06 6.22E-06 7.18E-06  .00E+00 6.70E-06 6.47E-06 1.01E-05 1.30E-05 5.82E-06 7.66E-06
P-32   2W  .00E+00 1.10E+00 5.70E-02 1.60E-02 1.00E+05 2.00E+04 1.77E+01 1.26E-03      1.0 3.60E+02
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
         D 2.42E-06 5.36E-06 2.68E-05  .00E+00 2.42E-06 2.42E-06 2.99E-05 2.91E-05 2.42E-06 8.77E-06
           9.25E-06 2.24E-06 5.55E-06  .00E+00 1.79E-06 1.79E-06 2.21E-05 2.15E-05 1.79E-06 6.07E-06
         W 2.42E-06 5.36E-06 2.68E-05  .00E+00 2.42E-06 2.42E-06 2.99E-05 2.91E-05 2.42E-06 8.77E-06
           9.47E-05 2.48E-06 1.14E-05  .00E+00 1.25E-06 1.25E-06 1.54E-05 1.50E-05 1.25E-06 1.55E-05
P-33   2W  .00E+00 1.10E+00 5.70E-02 1.60E-02 1.00E+05 2.00E+04 9.96E+00 1.26E-03      1.0 3.60E+02
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
         D 3.47E-07 6.73E-07 3.13E-06  .00E+00 3.47E-07 3.47E-07 1.85E-06 4.88E-06 3.47E-07 9.18E-07
           1.10E-06 3.08E-07 6.85E-07  .00E+00 2.58E-07 2.58E-07 1.37E-06 3.64E-06 2.58E-07 6.33E-07
         W 3.47E-07 6.73E-07 3.13E-06  .00E+00 3.47E-07 3.47E-07 1.85E-06 4.88E-06 3.47E-07 9.18E-07
           1.56E-05 3.29E-07 1.39E-06  .00E+00 1.87E-07 1.87E-07 9.95E-07 2.65E-06 1.87E-07 2.32E-06
S-35   2W  .00E+00 5.90E-01 1.00E-01 1.60E-02 7.50E+02 1.00E+02 2.88E+00 1.20E-02      1.0 4.20E+01
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
           .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00  .00E+00
         D 2.82E-07 4.92E-07 2.11E-06  .00E+00 2.82E-07 2.82E-07 2.82E-07 2.82E-07 2.82E-07 4.48E-07
           7.55E-07 2.43E-07 4.92E-07  .00E+00 2.11E-07 2.11E-07 2.11E-07 2.11E-07 2.11E-07 3.02E-07
         W 2.82E-07 4.92E-07 2.11E-06  .00E+00 2.82E-07 2.82E-07 2.82E-07 2.82E-07 2.82E-07 4.48E-07
           1.88E-05 2.66E-07 1.03E-06  .00E+00 1.68E-07 1.68E-07 1.68E-07 1.68E-07 1.68E-07 2.48E-06
CL-36  2W  .00E+00 5.00E+00 8.00E-02 1.70E-02 5.00E+01 1.00E+02 2.30E-06 1.15E-01      1.0 5.00E+00
           2.65E-13 6.84E-14 1.38E-13  .00E+00 4.02E-16 3.26E-15 8.70E-16 4.30E-13 1.68E-13 4.66E-12
           2.41E-12 6.22E-13 1.25E-12  .00E+00 3.66E-15 2.96E-14 7.92E-13 3.92E-12 1.52E-12 4.24E-11
         D 2.96E-06 4.11E-06 2.96E-06  .00E+00 2.96E-06 2.96E-06 2.96E-06 2.96E-06 2.96E-06 3.03E-06
           4.92E-06 2.04E-05 1.86E-06  .00E+00 1.86E-06 1.86E-06 1.86E-06 1.86E-06 1.86E-06 2.24E-06
         W 2.96E-06 4.11E-06 2.96E-06  .00E+00 2.96E-06 2.96E-06 2.96E-06 2.96E-06 2.96E-06 3.03E-06
           1.69E-04 2.46E-06 1.86E-06  .00E+00 1.86E-06 1.86E-06 1.86E-06 1.86E-06 1.86E-06 2.19E-05
CA-45  1W  .00E+00 3.60E-02 7.20E-04 1.10E-02 4.00E+01 3.30E+02 1.56E+00 9.86E-03      1.0 7.30E+01
           2.08E-15 7.12E-16 1.14E-15  .00E+00 2.86E-17 7.88E-17 6.95E-16 3.39E-15 2.02E-15 2.14E-14
           7.92E-15 2.71E-15 4.36E-15  .00E+00 1.09E-16 3.00E-16 2.65E-15 1.29E-14 7.69E-15 8.17E-14
         W 1.98E-07 5.29E-07 1.04E-05  .00E+00 1.98E-07 1.98E-07 1.28E-05 1.94E-05 1.98E-07 3.16E-06
           3.58E-05 3.26E-07 5.11E-06  .00E+00 1.66E-07 1.66E-07 1.08E-05 1.62E-05 1.66E-07 6.62E-06
SC-46  1Y 1.42E-05 1.10E-03 1.60E-02 5.00E-06 2.00E+00 1.00E+03 3.01E+00 1.11E-04 9.00E+00 7.30E+01
           1.72E-04 1.59E-04 1.57E-04  .00E+00 1.70E-04 1.61E-04 1.74E-04 1.96E-04 2.16E-04 1.94E-04
           9.30E-03 8.62E-03 8.50E-03  .00E+00 9.22E-03 8.74E-03 9.41E-03 1.01E-02 1.17E-02 1.05E-02
         Y 1.80E-07 2.53E-06 3.85E-05  .00E+00 1.05E-06 7.47E-07 1.48E-06 5.14E-07 2.85E-08 6.40E-06
           1.71E-04 1.53E-05 1.95E-05  .00E+00 6.66E-05 1.56E-05 8.18E-06 8.22E-06 7.47E-06 2.96E-05
CR-51  3Y 2.03E-07 1.30E-02 9.20E-03 1.60E-03 2.00E+02 2.00E+03 9.13E+00 1.26E-03     10.0 3.60E+02
           2.89E-06 2.65E-06 2.60E-06  .00E+00 2.78E-06 2.68E-06 2.99E-06 3.69E-06 3.67E-06 3.41E-06
           1.35E-04 1.23E-04 1.21E-04  .00E+00 1.29E-04 1.25E-04 1.39E-04 1.72E-04 1.71E-04 1.58E-04
         D 1.62E-08 6.70E-08 9.18E-07  .00E+00 3.14E-08 2.59E-08 4.63E-08 2.91E-08 1.37E-08 1.47E-07
           1.41E-07 9.10E-08 2.19E-07  .00E+00 8.18E-08 8.03E-08 9.92E-08 1.01E-07 6.73E-08 1.09E-07
         W 1.62E-08 6.70E-08 8.18E-07  .00E+00 3.14E-08 2.59E-08 4.63E-08 2.91E-08 1.37E-08 1.47E-07
           1.39E-06 8.69E-08 4.18E-07  .00E+00 4.96E-08 0.18E-08 6.92E-08 5.55E-08 4.07E-08 2.62E-07
         Y 1.62E-08 6.70E-08 8.18E-07  .00E+00 3.14E-08 2.59E-08 4.63E-08 2.91E-08 1.37E-09 1.47E-07
           1.98E-06 9.47E-08 4.37E-07  .00E+00 4.74E-08 9.51E-08 6.92E-08 5.14E-08 4.00E-08 3.34E-07
MN-54  2W 5.94E-06 1.20E-01 3.00E-04 3.30E-04 4.00E+02 9.00E+04 8.09E-01 1.26E-03     10.0 3.60E+02
           7.42E-05 6.88E-05 6.75E-05  .00E+00 7.32E-05 6.95E-05 7.53E-05 8.18E-05 9.36E-05 8.41E-05
           3.85E-03 3.57E-03 3.51E-03  .00E+00 3.80E-03 3.61E-03 3.91E-03 4.25E-03 4.88E-03 4.37E-03
         D 8.47E-07 1.52E-06 8.14E-06  .00E+00 1.41E-06 3.70E-06 1.81E-06 2.11E-06 4.92E-07 2.77E-06
           4.37E-06 3.49E-06 4.37E-06  .00E+00 5.07E-06 1.71E-05 6.14E-06 9.47E-06 2.41E-06 5.25E-06
         W 8.47E-06 1.52E-06 8.14E-06  .00E+00 1.41E-06 3.70E-06 1.81E-06 2.11E-06 4.92E-07 2.77E-06
           2.46E-05 4.25E-06 4.88E-06  .00E+00 3.29E-06 9.14E-06 4.07E-06 4.62E-06 2.74E-06 6.70E-06
```

FE-55	2W	.00E+00	4.20E-04	1.90E-02	2.70E-04	1.00E+02	3.20E+03	2.57E-01	1.48E-02	1.0	5.40E+03
		1.28E-09	3.24E-10	6.53E-10	.00E+00	1.81E-12	1.55E-11	4.13E-10	2.04E-09	7.96E-10	2.21E-08
		6.52E-09	1.68E-09	3.39E-09	.00E+00	9.89E-12	8.02E-11	2.14E-09	1.06E-08	4.13E-09	1.15E-07
	D	3.77E-07	4.00E-07	1.12E-06	.00E+00	3.81E-07	1.27E-06	3.89E-07	3.89E-07	4.07E-07	6.07E-07
		1.92E-06	1.88E-06	2.00E-06	.00E+00	1.88E-06	6.25E-06	1.91E-06	1.90E-06	2.01E-06	2.69E-06
	W	3.77E-07	4.00E-07	1.12E-06	.00E+00	3.81E-07	1.27E-06	3.89E-07	3.89E-07	4.07E-07	6.07E-07
		3.92E-06	6.47E-07	1.02E-06	.00E+00	6.40E-07	2.13E-06	6.51E-07	6.47E-07	6.85E-07	1.34E-06
FE-59	2W	8.32E-06	4.20E-04	1.90E-02	2.70E-04	1.00E+02	3.20E+03	5.67E+00	1.48E-02	1.0	5.40E+03
		9.74E-05	9.01E-05	8.94E-05	.00E+00	9.68E-05	9.18E-05	9.83E-05	1.05E-04	1.22E-04	1.10E-04
		5.48E-03	5.06E-03	5.02E-03	.00E+00	5.44E-03	5.16E-03	5.53E-03	5.88E-03	6.86E-03	6.17E-03
	D	2.35E-06	4.11E-06	3.12E-05	.00E+00	3.36E-06	5.70E-06	3.13E-06	2.45E-06	2.23E-06	6.70E-06
		1.29E-05	1.27E-05	1.78E-05	.00E+00	1.39E-05	2.63E-05	1.16E-05	1.08E-05	1.09E-05	1.48E-05
	W	2.35E-06	4.11E-06	3.12E-05	.00E+00	3.36E-06	5.70E-06	3.13E-06	2.45E-06	2.23E-06	6.70E-06
		5.11E-05	6.25E-06	1.66E-05	.00E+00	5.22E-06	9.92E-06	4.85E-06	4.11E-06	4.33E-06	1.22E-05
CO-57	2Y	4.02E-07	1.50E-02	9.70E-03	1.80E-03	5.00E+01	2.00E+02	9.34E-01	1.48E-02	1.0	3.60E+03
		1.15E-05	1.02E-05	9.92E-06	.00E+00	1.05E-05	1.04E-05	9.98E-06	1.85E-05	1.60E-05	1.43E-05
		5.12E-04	4.58E-04	4.44E-04	.00E+00	4.71E-04	4.63E-04	4.47E-04	8.27E-04	7.16E-04	6.36E-04
	W	1.07E-07	3.35E-07	4.66E-06	.00E+00	1.82E-07	3.26E-07	3.27E-07	1.82E-07	7.14E-08	7.44E-07
		1.50E-05	8.32E-07	2.55E-06	.00E+00	5.36E-07	1.36E-06	9.40E-07	7.29E-07	4.18E-07	2.63E-06
	Y	1.07E-07	3.35E-07	4.66E-06	.00E+00	1.82E-07	3.26E-07	3.27E-07	1.82E-07	7.14E-08	7.44E-07
		6.25E-05	2.03E-06	2.46E-06	.00E+00	9.58E-07	2.67E-06	2.18E-06	1.67E-06	1.00E-06	9.07E-06
CO-58	2Y	7.03E-06	1.50E-02	9.70E-03	1.80E-03	5.00E+01	2.00E+02	3.57E+00	1.48E-02	1.0	3.60E+03
		8.69E-05	8.04E-05	7.88E-05	.00E+00	8.54E-05	8.13E-05	8.83E-05	9.69E-05	1.09E-04	9.87E-05
		4.45E-03	4.12E-03	4.04E-03	.00E+00	4.38E-03	4.17E-03	4.53E-03	4.96E-03	5.60E-03	5.05E-03
	W	3.16E-07	1.42E-06	1.47E-05	.00E+00	7.77E-07	9.10E-07	9.62E 07	4.63E-07	2.33E-07	2.99E-06
		2.94E-05	3.34E-06	7.47E-06	.00E+00	2.09E-06	4.25E-06	2.34E-06	1.77E-06	2.04E-06	6.36E-06
	Y	3.16E-07	1.42E-06	1.47E-05	.00E+00	7.77E-07	9.10E-07	9.62E-07	4.63E-07	2.33E-07	2.99E-06
		5.92E-05	5.14E-06	7.36E-06	.00E+00	2.79E-06	6.07E-06	3.42E-06	2.56E-06	3.23E-06	1.08E-05
CO-60	2Y	1.76E-05	1.50E-02	9.70E-03	1.80E-03	5.00E+01	2.00E+02	1.32E-01	1.48E-02	1.0	3.60E+03
		2.02E-04	1.86E-04	1.85E-04	.00E+00	2.01E-04	1.91E-04	2.04E-04	2.16E-04	2.52E-04	2.27E-04
		1.15E-02	1.06E-02	1.06E-02	.00E+00	1.15E-02	1.09E-02	1.16E-02	1.23E-02	1.44E-02	1.30E-02
	W	3.24E-06	5.96E-06	4.11E-05	.00E+00	5.00E-06	8.62E-06	4.88E-06	3.47E-06	2.92E-06	1.02E-05
		1.32E-04	1.99E-05	3.02E-05	.00E+00	1.66E-05	3.39E-05	1.57E-05	1.31E-05	1.38E-05	3.31E-05
	Y	3.24E-06	5.96E-06	4.11E-05	.00E+00	5.00E-06	8.62E-06	4.88E-06	3.47E-06	2.92E-06	1.02E-05
		1.28E-03	1.01E-04	2.93E-05	.00E+00	5.77E-05	1.24E-04	6.36E-05	5.00E-05	5.99E-05	2.19E-04
NI-59	2W	.00E+00	2.10E-02	2.00E-03	1.00E-03	1.00E+02	1.00E+02	9.24E-06	1.48E-02	1.0	3.60E+03
		2.37E-09	6.10E-10	1.23E-09	.00E+00	3.59E-12	2.91E-11	7.77E-10	3.84E-09	1.50E-09	4.16E-08
		1.10E-08	2.83E-09	5.69E-09	.00E+00	1.66E-11	1.35E-10	3.60E-09	1.78E-08	6.93E-09	1.93E-07
	D	1.30E-07	1.52E-07	9.99E-07	.00E+00	1.32E-07	1.32E-07	1.35E-07	1.34E-07	1.44E-07	2.10E-07
		1.33E-06	1.27E-06	1.42E-06	.00E+00	1.28E-06	1.28E-06	1.31E-06	1.30E-06	1.39E-06	1.32E-06
	W	1.30E-07	1.52E-07	9.99E-07	.00E+00	1.32E-07	1.32E-07	1.35E-07	1.34E-07	1.44E-07	2.10E-07
		4.44E-06	3.62E-07	8.29E-07	.00E+00	3.85E-07	3.85E-07	3.92E-07	3.89E-07	4.22E-07	9.18E-07
NI-63	2W	.00E+00	2.10E-02	2.00E-03	1.00E-03	1.00E+02	1.00E+02	6.93E-03	1.48E-02	1.0	3.60E+03
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
	D	3.15E-07	3.89E-07	3.40E-06	.00E+00	3.15E-07	3.15E-07	3.15E-07	3.15E-07	3.15E-07	5.77E-07
		3.23E-06	3.05E-06	3.52E-06	.00E+00	3.05E-06	3.04E-06	3.04E-06	3.04E-06	3.04E-06	3.10E-06
	W	3.15E-07	3.89E-07	3.40E-06	.00E+00	3.15E-07	3.15E-07	3.15E-07	3.15E-07	3.15E-07	5.77E-07
		1.14E-05	9.51E-07	2.49E-06	.00E+00	9.18E-07	9.14E-07	9.14E-07	9.14E-07	9.14E-07	2.30E-06
ZN-65	3Y	4.11E-06	1.10E-01	1.20E-01	1.00E-02	2.00E+03	1.00E+04	1.03E+00	1.48E-02	1.0	7.30E+01
		4.85E-05	4.49E-05	4.44E-05	.00E+00	4.81E-05	4.56E-05	4.90E-05	5.24E-05	6.09E-05	5.48E-05
		2.68E-03	2.48E-03	2.45E-03	.00E+00	2.66E-03	2.52E-03	2.71E-03	2.89E-03	3.37E-03	3.02E-03
	D	1.14E-05	1.25E-05	1.84E-05	.00E+00	1.43E-05	1.36E-05	1.66E-05	1.66E-05	1.19E-05	1.44E-05
		7.77E-05	1.39E-05	9.99E-06	.00E+00	1.14E-05	1.61E-05	1.34E-05	1.24E-05	1.12E-05	2.04E-05
	W	1.14E-05	1.25E-05	1.84E-05	.00E+00	1.43E-05	1.36E-05	1.66E-05	1.66E-05	1.19E-05	1.44E-05
		7.77E-05	1.39E-05	9.99E-06	.00E+00	1.14E-05	1.61E-05	1.34E-05	1.24E-05	1.12E-05	2.04E-05
	Y	1.14E-05	1.25E-05	1.84E-05	.00E+00	1.43E-05	1.36E-05	1.66E-05	1.66E-04	1.19E-05	1.44E-05
		7.77E-05	1.39E-05	9.99E-06	.00E+00	1.14E-05	1.61E-05	1.34E-05	1.24E-05	1.12E-05	2.04E-05
SE-75	2W	2.02E-06	1.30E+00	1.50E-02	4.00E-03	1.70E+02	1.70E+02	2.10E+00	1.20E-02	9.00E+00	4.20E+01
		3.59E-05	3.26E-05	3.20E-05	.00E+00	3.40E-05	3.30E-05	3.55E-05	4.98E-05	4.71E-05	4.32E-05
		1.65E-03	1.50E-03	1.47E-03	.00E+00	1.56E-03	1.52E-03	1.63E-03	2.29E-03	2.16E-03	1.98E-03
	D	6.14E-06	6.07E-06	7.29E-06	.00E+00	2.65E-05	2.12E-05	7.66E-06	6.29E-06	4.18E-06	9.62E-06
		5.03E-06	5.88E-06	4.66E-06	.00E+00	1.68E-05	1.59E-05	5.70E-06	4.70E-06	3.15E-06	7.22E-06
	W	6.14E-06	6.07E-06	7.29E-06	.00E+00	2.65E-05	2.12E-05	7.66E-06	6.29E-06	4.18E-06	9.62E-06
		2.01E-05	5.96E-06	4.29E-06	.00E+00	1.66E-05	1.43E-05	5.55E-06	4.55E-06	3.10E-06	8.47E-06
RB-86	1D	6.67E-07	1.30E-01	1.10E-02	1.20E-02	2.00E+03	1.00E+03	1.38E+01	1.62E-04	1.0	7.20E+02
		7.97E-06	7.38E-06	7.30E-06	.00E+00	7.91E-06	7.50E-06	8.05E-06	8.61E-06	1.00E-05	8.99E-06
		4.38E-04	4.06E-04	4.01E-04	.00E+00	4.35E-04	4.12E-04	4.43E-04	4.74E-04	5.52E-04	4.95E-04
	D	7.92E-06	1.08E-05	8.03E-06	.00E+00	7.99E-06	7.99E-05	1.38E-05	2.54E-05	7.92E-06	9.36E-06
		1.22E-05	5.40E-06	5.00E-06	.00E+00	5.00E-06	5.00E-06	8.58E-06	1.58E-05	4.92E-06	6.62E-06
SR-85	2Y	3.37E-06	7.50E-02	5.80E-04	1.40E-03	3.00E+01	1.00E+02	3.90E+00	9.86E-03	1.0	7.30E+01
		4.59E-05	4.22E-05	4.12E-05	.00E+00	4.46E-05	4.28E-05	4.70E-05	5.37E-05	5.71E-05	5.31E 05
		2.23E-03	2.05E-03	2.00E-03	.00E+00	2 [illegible] E-03	2.08E-03	2.28E-03	2.61E-03	2.77E-03	2.56E-03

	D	7.62E-07	1.14E-06	5.55E-06	.00E+00	9.40E-07	8.03E-07	2.21E-06	2.24E-06	7.58E-07	1.98E-06
		1.72E-06	1.21E-06	2.15E-06	.00E+00	1.36E-06	1.23E-06	3.40E-06	3.77E-06	1.34E-06	1.92E-06
	Y	6.18E-08	6.44E-07	6.73E-06	.00E+00	2.06E-07	2.05E-07	4.81E-07	2.11E-07	3.01E-08	1.49E-06
		2.65E-03	2.44E-06	3.37E-06	.00E+00	1.36E-06	2.85E-06	1.72E-06	1.29E-06	1.42E-06	5.03E-06
SR-89	2Y	9.80E-10	7.50E-02	3.90E-04	1.40E-03	3.00E+01	1.00E+02	5.01E+00	9.86E-03	1.0	7.30E+01
		1.20E-08	1.11E-08	1.09E-08	.00E+00	1.19E-08	1.13E-08	1.22E-08	1.31E-08	1.51E-08	1.36E-08
		6.34E-07	5.88E-07	5.78E-07	.00E+00	6.27E-07	5.95E-07	6.43E-07	6.94E-07	8.01E-07	7.17E-07
	D	8.88E-07	3.37E-06	7.86E-05	.00E+00	8.88E-07	8.88E-07	1.20E-05	1.78E-05	8.88E-07	9.25E-06
		7.99E-06	1.92E-06	1.32E-05	.00E+00	1.54E-06	1.54E-06	2.08E-05	3.10E-05	1.54E-06	6.51E-06
	Y	2.95E-08	2.52E-08	1.07E-04	.00E+00	2.95E-08	2.95E-08	4.00E-07	5.96E-07	2.95E-08	9.25E-06
		3.09E-04	1.22E-08	5.14E-05	.00E+00	2.94E-08	2.96E-08	3.96E-07	5.88E-07	2.95E-08	4.14E-05
SR-90	2Y	.00E+00	7.50E-02	5.80E-04	1.40E-03	3.00E+01	1.00E+02	2.42E-02	9.86E-03	1.0	7.30E+01
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
	I	5.59E-06	6.47E-06	7.28E-05	.00E+00	5.59E-06	5.59E-06	7.18E-04	1.55E-03	5.59E-06	1.42E-04
		1.38E-05	9.82E-06	2.02E-05	.00E+00	9.77E-06	9.77E-06	1.24E-03	2.69E-03	9.77E-06	2.39E-04
	Y	1.86E-07	1.06E-06	9.69E-05	.00E+00	1.86E-07	1.86E-07	2.39E-05	5.14E-05	1.86E-07	1.20E-05
		1.06E-02	2.17E-06	7.62E-05	.00E+00	9.95E-07	9.95E-07	1.21E-04	2.62E-04	9.95E-07	1.30E-03
ZR-95	2Y	5.46E-06	7.70E-04	2.10E-02	3.00E-05	3.30E+00	6.70E+00	3.95E+00	9.86E-03	1.0	1.00E+04
		6.58E-05	6.09E-05	5.97E-05	.00E+00	6.47E-05	6.16E-05	6.69E-05	7.34E-05	8.28E-05	7.47E-05
		3.35E-03	3.11E-03	3.04E-03	.00E+00	3.30E-03	3.14E-03	3.41E-03	3.74E-03	4.22E-03	3.81E-03
	W	8.66E-08	1.32E-06	2.89E-05	.00E+00	4.18E-07	2.88E-07	7.92E-07	1.80E-06	3.06E-08	3.77E-06
		6.88E-05	4.03E-06	1.53E-05	.00E+00	3.02E-06	4.37E-06	1.20E-05	8.03E-05	2.89E-06	1.59E-05
	Y	8.66E-08	1.32E-06	2.89E-05	.00E+00	4.18E-07	2.86E-07	7.92E-07	1.80E-06	3.06E-08	3.77E-06
		1.51E-04	6.77E-06	1.46E-05	.00E+00	3.56E-06	7.81E-06	5.00E-06	8.62E-06	4.29E-06	2.33E-05
NB-94	2Y	1.14E-05	9.40E-03	2.50E-01	2.00E-02	3.00E+04	1.00E+02	3.42E-05	1.11E-02	1.0	1.00E+04
		1.40E-04	1.30E-04	1.27E-04	.00E+00	1.38E-04	1.31E-04	1.42E-04	1.55E-04	1.76E-04	1.59E-04
		7.22E-03	6.69E-03	6.56E-03	.00E	7.12E-03	6.76E-03	7.34E-03	8.01E-03	9.10E-03	8.20E-03
	W	6.36E-07	2.85E-06	4.62E-05	.00E+00	2.57E-06	1.04E-06	2.73E-06	2.83E-06	4.55E-07	7.14E-06
		1.55E-04	1.31E-05	3.07E-05	.00E+00	2.56E-05	1.30E-05	2.36E-05	3.37E-05	9.73E-06	3.61E-05
	Y	6.36E-07	2.85E-06	4.63E-05	.00E+00	2.57E-06	1.04E-06	2.73E-06	2.33E-06	4.55E-07	7.14E-06
		2.77E-03	1.18E-04	3.49E-05	.00E+00	7.10E-05	1.45E-04	6.36E-05	7.29E-05	8.21E-05	4.14E-04
NB-95	1Y	5.64E-08	9.40E-03	2.50E-01	2.00E-02	3.00E+04	1.00E+02	7.23E+00	1.11E-02	1.0	1.00E+04
		6.84E-05	6.33E-05	6.20E-05	.00E+00	6.73E-05	6.40E-05	6.95E-05	7.60E-05	8.61E-05	7.76E-05
		3.50E-03	3.24E-03	3.18E-03	.00E+00	3.45E-03	3.28E-03	3.56E-03	3.89E-03	4.41E-03	3.97E-03
	Y	1.01E-07	1.04E-06	1.48E-05	.00E+00	5.07E-07	3.07E-07	7.36E-07	1.09E-06	4.37E-08	2.57E-06
		3.08E-05	2.35E-06	7.14E-06	.00E+00	1.28E-06	2.47E-06	1.64E-06	1.90E-06	1.02E-06	5.81E-06
MO-99	2Y	1.08E-06	1.20E-01	6.80E-03	1.40E-03	1.00E+01	1.00E+01	9.20E+01	1.15E-01	2.00E+00	5.00E+00
		1.38E-05	1.28E-05	1.26E-05	.00E+00	1.36E-05	1.30E-05	1.40E-05	1.62E-05	1.77E-05	1.60E-05
		6.98E-04	6.44E-04	6.31E-04	.00E+00	6.83E-04	6.51E-04	7.06E-04	8.08E-04	8.85E-04	7.99E-04
	D	7.14E-07	2.47E-06	1.16E-05	.00E+00	9.21E-06	9.84E-06	1.97E-06	2.85E-06	6.07E-07	3.04E-06
		4.33E-06	3.88E-07	2.15E-06	.00E+00	6.47E-06	6.92E-06	1.37E-06	2.00E-06	4.33E-07	2.01E-06
	Y	3.59E-08	1.00E-06	5.07E-05	.00E+00	6.55E-07	6.62E-07	3.08E-07	2.34E-07	3.81E-08	5.03E-06
		1.59E-05	8.62E-07	2.04E-05	.00E+00	3.46E-07	4.03E-07	1.94E-07	1.53E-07	5.62E-08	3.96E-06
TC-99	2W	.00E+00	1.10E+00	8.70E-03	9.90E-03	1.50E+01	5.00E+00	3.25E-06	1.15E-01	1.0	5.00E+00
		4.94E-11	4.30E-11	4.04E-11	.00E+00	4.56E-11	4.46E-11	3.62E-11	8.62E-11	7.25E-11	6.26E-11
		2.09E-09	1.82E-09	1.71E-09	.00E+00	1.93E-09	1.89E-09	1.53E-09	3.65E-09	3.07E-09	3.65E-09
	D	2.23E-07	1.25E-05	4.07E-06	.00E+00	2.23E-07	3.05E-07	2.23E-07	2.23E-07	5.99E-06	1.46E-06
		1.20E-06	9.14E-06	7.58E-07	.00E+00	1.67E-07	2.28E-07	1.67E-07	1.67E-07	4.48E-06	1.02E-06
	W	2.23E-07	1.25E-05	4.07E-06	.00E+00	2.23E-07	3.05E-07	2.23E-07	2.23E-07	5.99E-06	1.46E-06
		6.18E-05	8.21E-06	2.11E-06	.00E+00	1.48E-07	2.01E-07	1.48E-07	1.48E-07	3.96E-06	8.32E-06
TC-99M	2W	4.42E-07	1.10E+00	8.70E-03	9.90E-03	1.50E+01	5.00E+00	1.00E+03	1.15E-01	1.0	5.00E+00
		1.19E-05	1.07E-05	1.05E-05	.00E+00	1.10E-05	1.08E-05	1.09E-05	1.87E-05	1.64E-05	1.48E-05
		5.38E-04	4.83E-04	4.72E-04	.00E+00	4.96E-04	4.88E-04	4.91E-04	8.43E-04	7.41E-04	6.63E-04
	D	1.16E-06	2.65E-07	9.40E-08	.00E+00	1.92E-08	1.75E-08	2.33E-08	1.50E-08	3.13E-07	6.22E-08
		8.44E-08	1.08E-07	1.85E-08	.00E+00	8.06E-09	1.18E-08	1.24E-08	9.89E-09	1.85E-07	3.26E-08
	W	1.16E-08	2.65E-07	9.40E-08	.00E+00	1.92E-08	1.75E-08	2.33E-08	1.50E-08	3.13E-07	6.22E-08
		1.14E-07	5.62E-08	1.42E-08	.00E+00	5.70E-09	9.18E-09	8.84E-09	6.59E-06	7.73E-08	2.67E-08
RU-103	1Y	3.67E-06	1.40E-03	4.00E-01	6.10E-07	1.00E+01	3.00E+02	6.42E+00	1.15E-01	1.0	5.00E+00
		4.35E-05	4.00E-05	3.90E-05	.00E+00	4.23E-05	4.05E-05	4.45E-05	5.10E-05	5.41E-05	5.00E-05
		2.11E-03	1.94E-03	1.89E-03	.00E+00	2.05E-03	1.96E-03	2.16E-03	2.47E-03	2.62E-03	2.42E-03
	Y	2.70E-07	1.16E-06	2.42E-05	.00E+00	4.85E-07	4.14E-07	6.14E-07	3.56E-07	2.31E-07	3.05E-06
		5.77E-05	1.87E-06	1.16E-05	.00E+00	9.66E-07	1.84E-06	1.13E-03	8.77E-07	9.51E-07	8.95E-06
RU-106	1Y	1.57E-06	1.40E-03	4.00E-01	6.10E-07	1.00E+01	3.00E+02	6.86E-01	1.15E-01	1.0	5.00E+00
		1.84E-05	1.70E-05	1.66E-05	.00E+00	1.80E-05	1.72E-05	1.88E-05	2.11E-05	2.29E-05	2.10E-05
		9.22E-04	8.50E-04	8.32E-04	.00E+00	9.02E-04	8.61E-04	9.41E-04	1.05E-03	1.15E-03	1.05E-03
	Y	5.25E-06	1.15E-05	2.62E-04	.00E+00	5.36E-06	5.33E-06	5.40E-06	5.29E-06	5.22E-06	2.74E-05
		3.85E-03	1.08E-05	1.37E-04	.00E+00	6.07E-06	8.55E-06	6.51E-06	5.96E-06	8.36E-06	4.77E-04
AG-108	3Y	1.22E-05	1.50E-01	1.90E-03	1.90E-02	2.30E+00	7.70E+02	5.46E-03	1.62E-04	1.0	7.20E+02
		1.45E-04	1.33E-04	1.31E-04	.00E+00	1.41E-04	1.35E-04	1.48E-04	1.67E-04	1.82E-04	1.66E-04
		7.17E-03	6.61E-03	6.47E-03	.00E+00	7.01E-03	6.69E-03	7.31E-03	8.23E-03	8.99E-03	8.20E-03
	D	2.23E-06	3.85E-06	2.84E-03	.00E+00	3.92E-06	2.55E-05	2.45E-06	1.31E-06	4.81E-07	7.62E-06
		2.22E-05	1.77E-05	1.05E-05	.00E+00	3.04E-05	2.41E-04	1.14E-05	8.62E-06	4.59E-08	3.01E-05

	W	2.23E-06	3.85E-06	2.84E-05	[illegible]	3.92E-06	2.55E-05	2.45E-06	1.31E-06	4.81E-07	7.62E-06
		1.01E-04	1.25E-05	1.63E-05	.00E+00	1.29E-05	8.07E-05	8.33E-06	6.18E-06	5.51E-06	2.53E-05
	Y	2.23E-06	3.85E-06	2.84E-05	.00E+00	3.92E-06	2.55E-05	2.45E-06	1.31E-06	4.81E-07	7.62E-06
		1.69E-03	1.15E-04	2.20E-05	.00E+00	5.62E-05	1.82E-04	7.92E-05	6.22E-05	7.44E-05	2.83E-04
AG-110	3Y	2.02E-05	1.50E-01	1.90E-03	1.90E-02	2.30E+00	7.70E+02	1.01E+00	1.62E-04	1.0	7.20E+02
		2.37E-04	2.19E-04	2.16E-04	.00E+00	2.34E-04	2.22E-04	2.40E-04	2.61E-04	2.97E-04	2.68E-04
		1.25E-02	1.16E-02	1.14E-02	.00E+00	1.24E-02	1.18E-02	1.27E-02	1.38E-02	1.57E-02	1.42E-02
	D	3.07E-06	5.55E-06	4.00E-05	.00E+00	5.55E-06	3.19E-05	3.49E-06	1.82E-06	6.70E-07	1.08E-05
		3.00E-05	2.41E-05	1.45E-05	.00E+00	4.11E-05	3.00E-04	1.49E-05	1.13E-05	6.29E-06	3.96E-05
	W	3.07E-06	5.55E-06	4.00E-05	.00E+00	5.55E-06	3.19E-05	3.49E-06	1.82E-06	6.70E-07	1.08E-05
		1.17E-04	1.66E-05	2.19E-05	.00E+00	1.67E-05	8.47E-05	1.07E-05	7.88E-06	7.44E-06	3.09E-05
	Y	3.07E-06	5.55E-06	4.00E-05	.00E+00	5.55E-06	3.19E-05	3.49E-06	1.82E-06	6.70E-07	1.08E-05
		4.44E-04	3.89E-05	2.20E-05	.00E+00	2.29E-05	6.62E-05	2.49E-05	1.92E-05	2.36E-05	8.03E-05
CD-109	3Y	1.17E-08	3.00E-01	5.30E-04	1.00E-03	2.00E+02	2.00E+03	5.45E-01	1.48E-02	1.0	7.30E+01
		7.74E-07	5.59E-07	5.34E-07	.00E+00	9.06E-07	4.90E-07	3.86E-07	1.32E-06	1.39E-06	1.84E-06
		1.87E-05	1.48E-05	1.41E-05	.00E+00	1.97E-05	1.44E-05	1.14E-05	3.22E-05	3.05E-05	3.35E-05
	D	1.17E-06	1.51E-06	1.71E-05	.00E+00	1.51E-04	2.73E-05	1.37E-06	1.21E-06	1.02E-06	1.31E-05
		1.24E-05	1.07E-05	1.24E-05	.00E+00	1.46E-03	2.64E-04	1.28E-05	1.16E-05	9.84E-06	1.14E-04
	W	1.17E-06	1.51E-06	1.71E-05	.00E+00	1.51E-04	2.73E-05	1.37E-06	1.21E-06	1.02E-06	1.31E-05
		5.40E-05	3.34E-06	1.09E-05	.00E+00	4.22E-04	7.59E-06	3.77E-06	3.43E-06	2.83E-06	3.96E-05
	Y	1.17E-06	1.51E-06	1.71E-05	.00E+00	1.51E-04	2.73E-05	1.37E-06	1.21E-06	1.02E-06	1.31E-05
		2.89E-04	1.54E-06	9.25E-06	.00E+00	1.24E-04	2.32E-06	1.65E-06	1.40E-06	8.88E-07	4.51E-05
SN-113	2W	1.87E-06	2.50E-03	8.00E-02	1.20E-03	3.00E+03	1.00E+03	2.20E+00	1.62E-04	8.50E+01	7.20E+02
		2.41E-05	2.19E-05	2.15E-05	.00E+00	2.36E-05	2.22E-05	2.46E-05	2.98E-05	3.06E-05	2.88E-05
		1.13E-03	1.02E-03	1.01E-03	.00E+00	1.09E-03	1.04E-03	1.15E-03	1.38E-03	1.47E-03	1.32E-03
	D	9.40E-08	5.29E-07	2.93E-05	.00E+00	2.04E-07	1.61E-07	6.59E-07	8.66E-07	7.99E-08	3.08E-06
		3.52E-06	1.82E-06	6.51E-06	.00E+00	1.93E-06	1.79E-06	9.21E-06	1.87E-05	1.88E-06	4.00E-06
	W	9.40E-08	5.29E-07	2.93E-05	.00E+00	2.04E-07	1.61E-07	6.59E-07	8.66E-07	7.99E-08	3.08E-06
		6.81E-05	1.57E-06	1.45E-05	.00E+00	8.84E-07	1.46E-06	2.05E-06	4.88E-06	8.40E-07	1.07E-05
SN-126	2W	1.47E-05	2.50E-03	8.00E-02	1.20E-03	3.00E+03	1.00E+03	6.93E-06	1.62E-04	8.50E+01	7.20E+02
		1.46E-04	1.34E-04	1.32E-04	.00E+00	1.42E-04	1.36E-04	1.47E-04	1.70E-04	1.84E-04	1.68E-04
		7.23E-03	6.66E-03	6.51E-03	.00E+00	7.06E-03	6.74E-03	7.32E-03	8.38E-03	9.11E-03	8.28E-03
	D	2.22E-06	5.92E-06	1.60E-04	.00E+00	3.03E-06	2.53E-06	1.01E-05	1.87E-05	2.04E-06	1.95E-05
		5.96E-05	4.51E-05	7.92E-05	.00E+00	5.33E-05	4.74E-05	2.08E-04	4.37E-04	4.85E-05	8.73E-05
	W	2.22E-06	5.92E-06	1.60E-04	.00E+00	3.03E-06	2.53E-06	1.01E-05	1.87E-05	2.04E-06	1.95E-05
		5.59E-04	2.22E-05	9.66E-05	.00E+00	1.89E-05	2.27E-05	6.25E-05	1.23E-04	1.81E-05	9.95E-05
SB-124	2W	1.38E-05	1.10E-02	4.00E-03	1.10E-04	1.00E+00	1.00E+01	4.20E+00	1.62E-04	9.00E+00	7.30E+01
		1.56E-04	1.44E-04	1.43E-04	.00E+00	1.55E-04	1.47E-04	1.59E-04	1.70E-04	1.92E-04	1.76E-04
		8.62E-03	8.15E-03	8.08E-03	.00E+00	8.77E-03	8.32E-03	8.94E-03	9.58E-03	1.08E-02	9.95E-03
	D	6.11E-07	3.81E-06	7.88E-05	.00E+00	1.35E-06	2.42E-06	2.28E-06	2.96E-06	4.37E-07	9.81E-06
		7.51E-06	2.95E-06	1.46E-05	.00E+00	2.84E-06	9.32E-06	5.66E-06	1.26E-05	2.10E-06	5.55E-06
	W	2.00E-07	3.50E-06	8.62E-05	.00E+00	9.43E-07	8.07E-07	1.41E-06	6.99E-07	6.51E-08	1.01E-05
		1.53E-04	5.77E-06	4.03E-05	.00E+00	2.87E-06	6.51E-06	4.03E-06	4.59E-06	2.49E-06	2.52E-05
SB-125	2W	3.13E-06	1.10E-02	4.00E-03	1.10E-04	1.00E+00	1.00E+01	2.50E-01	1.62E-04	9.00E+00	7.30E+01
		3.82E-05	3.51E-05	3.42E-05	.00E+00	3.74E-05	3.55E-05	3.88E-05	4.52E-05	4.81E-05	4.43E-05
		1.85E-03	1.70E-03	1.66E-03	.00E+00	1.80E-03	1.72E-03	1.88E-03	2.18E-03	2.32E-03	2.13E-03
	D	2.23E-07	1.10E-06	2.14E-05	.00E+00	4.18E-07	9.21E-07	8.36E-07	2.17E-06	1.71E-07	2.81E-06
		2.36E-06	1.14E-06	4.25E-06	.00E+00	1.12E-06	3.92E-06	2.40E-06	1.01E-05	8.44E-07	2.13E-06
	W	5.03E-08	9.51E-07	2.33E-05	.00E+00	2.43E-07	2.32E-07	4.48E-07	3.35E-07	2.06E-08	2.80E-06
		8.03E-05	2.33E-06	1.24E-05	.00E+00	1.24E-06	3.17E-06	1.98E-06	3.62E-06	1.20E-06	1.22E-05
I-125	1D	3.14E-07	4.50E-03	7.00E-03	9.90E-03	1.50E+01	5.00E+00	4.20E+00	1.15E-01	1.0	5.00E+00
		1.09E-06	7.73E-07	6.76E-07	.00E+00	1.87E-06	7.90E-07	3.98E-07	1.89E-06	2.28E-06	2.47E-06
		2.45E-05	1.73E-05	1.51E-05	.00E+00	4.20E-05	1.76E-05	8.91E-06	4.24E-05	5.08E-05	5.57E-05
	D	1.51E-07	2.52E-07	1.10E-07	.00E+00	1.00E-07	1.09E-07	2.52E-07	2.45E-07	1.27E-03	3.85E-05
		4.40E-07	9.18E-08	6.88E-08	.00E+00	6.33E-08	7.40E-08	1.63E-07	1.58E-07	7.99E-04	2.42E-05
I-129	1D	1.61E-08	4.50E-03	7.00E-03	9.90E-03	1.50E+01	5.00E+00	4.42E-08	1.15E-01	1.0	5.00E+00
		1.07E-06	7.79E-07	6.69E-07	.00E+00	1.77E-06	8.43E-07	4.02E-07	1.87E-06	2.17E-06	2.20E-06
		2.06E-05	1.51E-05	1.29E-05	.00E+00	3.39E-05	1.65E-05	7.82E-06	3.62E-05	4.15E-05	4.17E-05
	D	6.11E-07	8.10E-07	5.14E-07	.00E+00	4.96E-07	5.11E-07	8.18E-07	6.03E-07	9.18E-03	2.76E-04
		1.16E-06	3.67E-07	3.24E-07	.00E+00	3.12E-07	3.26E-07	5.18E-07	5.11E-07	5.77E-03	1.74E-04
I-131	1D	2.65E-06	4.50E-03	7.00E-03	9.90E-03	1.50E+01	5.00E+00	3.14E+01	1.15E-01	1.0	5.00E+00
		3.47E-05	3.18E-05	3.12E-05	.00E+00	3.36E-05	3.22E-05	3.57E-05	4.28E-05	4.38E-05	4.04E-05
		1.64E-03	1.51E-03	1.48E-03	.00E+00	1.59E-03	1.52E-03	1.69E-03	2.02E-03	2.07E-03	1.91E-03
	D	3.77E-07	1.13E-06	1.57E-07	.00E+00	1.67E-07	1.83E-07	3.49E-07	3.23E-07	1.76E-03	5.33E-05
		2.43E-06	2.78E-07	9.58E-08	.00E+00	1.12E-07	1.44E-07	2.32E-07	2.12E-07	1.08E-03	3.29E-05
CS-134	1D	1.16E-05	5.00E-03	1.40E-02	7.10E-03	2.00E+03	1.00E+02	3.36E-01	1.62E-04	1.0	7.20E+02
		1.39E-04	1.28E-04	1.26E-04	.00E+00	1.36E-04	1.30E-04	1.41E-04	1.56E-04	1.74E-04	1.58E-04
		7.04E-03	6.51E-03	6.38E-03	.00E+00	6.91E-03	6.58E-03	7.17E-03	7.91E-03	8.83E-03	8.01E-03
	D	6.51E-05	7.44E-05	8.10E-05	.00E+00	7.44E-05	7.44E-05	6.92E-05	6.44E-05	6.51E-05	7.33E-05
		4.37E-05	4.62E-05	5.11E-05	.00E+00	4.70E-05	4.70E-05	4.37E-05	4.07E-05	4.11E-05	4.62E-05
CS-135	1D	.00E+00	5.00E-03	1.40E-02	7.10E-03	2.00E+03	1.00E+02	3.01E-07	1.62E-04	1.0	7.20E+02
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00

	D	7.07E-06	7.36E-06	7.07E-06	.00E+00	7.07E-06	7.07E-06	7.07E-06	7.07E-06	7.07E-06	7.07E-06
		5.22E-06	4.48E-06	4.44E-06	.00E+00	4.44E-06	4.44E-06	4.44E-06	4.44E-06	4.44E-06	4.55E-06
CS-136	1D	1.51E-05	5.00E-03	1.40E-02	7.10E-03	2.00E+03	1.00E+02	1.92E+01	1.62E-04	1.0	7.20E+02
		1.88E-04	1.74E-04	1.71E-04	.00E+00	1.86E-04	1.70E-04	1.90E-04	2.12E-04	2.38E-04	2.14E-04
		9.91E-03	9.16E-03	9.02E-03	.00E+00	9.77E-03	9.29E-03	1.00E-02	1.11E-02	1.25E-02	1.13E-02
	D	9.69E-06	1.25E-05	1.26E-05	.00E+00	1.17E-05	1.17E-05	1.09E-05	1.00E-05	1.01E-05	1.12E-05
		8.56E-06	7.25E-06	7.81E-06	.00E+00	7.29E-06	7.40E-06	6.88E-06	6.29E-06	6.40E-06	7.23E-06
CS-137	1D	4.60E-06	5.00E-03	1.40E-02	7.10E-03	2.00E+03	1.00E+02	2.31E-02	[illegible]	1.0	7.20E+02
		5.36E-05	4.95E-05	4.84E-05	.00E+00	5.26E-05	5.00E-05	5.46E-05	6.06E-05	6.72E-05	6.11E-05
		2.68E-03	2.48E-03	2.45E-03	.00E+00	2.63E-03	2.51E-03	2.74E-03	3.04E-03	3.37E-03	3.06E-03
	D	4.70E-05	5.14E-05	5.33E-05	.00E+00	5.07E-05	5.03E-05	4.88E-05	4.66E-05	4.66E-05	5.06E-05
		3.26E-05	3.19E-05	3.36E-05	.00E+00	3.19E-05	3.18E-05	3.07E-05	2.94E-05	2.93E-05	3.18E-05
BA-140	1D	[illegible]	[illegible]	9.70E-05	3.50E-04	4.00E+00	2.00E+02	1.97E+01	1.11E-04	9.00E+00	7.30E+01
		1.70E-05	1.56E-05	1.52E-05	.00E+00	1.66E-05	1.56E-05	1.72E-05	2.05E-05	2.15E-05	1.98E-05
		8.13E-04	7.46E-04	7.29E-04	.00E+00	7.90E-04	7.36E-04	8.27E-04	9.75E-04	1.02E-03	9.41E-04
	D	2.45E-07	2.16E-06	[illegible]	.00E+00	5.59E-07	4.33E-07	1.62E-06	2.05E-06	1.94E-07	[illegible]
		6.14E-06	1.25E-06	1.61E-05	.00E+00	1.07E-06	1.05E-06	[illegible]	8.22E-06	9.47E-06	[illegible]
LA-140	1W	1.66E-05	2.50E-03	2.00E-04	2.00E-05	2.50E+01	1.00E+03	1.51E+02	1.11E-04	9.00E+00	7.30E+01
		1.89E-04	1.75E-04	1.74E-04	.00E+00	1.83E-04	1.70E-04	1.91E-04	2.05E-04	2.33E-04	2.13E-04
		1.09E-02	1.01E-02	1.00E-02	.00E+00	1.09E-02	1.03E-02	1.11E-02	1.18E-02	1.34E-02	1.23E-02
	W	1.48E-07	4.03E-06	[illegible]	.00E+00	6.25E-07	6.25E-07	1.04E-06	3.01E-07	2.37E-08	8.44E-06
		1.56E-05	1.73E-06	2.03E-05	.00E+00	6.33E-07	2.63E-06	7.92E-07	5.22E-07	2.54E-07	4.85E-05
CE-141	3Y	2.96E-07	7.30E-04	1.20E-03	2.00E-05	1.00E+00	1.00E+03	7.79E+00	4.67E-04	10.0	7.20E+03
		7.02E-06	6.28E-06	6.10E-06	.00E+00	6.69E-06	6.37E-06	6.31E-06	1.10E-05	9.80E-06	8.78E-06
		3.11E-04	2.79E-04	2.71E-04	.00E+00	2.93E-04	2.82E-04	2.82E-04	4.55E-04	4.31E-04	3.86E-04
	Y	5.29E-09	8.25E-07	3.20E-05	.00E+00	4.40E-08	7.25E-08	1.25E-07	8.51E-08	6.66E-10	2.90E-06
		6.18E-05	5.92E-07	1.52E-05	.00E+00	1.19E-07	9.66E-07	3.32E-07	9.40E-07	9.43E-08	8.95E-06
	W	5.29E-09	8.25E-07	3.20E-05	.00E+00	4.40E-08	7.25E-08	1.25E-07	8.51E-08	6.66E-10	2.90E-06
		4.14E-05	6.96E-07	1.42E-05	.00E+00	3.55E-07	1.28E-05	1.55E-06	1.40E-05	1.71E-07	8.32E-06
	D	5.29E-09	8.25E-07	3.20E-05	.00E+00	4.40E-08	7.25E-08	1.25E-07	8.51E-08	6.66E-10	2.90E-06
		4.14E-05	6.96E-07	1.42E-05	.00E+00	3.55E-07	1.28E-05	1.55E-06	1.40E-05	1.71E-07	6.32E-06
CE-144	3Y	2.83E-07	7.30E-04	1.20E-03	2.00E-05	1.00E+00	1.00E+03	8.91E-01	4.67E-04	10.0	7.20E+03
		4.33E-06	3.94E-06	3.85E-06	.00E+00	4.31E-06	4.02E-06	4.08E-06	5.36E-06	5.65E-06	5.14E-06
		2.91E-04	2.11E-04	2.08E-04	.00E+00	2.29E-04	2.18E-04	2.23E-04	2.86E-04	2.95E-04	2.70E-04
	Y	2.41E-08	4.11E-06	2.46E-04	.00E+00	4.81E-08	2.56E-06	3.30E-07	4.74E-07	1.91E-08	2.10E-05
		2.93E-03	4.40E-06	1.37E-04	.00E+00	1.16E-06	9.58E-05	1.07E-05	1.75E-05	1.08E-06	3.74E-04
	W	2.41E-08	4.11E-06	2.46E-04	.00E+00	4.81E-08	2.56E-06	3.30E-07	4.74E-07	1.91E-08	2.10E-05
		6.77E-04	1.04E-05	1.28E-04	.00E+00	8.03E-06	[illegible]	[illegible]	1.68E-04	6.96E-06	2.18E-04
	D	2.41E-08	4.11E-06	2.46E-04	.00E+00	4.81E-08	2.56E-06	[illegible]	4.74E-07	1.91E-08	[illegible]
		6.77E-04	1.04E-05	1.28E-04	.00E+00	8.03E-06	[illegible]	[illegible]	1.68E-04	6.96E-06	[illegible]
EU-152	1W	7.79E-06	2.50E-03	4.80E-03	2.00E-05	2.50E+01	[illegible]	[illegible]	1.11E-04	9.00E+00	7.30E+01
		9.71E-05	8.93E-05	8.80E-05	.00E+00	9.66E-05	[illegible]	[illegible]	1.11E-04	1.23E-04	1.11E-04
		5.17E-03	4.77E-03	4.71E-03	.00E+00	5.13E-03	[illegible]	[illegible]	[illegible]	6.53E-03	5.90E-03
	W	8.68E-07	2.38E-06	3.70E-05	.00E+00	1.72E-06	1.11E-05	3.60E-06	7.73E-08	2.46E-07	6.47E-06
		2.19E-04	7.36E-05	5.55E-05	.00E+00	1.37E-04	1.29E-03	[illegible]	8.88E-04	[illegible]	[illegible]
EU-154	1W	8.63E-06	2.50E-03	4.80E-03	2.00E-05	2.50E+01	1.00E+03	[illegible]	1.11E-04	[illegible]	[illegible]
		1.06E-04	9.80E-05	9.67E-05	.00E+00	1.05E-04	9.97E-05	1.06E-04	1.19E-04	1.34E-04	[illegible]
		5.72E-03	5.29E-03	5.22E-03	.00E+00	5.66E-03	5.37E-03	5.75E-03	6.37E-03	7.22E-03	6.50E-03
	W	7.99E-07	3.03E-06	5.66E-05	.00E+00	1.66E-06	1.37E-05	4.25E-06	1.65E-05	2.11E-07	9.55E-06
		2.93E-04	6.66E-05	6.62E-05	.00E+00	1.25E-04	1.58E-03	3.62E-04	1.84E-03	2.64E-03	2.86E-04
YB-169	2Y	8.78E-07	2.50E-03	4.00E-03	2.00E-05	2.50E+01	1.00E+03	7.91E+00	1.11E-04	9.00E+00	7.30E+01
		2.76E-05	2.42E-05	2.28E-05	.00E+00	2.73E-05	2.53E-05	2.20E-05	4.47E-05	4.03E-05	3.56E-05
		1.13E-03	9.93E-04	9.43E-04	.00E+00	1.10E-03	1.03E-03	9.38E-04	1.78E-03	1.61E-03	1.43E-03
	W	1.80E-08	9.66E-07	2.63E-05	.00E+00	1.81E-07	1.24E-07	6.14E-07	2.71E-07	1.36E-08	3.00E-06
		3.45E-03	1.07E-06	1.18E-05	.00E+00	9.32E-07	1.52E-06	3.74E-06	2.72E-05	3.05E-07	6.99E-06
	Y	1.80E-08	9.66E-07	2.63E-05	.00E+00	1.81E-07	1.24E-07	6.14E-07	2.71E-07	1.36E-08	3.00E-06
		5.14E-05	1.29E-06	1.25E-05	.00E+00	4.51E-07	1.21E-06	1.41E-06	2.33E-06	3.17E-07	8.07E-06
PB-210	1D	1.03E-08	4.00E-03	7.10E-04	1.20E-04	1.00E+02	1.00E+02	3.11E-02	4.11E-03	8.40E+02	7.20E+03
		1.43E-07	1.10E-07	9.65E-08	.00E+00	1.63E-07	1.23E-07	6.45E-08	2.63E-07	2.42E-07	3.00E-07
		4.23E-06	3.35E-06	2.87E-06	.00E+00	5.01E-06	3.79E-06	1.93E-06	7.81E-06	7.30E-06	6.70E-06
	D	4.62E-04	4.62E-04	4.81E-04	.00E+00	1.04E-02	2.25E-02	5.48E-03	7.99E-02	[illegible]	5.36E-03
		1.18E-03	1.18E-03	1.18E-03	.00E+00	2.63E-02	5.70E-02	1.79E-02	2.02E-01	1.18E-03	1.36E-02
PO-210	2W	6.13E-11	2.60E-04	4.00E-03	3.40E-04	[illegible]	2.00E+04	1.83E+00	4.11E-03	9.00E+00	7.30E+01
		7.59E-10	7.03E-10	6.89E-10	.00E+00	7.48E-10	7.10E-10	7.71E-10	8.40E-10	9.56E-10	8.60E-10
		3.91E-08	3.63E-08	3.56E-08	.00E+00	3.86E-08	3.66E-08	3.97E-08	4.33E-08	[illegible]	4.44E-08
	W	3.05E-04	3.09E-04	4.85E-04	.00E+00	9.44E-03	1.62E-03	3.05E-04	3.05E-04	3.05E-04	1.90E-03
		4.81E-02	4.66E-04	5.51E-04	.00E+00	1.44E-02	2.48E-03	4.66E-04	[illegible]	4.66E-04	8.56E-03
	D	3.05E-04	3.09E-04	4.85E-04	.00E+00	9.44E-03	1.62E-03	3.05E-04	3.05E-04	3.05E-04	1.90E-03
		2.70E-03	1.49E-03	1.52E-03	.00E+00	4.62E-02	7.99E-03	1.49E-03	1.49E-03	1.49E-03	9.40E-03
RN-222	1*	1.23E-05	3.50E+00	2.00E-02	2.00E-02	[illegible]	1.00E+00	6.62E+01	1.00E+00	1.00E+00	1.00E+00
		3.50E-08	3.22E-08	3.14E-08	.00E+00	3.40E-08	3.26E-08	3.58E-08	4.09E-08	4.35E-08	4.02E-08
		1.70E-06	1.56E-06	1.53E-06	.00E+00	1.65E-06	1.58E-06	1.74E-06	1.99E-06	2.11E-06	1.95E-06
	*	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00

		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
RA-226	2W	1.24E-05	1.40E-02	5.10E-04	5.90E-04	5.00E+01	2.50E+02	4.33E-04	4.11E-03	3.00E+01	2.50E+02
		6.22E-07	5.61E-07	5.50E-07	.00E+00	5.85E-07	5.69E-07	5.87E-07	9.17E-07	8.37E-07	7.60E-07
		2.82E-05	2.54E-05	2.49E-05	.00E+00	2.65E-05	2.58E-05	2.71E-05	4.15E-05	3.79E-05	3.43E-05
	W	3.09E-04	3.42E-04	4.85E-04	.00E+00	3.39E-04	3.39E-04	2.21E-03	[illegible]53E-02	3.39E-04	1.32E-03
		5.96E-02	3.77E-04	4.51E-04	.00E+00	3.77E-04	3.77E-04	2.46E-03	[illegible].61E-02	3.77E-04	8.58E-03
RA-228	2W	6.47E-08	1.40E-02	5.10E-04	5.90E-04	5.00E+01	2.50E+02	1.21E-01	4.11E-03	3.00E+01	2.50E+02
		3.79E-15	9.78E-16	1.97E-15	.00E+00	5.75E-16	4.66E-17	1.35E-15	6.16E-15	2.40E-15	6.67E-14
		1.82E-14	4.682-15	9.45E-15	.00E+00	2.76E-17	2.24E-16	5.97E-15	2.95E-14	1.15E-14	3.20E-13
	W	5.81E-04	5.81E-04	6.59E-04	.00E+00	5.81E-04	5.81E-04	2.42E-03	2.15E-02	5.81E-04	1.44E-03
		2.87E-02	6.81E-04	7.25E-04	.00E+00	6.77E-04	6.81E-04	2.73E-03	2.41E-02	6.77E-04	4.77E-03
AC-227	2Y	1.43E-06	2.50E-03	6.00E-02	2.00E-05	2.50E+01	1.00E+03	3.16E-02	4.11E-03	3.00E+02	2.[illegible]0E+03
		1.17E-08	9.95E-09	9.78E-09	.00E+00	9.97E-09	9.81E-09	9.45E-09	1.93E-08	1.67E-08	2.12E-08
		4.83E-07	4.28E-07	4.13E-07	.00E+00	4.40E-07	4.32E-07	4.03E-07	7.96E-07	6.81E-07	6.29E-07
	Y	8.1[illegible]E-07	7.25E-07	2.83E-05	.00E+00	1.09E-06	5.70E-02	2.00E-02	2.49E-01	2.79E-07	1.41E-02
		5.70E+00	5.07E-05	1.63E-04	.00E+00	5.85E-05	2.49E+00	6.62E-01	1.06E+01	2.39E-05	1.29E+00
	W	8.14E-07	7.25E-07	2.83E-05	.00E+00	1.09E-06	5.70E-02	2.00E-02	2.49E-01	2.79E-07	1.41E-02
		2.52E-01	7.18E-05	1.47E-04	.00E+00	1.32E-04	6.85E+00	2.40E+00	3.00E+01	3.41E-05	1.72E+00
TH-228	2Y	1.05E-05	4.20E-03	2.00E-04	5.00E-06	3.00E+01	5.00E+02	3.63E-01	4.11E-03	100.0	7.20E+03
		1.85E-07	1.60E-07	1.54E-07	.00E+00	1.68E-07	1.64E-07	1.50E-07	3.00E-07	2.59E-07	2.77E-07
		7.81E-06	6.00E-06	6.60E-06	.00E+00	7.28E-06	7.09E-06	6.51E-06	1.26E-05	1.10E-05	9.89E-06
	Y	8.55E-06	1.35E-05	4.88E-04	.00E+00	8.62E-06	7.44E-05	7.14E-04	8.77E-03	8.51E-06	3.96E-04
		2.50E+00	6.73E-04	1.20E-03	.00E+00	8.51E-04	7.29E-03	6.92E-02	8.47E-01	8.51E-04	3.42E-01
	W	8.55E-06	1.35E-05	4.88E-04	.00E+00	8.62E-06	7.44E-05	7.14E-04	8.77E-03	8.51E-06	3.96E-04
		3.51E-01	5.00E-03	5.33E-03	.00E+00	5.00E-03	4.33E-02	4.14E-01	5.07E+00	4.96E-03	2.50E-01
TH-229	2Y	3.03E-07	4.20E-03	2.00E-04	5.00E-06	3.00E+01	5.00E+02	9.44E-05	4.11E-03	100.0	7.20E+03
		8.02E-06	7.04E-06	6.72E-06	.00E+00	7.45E-06	7.22E-06	6.47E-06	1.33E-05	1.14E-05	1.05E-05
		3.44E-04	3.03E-04	2.93E-04	.00E+00	3.20E-04	3.11E-04	2.80E-04	5.67E-04	4.90E-04	4.32E-04
	Y	1.69E-05	2.16E-05	2.34E-04	.00E+00	1.69E-05	1.47E-04	7.07E-03	8.81E-02	1.68E-05	3.53E-03
		7.36E+00	4.37E-03	[illegible].59E-03	.00E+00	4.37E-03	3.81E-02	1.70E+00	2.12E+01	4.37E-03	1.73E+00
	W	1.69E-05	2.16E-05	2.34E-04	.00E+00	1.69E-05	1.47E-04	7.07E-03	8.81E-02	1.68E-05	3.53E-03
		2.94E-01	1.02E-02	1.04E-02	.00E+00	1.02E-02	8.92E-02	4.25E+00	5.29E+01	1.02E-02	2.15E+00
TH-230	2Y	4.92E-10	4.20E-03	2.00E-04	5.00E-06	3.00E+01	5.00E+02	9.00E-06	4.11E-03	100.0	7.20E+03
		3.86E-08	3.09E-08	2.97E-08	.00E+00	3.2[illegible]E-08	3.12E-08	2.56E-08	6.59E-08	5.48E-08	9.07E-08
		1.41E-06	1.21E-06	1.19E-06	.00E+00	1.33E-06	1.27E-06	1.02E-06	2.41E-06	2.07E-06	1.96E-06
	Y	2.52E-06	6.55E-06	1.82E-04	.00E+00	2.52E-06	2.20E-05	1.07E-03	1.33E-02	2.52E-06	5.48E-04
		1.11E+00	6.40E-04	7.40E-04	.00E+00	6.36E-04	5.59E-03	2.59E-01	3.22E+00	6.36E-04	2.62E-01
	W	2.52E-06	6.55E-06	1.82E-04	.00E+00	2.52E-06	2.20E-05	1.07E-03	1.33E-02	2.52E-06	5.48E-04
		5.96E-02	1.51E-03	1.60E-03	.00E+00	1.51E-03	1.32E-02	6.40E-01	7.99E+00	1.51E-03	3.26E-01
TH-232	2Y	2.57E-10	4.20E-03	2.00E-04	5.00E-06	3.00E+01	5.00E+02	4.92E-11	4.11E-03	100.0	7.20E+03
		1.96E-08	1.43E-08	1.41E-08	.00E+00	1.48E-08	1.38E-08	1.13E-08	3.40E-08	2.73E-08	6.66E-08
		5.96E-07	4.98E-07	4.81E-07	.00E+00	5.61E-07	5.24E-07	3.97E-07	1.04E-06	8.93E-07	9.33E-07
	Y	4.62E-06	7.92E-06	1.58E-04	.00E+00	4.62E-06	3.77E-05	5.48E-03	6.84E-02	4.48E-06	2.73E-03
		3.48E+00	2.24E-03	2.32E-03	.00E+00	2.25E-03	1.86E-02	1.48E+00	1.85E+01	2.22E-03	1.15E+00
	W	4.62E-06	7.92E-06	1.58E-04	.00E+00	4.62E-06	3.77E-05	5.48E-03	6.84E-02	4.48E-06	2.73E-03
		5.33E-02	2.74E-03	2.91E-03	.00E+00	2.83E-03	2.31E-02	3.30E+00	4.11E+01	2.75E-03	1.54E+00
PA-231	2Y	1.70E-07	2.50E-03	6.00E-02	5.00E-06	1.10E+01	1.10E+02	2.13E-05	4.11E-03	8.40E+02	7.20E+03
		2.76E-06	2.49E-06	2.44E-06	.00E+00	2.66E-06	2.51E-06	2.72E-06	3.73E-06	3.62E-06	3.58E-06
		1.25E-04	1.13E-04	1.11E-04	.00E+00	1.20E-04	1.15E-04	1.25E-04	1.68E-04	1.63E-04	1.51E-04
	Y	2.52E-07	4.62E-06	1.98E-04	.00E+00	2.51E-05	1.61E-05	2.14E-02	2.67E-01	2.34E-07	1.06E-02
		2.76E+00	1.84E-05	1.35E-04	.00E+00	2.25E-03	1.40E-03	1.07E+00	1.33E+01	1.65E-05	8.58E-01
	W	2.52E-07	4.62E-06	1.98E-04	.00E+00	2.51E-05	1.61E-05	2.14E-02	2.67E-01	2.34E-07	1.06E-02
		6.36E-02	1.98E-05	1.33E-04	.00E+00	3.08E-03	1.98E-03	2.58E+00	3.22E+01	2.83E-05	1.28E+00
U-232	3Y	4.45E-10	2.50E-03	3.40E-04	6.10E-04	2.00E+00	6.00E+01	9.63E-03	1.25E-04	8.40E+02	7.20E+03
		2.86E-08	2.04E-08	2.08E-08	.00E+00	1.97E-08	1.66E-08	1.73E-08	4.82E-08	3.89E-08	1.03E-07
		8.37E-07	7.07E-07	6.68E-07	.00E+00	7.74E-07	7.30E-07	6.08E-07	1.41E-06	1.22E-06	1.33E-06
	Y	1.23E-06	5.81E-06	2.06E-04	.00E+00	2.32E-04	1.21E-06	6.22E-05	9.81E-04	1.20E-06	6.92E-05
		5.48E+00	1.20E-04	2.33E-04	.00E+00	1.02E-02	1.30E-04	1.73E-03	2.64E-02	8.99E-05	8.59E-01
	W	3.07E-05	3.47E-05	2.25E-04	.00E+00	5.81E-03	3.04E-05	1.55E-03	2.45E-02	3.00E-05	1.31E-03
		9.21E-02	9.44E-05	2.01E-04	.00E+00	1.75E-02	9.25E-05	4.55E-03	7.18E-02	9.14E-05	1.49E-02
	D	3.07E-05	3.47E-05	2.25E-04	.00E+00	5.81E-03	3.04E-05	1.55E-03	2.45E-02	3.00E-05	1.31E-03
		1.51E-03	2.92E-04	3.26E-04	.00E+00	5.62E-02	2.94E-04	1.50E-02	2.38E-01	2.90E-04	1.[illegible]7E-02
U-233	3Y	7.23E-10	2.50E-03	3.40E-04	6.10E-04	2.00E+00	6.00E+01	4.35E-06	1.25E-04	8.40E+02	7.20E+03
		2.26E-08	1.87E-08	1.86E-08	.00E+00	1.83E-08	1.81E-08	1.77E-08	3.73E-08	3.10E-08	5.00E-08
		8.90E-07	7.86E-07	7.80E-07	.00E+00	8.07E-07	7.93E-07	7.45E-07	1.47E-06	1.26E-06	1.20E-06
	Y	3.89E-07	4.51E-06	1.84E-04	.00E+00	7.03E-05	3.89E-07	1.09E-05	1.71E-04	3.89E-07	2.65E-05
		1.12E+00	1.24E-05	1.[illegible]E-04	.00E+00	1.80E-03	1.01E-05	2.73E-04	4.29E-03	9.99E-06	1.35E-01
	W	9.69E-06	1.38E-05	1.84E-04	.00E+00	1.75E-03	9.69E-06	2.72E-04	4.29E-03	9.69E-06	2.89E-04
		5.99E-02	3.03E-05	1.17E-04	.00E+00	5.11E-03	2.82E-05	7.92E-04	1.24E-02	2.82E-05	7.99E-03
	D	9.69E-06	1.38E-05	1.84E-04	.00E+00	1.75E-03	9.69E-06	2.72E-04	4.29E-03	9.69E-06	2.89E-04
		1.19E-03	9.44E-05	1.21E-04	.00E+00	1.70E-02	9.40E-05	2.63E-03	4.14E-02	9.40E-05	2.79E-03
U-234	3Y	1.59E-10	2.50E-03	3.40E-04	6.10E-04	2.00E+00	6.00E+01	2.84E-06	1.25E-04	8.40E+02	7.20E+03
		1.74E-08	1.11E-08	1.19E-08	.00E+00	1.00E-08	9.34E-09	9.15E-09	2.95E-08	2.31E-08	8.07E-08

		4.11E-07	3.37E-07	3.19E-07	.00E+00	3.74E-07	3.48E-07	2.76E-07	7.09E-07	6.08E-07	7.65E-07
	Y	3.81E-07	4.51E-06	1.83E-04	.00E+00	6.92E-05	3.81E-07	1.07E-05	1.67E-04	3.81E-07	2.61E-05
		1.10E+00	1.22E-05	1.15E-04	.00E+00	1.77E-02	9.88E-06	2.67E-04	4.18E-03	9.81E-06	1.32E-01
	W	9.55E-06	1.37E-05	1.83E-04	.00E+00	1.73E-03	9.55E-06	2.67E-04	4.18E-03	9.55E-06	2.83E-04
		5.82E-02	2.98E-05	1.17E-04	.00E+00	5.03E-03	2.78E-05	7.77E-04	1.22E-02	2.78E-05	7.88E-03
	D	9.55E-06	1.37E-05	1.83E-04	.00E+00	1.73E-03	9.55E-06	2.67E-04	4.18E-03	9.55E-06	2.83E-04
		1.16E-03	9.32E-05	1.19E-04	.00E+00	1.67E-02	9.25E-05	2.58E-03	4.03E-02	9.25E-05	2.73E-03
U-235	3Y	6.41E-07	2.50E-03	3.40E-04	6.10E-04	2.00E+00	8.00E+01	9.85E-10	1.25E-04	8.40E+02	7.20E+03
		1.29E-05	1.26E-05	1.22E-05	.00E+00	1.30E-05	1.27E-05	1.33E-05	2.07E-05	1.88E-05	1.71E-05
		6.31E-04	5.70E-04	5.59E-04	.00E+00	5.92E-04	5.77E-04	6.06E-04	9.36E-04	8.51E-04	7.70E-04
	Y	3.74E-07	4.55E-06	1.97E-04	.00E+00	6.40E-05	4.22E-07	1.03E-05	1.55E-04	3.63E-07	2.67E-05
		1.02E+00	2.50E-05	1.27E-04	.00E+00	1.65E-03	2.72E-05	2.65E-04	3.88E-03	1.52E-05	1.23E-01
	W	9.10E-06	1.32E-05	1.96E-04	.00E+00	1.60E-03	9.10E-06	2.52E-04	3.88E-03	9.07E-06	2.66E-04
		5.48E-02	2.92E-05	1.21E-04	.00E+00	4.66E-03	2.73E-05	7.33E-04	1.13E-02	2.67E-05	7.29E-03
	D	9.10E-06	1.32E-05	1.96E-04	.00E+00	1.60E-03	9.10E-06	2.52E-04	3.88E-03	9.07E-06	2.66E-04
		1.09E-03	8.77E-05	1.17E-04	.00E+00	1.55E-02	8.73E-05	2.43E-03	3.74E-02	8.77E-05	2.53E-03
U-236	3Y	2.62E-10	2.50E-03	3.40E-04	6.10E-04	2.00E+00	6.00E+01	2.96E-08	1.25E-04	8.40E+02	7.20E+03
		1.40E-08	8.41E-09	8.17E-09	.00E+00	6.83E-09	6.66E-09	6.53E-09	2.41E-08	1.81E-08	7.33E-08
		2.99E-07	2.39E-07	2.21E-07	.00E+00	2.61E-07	2.48E-07	1.72E-07	5.39E-07	4.47E-07	6.05E-07
	Y	3.62E-07	4.25E-06	1.73E-04	.00E+00	6.55E-05	3.62E-07	1.01E-05	1.58E-04	3.62E-07	2.47E-05
		1.04E+00	1.15E-05	1.09E-04	.00E+00	1.68E-03	9.32E-06	2.53E-04	3.96E-03	9.29E-06	1.25E-01
	W	9.07E-06	1.29E-05	1.73E-04	.00E+00	1.64E-03	9.07E-06	2.53E-04	3.96E-03	9.07E-06	2.69E-04
		5.59E-02	2.83E-05	1.10E-04	.00E+00	4.77E-03	2.63E-05	7.36E-04	1.15E-02	2.63E-05	7.44E-03
	D	9.07E-06	1.29E-05	1.73E-04	.00E+00	1.64E-03	9.07E-06	2.53E-04	3.96E-03	9.07E-06	2.69E-04
		1.11E-03	8.81E-05	1.13E-04	.00E+00	1.58E-02	8.77E-05	2.44E-03	3.85E-02	8.77E-05	2.58E-03
U-238	3Y	8.03E-08	2.50E-03	3.40E-04	6.10E-04	2.00E+00	6.00E+01	1.54E-10	1.25E-04	8.40E+02	7.20E+03
		1.21E-08	7.22E-09	7.90E-09	.00E+00	5.85E-09	5.67E-09	5.56E-09	2.09E-08	1.57E-08	6.46E-08
		2.51E-07	1.99E-07	1.84E-07	.00E+00	2.19E-07	2.07E-07	1.41E-07	4.53E-07	3.76E-07	5.19E-07
	Y	3.41E-07	3.96E-06	1.69E-04	.00E+00	6.14E-05	3.43E-07	1.01E-05	1.49E-04	3.40E-07	2.38E-05
		9.84E-01	1.38E-05	1.23E-04	.00E+00	1.56E-03	1.16E-05	2.55E-04	3.74E-03	1.01E-05	1.18E-01
	W	8.51E-06	1.21E-05	1.69E-04	.00E+00	1.54E-03	8.51E-06	2.52E-04	3.74E-03	8.51E-06	2.55E-04
		5.25E-02	2.70E-05	1.18E-04	.00E+00	4.48E-03	2.49E-05	7.33E-04	1.09E-02	2.48E-05	7.03E-03
	D	8.51E-06	1.21E-05	1.69E-04	.00E+00	1.54E-03	8.51E-06	2.52E-04	3.74E-03	8.51E-06	2.55E-04
		1.04E-03	8.29E-05	1.07E-04	.00E+00	1.48E-02	8.21E-05	2.43E-03	3.62E-02	8.21E-05	2.45E-03
NP-237	2Y	1.13E-06	6.00E-02	2.00E-04	5.00E-06	1.00E+01	4.00E+02	3.24E-07	4.67E-04	3.00E+02	2.50E+03
		2.19E-06	1.87E-06	1.77E-06	.00E+00	2.11E-06	1.92E-06	1.61E-06	3.73E-06	3.25E-06	3.24E-06
		8.81E-05	7.67E-05	7.25E-05	.00E+00	8.37E-05	7.91E-05	6.70E-05	1.50E-04	1.29E-04	1.15E-04
	Y	5.66E-07	4.77E-06	1.97E-04	.00E+00	6.11E-07	3.60E-03	8.07E-03	1.01E-01	4.07E-07	4.44E-03
		5.96E-02	4.62E-05	1.59E-04	.00E+00	7.18E-05	4.33E-01	9.69E-01	1.21E+01	4.96E-05	5.40E-01
	W	5.66E-07	4.77E-06	1.97E-04	.00E+00	6.11E-07	3.60E-03	8.07E-03	1.01E-01	4.07E-07	4.44E-03
		5.96E-02	4.62E-05	1.59E-04	.00E+00	7.18E-05	4.33E-01	9.69E-01	1.21E+01	4.96E-05	5.40E-01
PU-236	2Y	1.46E-10	5.60E-04	3.90E-04	1.00E-07	2.50E+01	1.00E+02	2.43E-01	4.67E-04	10.0	7.20E+03
		1.59E-08	8.13E-09	8.70E-09	.00E+00	4.95E-09	4.84E-09	6.31E-09	2.68E-08	2.01E-08	9.92E-08
		2.09E-07	1.53E-07	1.46E-07	.00E+00	1.63E-07	1.51E-07	1.05E-07	3.76E-07	3.10E-07	5.96E-07
	Y	1.28E-09	4.96E-06	2.21E-04	.00E+00	1.81E-09	4.18E-05	1.66E-05	2.08E-04	5.77E-10	3.00E-05
		6.96E-01	8.92E-06	1.24E-04	.00E+00	8.25E-08	1.65E-01	6.70E-02	8.36E-01	3.10E-08	1.29E-01
	W	1.28E-07	5.07E-06	2.20E-04	.00E+00	1.36E-07	4.18E-03	1.66E-03	2.08E-02	5.77E-08	1.17E-03
		6.81E-02	1.48E-05	1.21E-04	.00E+00	1.88E-05	4.96E-01	1.98E-01	2.48E+00	6.88E-06	1.45E-01
PU-238	2Y	1.09E-10	5.60E-04	3.90E-04	1.00E-07	2.50E+01	1.00E+02	7.90E-03	4.67E-04	10.0	7.20E+03
		1.22E-08	5.67E-09	7.22E-09	.00E+00	2.67E-09	2.63E-09	4.51E-09	2.05E-08	1.51E-08	8.58E-08
		1.18E-07	7.83E-08	7.77E-08	.00E+00	8.04E-08	7.16E-08	5.31E-08	2.09E-07	1.71E-07	4.41E-07
	Y	3.20E-10	4.74E-06	2.10E-04	.00E+00	3.34E-10	1.08E-04	4.70E-05	5.85E-04	2.96E-10	4.96E-05
		1.18E+00	4.18E-06	1.22E-04	.00E+00	1.48E-06	5.07E-01	2.15E-01	2.68E+00	1.43E-06	2.88E-01
	W	3.14E-08	4.77E-06	2.10E-04	.00E+00	3.06E-08	1.08E-02	4.70E-03	5.85E-02	2.96E-08	3.20E-03
		6.81E-02	5.99E-06	1.11E-04	.00E+00	3.67E-06	1.30E+00	5.62E-01	7.03E+00	3.56E-06	3.92E-01
PU-239	2Y	1.89E-10	5.60E-04	3.90E-04	1.00E-07	2.50E+01	1.00E+02	2.87E-05	4.67E-04	10.0	7.20E+03
		9.94E-09	6.02E-09	6.53E-09	.00E+00	4.84E-09	4.65E-09	5.58E-09	1.47E-08	1.16E-08	3.78E-08
		2.42E-07	2.07E-07	2.03E-07	.00E+00	2.08E-07	2.05E-07	1.95E-07	4.01E-07	3.39E-07	4.11E-07
	Y	2.92E-10	4.40E-06	1.96E-04	.00E+00	3.25E-10	1.16E-04	5.22E-05	6.51E-04	2.77E-10	5.18E-05
		1.20E+00	3.96E-06	1.15E-04	.00E+00	1.42E-06	5.59E-01	2.43E-01	3.04E+00	1.39E-06	3.08E-01
	W	2.86E-08	4.44E-06	1.96E-04	.00E+00	2.83E-08	1.16E-02	5.22E-03	6.51E-02	2.77E-08	3.54E-03
		6.40E-02	5.62E-06	1.03E-04	.00E+00	3.41E-06	1.40E+00	6.25E-01	7.81E+00	3.34E-06	4.29E-01
PU-240	2Y	1.32E-10	5.60E-04	3.90E-04	1.00E-07	2.50E+01	1.00E+02	1.05E-04	4.67E-04	10.0	7.20E+03
		1.19E-08	5.63E-09	7.07E-09	.00E+00	2.86E-09	2.77E-09	4.43E-09	2.00E-08	1.49E-08	8.20E-08
		1.21E-07	8.14E-08	7.98E-08	.00E+00	8.62E-08	7.59E-08	5.45E-08	2.15E-07	1.77E-07	4.32E-07
	Y	3.04E-10	4.44E-06	1.98E-04	.00E+00	3.22E-10	1.16E-04	5.22E-05	6.51E-04	2.78E-10	5.18E-05
		1.20E+00	4.00E-06	1.15E-04	.00E+00	1.44E-06	5.59E-01	2.43E-01	3.04E+00	1.39E-06	3.08E-01
	W	2.99E-08	4.48E-06	1.97E-04	.00E+00	2.89E-08	1.16E-02	5.22E-03	6.51E-02	2.78E-08	3.54E-03
		6.40E-02	5.66E-06	1.04E-04	.00E+00	3.48E-06	1.40E+00	6.25E-01	7.81E+00	3.35E-06	4.29E-01
PU-241	2Y	1.77E-12	5.60E-04	3.90E-04	1.00E-07	2.50E+01	1.00E+02	4.81E-02	4.67E-04	10.0	7.20E+03
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
		.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00
	Y	1.66E-11	2.25E-08	9.99E-07	.00E+00	1.91E-11	2.01E-06	1.03E-06	1.29E-05	3.74E-12	7.66E-07

		1.18E-02	9.10E-08	6.70E-07	.00E+00	1.14E-07	1.11E-02	5.28E-03	6.50E-02	3.39E-08	4.96E-03
	W	1.65E-09	2.33E-08	9.99E-07	.00E+00	1.81E-09	2.01E-04	1.03E-04	1.28E-03	3.74E-10	6.84E-05
		2.75E-05	1.15E-07	5.88E-07	.00E+00	2.19E-07	2.43E-02	1.24E-02	1.55E-01	4.59E-08	8.25E-03
PU-242	2Y	1.29E-10	5.60E-04	3.90E-04	1.00E-07	2.50E+01	1.00E+02	1.83E-06	4.67E-04	10.0	7.20E+03
		1.01E-08	4.81E-09	5.99E-09	.00E+00	2.50E-09	2.44E-09	3.78E-09	1.69E-08	1.25E-08	6.82E-08
		1.07E-07	7.39E-08	7.20E-08	.00E+00	7.78E-08	6.98E-08	5.00E-08	1.92E-07	1.58E-07	3.67E-07
	Y	3.40E-10	4.22E-06	1.87E-04	.00E+00	6.48E-10	1.10E-04	4.96E-05	6.18E-04	2.73E-10	4.92E-05
		1.14E+00	3.92E-06	1.09E-04	.00E+00	1.51E-06	5.29E-01	2.31E-01	2.89E+00	1.27E-03	2.93E-01
	W	2.92E-08	4.25E-06	1.87E-04	.00E+00	3.03E-08	1.10E-02	4.96E-03	6.18E-02	2.70E-08	3.36E-03
		6.07E-02	5.51E-06	9.88E-05	.00E+00	3.60E-06	1.33E+00	5.96E-01	7.44E+00	3.25E-06	4.11E-01
PU-244	2Y	2.45E-06	5.60E-04	3.90E-04	1.00E-07	2.50E+01	1.00E+02	8.32E-09	4.67E-04	10.0	7.20E+03
		7.71E-09	3.31E-09	4.42E-09	.00E+00	1.85E-09	1.20E-09	2.68E-09	1.28E-09	9.39E-09	5.80E-08
		5.28E-08	3.03E-08	3.23E-08	.00E+00	3.26E-08	2.41E-08	2.03E-08	9.12E-08	7.63E-08	2.68E-07
	Y	3.44E-08	4.66E-06	3.09E-04	.00E+00	1.83E-07	1.10E-04	4.92E-05	6.11E-04	8.21E-09	5.85E-05
		1.12E+00	8.81E-05	2.19E-04	.00E+00	1.06E-04	5.25E-01	2.29E-01	2.85E+00	4.70E-05	2.89E-01
	W	1.20E-06	5.59E-06	3.09E-04	.00E+00	1.99E-06	1.09E-02	4.88E-03	6.07E-02	5.55E-07	3.32E-03
		6.03E-02	1.18E-04	2.40E-04	.00E+00	2.21E-04	1.32E+00	5.88E-01	7.33E+00	6.73E-05	4.03E-01
AM-241	2Y	7.65E-08	5.60E-03	3.90E-03	2.05E-05	2.50E+02	1.00E+03	1.60E-03	4.11E-03	100.	2.50E+03
		2.01E-06	1.64E-06	1.45E-06	.00E+00	1.98E-06	1.78E-06	1.08E-06	3.69E-06	3.17E-06	2.09E-06
		6.92E-05	5.69E-05	5.03E-05	.00E+00	6.91E-05	6.23E-05	3.74E-05	1.27E-04	1.10E-04	9.50E-05
	Y	1.24E-07	4.96E-06	2.15E-04	.00E+00	1.48E-07	1.20E-02	5.36E-03	6.70E-02	4.88E-08	3.64E-03
		6.81E-02	1.20E-05	1.17E-04	.00E+00	1.62E-05	1.45E+00	6.44E-01	8.03E+00	5.92E-06	4.44E-01
	W	1.24E-07	4.96E-06	2.15E-04	.00E+00	1.48E-07	1.20E-02	5.36E-03	6.70E-02	4.88E-08	3.64E-03
		6.81E-02	1.20E-05	1.17E-04	.00E+00	1.62E-05	1.45E+00	6.44E-01	8.03E+00	5.92E-06	4.44E-01
AM-243	2Y	6.84E-07	5.60E-03	3.90E-03	2.05E-05	2.50E+02	1.00E+03	9.39E-05	4.11E-03	100.	2.50E+03
		4.00E-06	4.15E-06	3.79E-06	.00E+00	4.54E-06	4.41E-06	3.12E-06	8.80E-06	7.43E-06	6.61E-06
		1.96E-04	1.67E-04	1.53E-04	.00E+00	1.86E-04	1.78E-04	1.26E-04	3.53E-04	2.97E-04	2.56E-04
	Y	7.21E-07	5.18E-06	2.23E-04	.00E+00	9.55E-07	1.19E-02	5.33E-03	6.66E-02	2.52E-07	3.62E-03
		6.59E-02	6.07E-05	1.58E-04	.00E+00	1.09E-04	1.43E+00	6.40E-01	8.03E+00	3.07E-05	4.40E-01
	W	7.21E-07	5.18E-06	2.23E-04	.00E+00	9.55E-07	1.19E-02	5.33E-03	6.66E-02	2.52E-07	3.62E-03
		6.59E-02	6.07E-05	1.58E-04	.00E+00	1.09E-04	1.43E+00	6.40E-01	8.03E+00	3.07E-05	4.40E-01
CM-242	2Y	4.81E-10	2.50E-03	2.00E-04	2.00E-05	2.50E+01	1.00E+03	1.56E+00	4.67E-04	3.00E+02	2.50E+03
		1.43E-08	6.71E-09	8.48E-09	.00E+00	2.78E-09	2.82E-09	5.24E-09	2.39E-08	1.86E-08	9.34E-08
		1.26E-07	8.17E-08	8.32E-08	.00E+00	7.56E-08	6.98E-08	5.72E-08	2.22E-07	1.82E-07	4.91E-07
	Y	3.27E-08	5.29E-06	2.31E-04	.00E+00	3.27E-08	4.18E-04	1.32E-04	1.65E-03	3.26E-08	1.15E-04
		5.74E-02	6.03E-06	1.15E-04	.00E+00	3.49E-06	4.51E-02	1.44E-02	1.80E-01	3.48E-06	1.73E-02
	W	3.27E-08	5.29E-06	2.31E-04	.00E+00	3.27E-08	4.18E-04	1.32E-04	1.65E-03	3.26E-08	1.15E-04
		5.74E-02	6.03E-06	1.15E-04	.00E+00	3.49E-06	4.51E-02	1.44E-02	1.80E-01	3.48E-06	1.73E-02
CM-243	2Y	5.20E-07	2.50E-03	2.00E-04	2.00E-05	2.50E+01	1.00E+03	2.43E-02	4.67E-04	3.00E+02	2.50E+03
		1.17E-05	1.05E-05	1.02E-05	.00E+00	1.09E-05	1.08E-05	1.08E-05	1.74E-05	1.58E-05	1.46E-05
		5.22E-04	4.70E-04	4.58E-04	.00E+00	4.91E-04	4.75E-04	4.88E-04	7.74E-04	7.05E-04	6.37E-04
	Y	2.86E-07	5.88E-06	2.48E-04	.00E+00	4.25E-07	8.84E-03	3.63E-03	4.55E-02	1.17E-07	2.51E-03
		7.18E-02	2.73E-05	1.43E-04	.00E+00	4.26E-05	1.07E+00	4.37E-01	5.44E+00	1.42E-05	3.07E-01
	W	2.86E-07	5.88E-06	2.48E-04	.00E+00	4.25E-07	8.84E-03	3.63E-03	4.55E-02	1.17E-07	2.51E-03
		7.18E-02	2.73E-05	1.43E-04	.00E+00	4.26E-05	1.07E+00	4.37E-01	5.44E+00	1.42E-05	3.07E-01
CM-244	2Y	5.94E-11	2.50E-03	2.00E-04	2.00E-05	2.50E+01	1.00E+03	3.83E-02	4.67E-04	3.00E+02	2.50E+03
		1.24E-08	5.62E-09	7.24E-09	.00E+00	2.07E-09	2.12E-09	4.42E-09	2.05E-08	1.59E-08	8.29E-08
		9.69E-08	5.96E-08	6.24E-08	.00E+00	5.26E-08	4.79E-08	4.17E-08	1.69E-07	1.38E-07	4.18E-07
	Y	3.26E-08	5.00E-06	2.21E-04	.00E+00	3.24E-08	7.36E-03	2.89E-03	3.61E-02	3.12E-08	2.02E-03
		7.14E-02	6.33E-06	1.16E-04	.00E+00	3.89E-06	8.84E-01	3.47E-01	4.33E+00	3.74E-06	2.48E-01
	W	3.26E-08	5.00E-06	2.21E-04	.00E+00	3.24E-08	7.36E-03	2.89E-03	3.61E-02	3.12E-08	2.02E-03
		7.14E-02	6.33E-06	1.16E-04	.00E+00	3.89E-06	8.34E-01	3.47E-01	4.32E+00	3.74E-06	2.48E-01
CM-248	2Y	.00E+00	2.50E-03	2.00E-04	2.00E-05	2.50E+01	1.00E+03	2.05E-06	4.67E-04	3.00E+02	2.50E+03
		9.01E-09	4.20E-09	5.31E-09	.00E+00	1.76E-09	1.75E-09	3.26E-09	1.50E-08	1.17E-08	5.88E-08
		7.80E-08	4.99E-08	5.08E-08	.00E+00	4.71E-08	4.24E-08	3.43E-08	1.37E-07	1.13E-07	3.08E-07
	Y	2.41E-05	6.40E-05	1.07E-03	.00E+00	6.59E-05	4.44E-02	2.01E-02	2.50E-01	1.43E-05	1.36E-02
		2.46E-01	3.29E-03	2.32E-03	.00E+00	7.10E-03	5.33E+00	2.41E+00	3.00E+01	1.74E-03	1.65E+00
	W	2.41E-05	6.40E-05	1.07E-03	.00E+00	6.59E-05	4.44E-02	2.01E-02	2.50E-01	1.43E-05	1.36E-02
		2.46E-01	3.29E-03	2.32E-03	.00E+00	7.10E-03	5.33E+00	2.41E+00	3.00E+01	1.74E-03	1.65E+00
CF-252	2Y	1.36E-08	2.50E-03	2.00E-04	2.00E-05	2.50E+01	1.00E+03	2.67E-01	4.11E-03	3.00E+02	2.50E+03
		1.09E-08	5.38E-09	6.56E-09	.00E+00	2.45E-09	2.42E-09	4.11E-09	1.81E-08	1.50E-08	6.34E-08
		1.09E-07	7.41E-08	7.46E-08	.00E+00	6.63E-08	6.38E-08	5.41E-08	1.91E-07	1.60E-07	3.75E-07
	Y	1.73E-06	2.03E-05	5.66E-04	.00E+00	5.92E-06	2.09E-03	1.74E-03	2.16E-02	9.92E-07	1.08E-03
		1.11E+00	3.06E-04	3.39E-04	.00E+00	1.57E-04	4.92E-02	4.07E-02	5.07E-01	1.18E-04	1.57E-01
	W	1.73E-06	2.03E-05	5.66E-04	.00E+00	5.92E-06	2.09E-03	1.74E-03	2.16E-02	9.92E-07	1.08E-03
		1.38E-01	1.86E-04	3.96E-04	.00E+00	3.34E-04	2.45E-01	2.04E-01	2.54E+00	1.25E-04	1.37E-01

IMPACTS-BRC INPUT FILE: TAPE2.DAT

```
7.400E-02       1.0      34.0 1.800E+01     500.0    1000.0       0.0       0.0       0.0       0.0
7.400E-02       1.0      34.0      18.0     500.0    1000.0       0.0       0.0       0.0       0.0
    0.074       1.0      91.0      46.5     500.0    1000.0       0.0       0.0       0.0       0.0
3.600E-02       1.0 4.550E+02 2.375E+02 2.500E+03 5.000E+03       0.0       0.0       0.0       0.0
7.400E-02       1.0      91.0      46.5     500.0    1000.0       0.0       0.0       0.0       0.0
9.180E-12 2.960E-11 7.700E+03 2.000E+05 4.500E+06 5.730E-10 1.510E-09 1.110E-07 2.280E+03 7.060E-05
4.610E+00 9.680E-11 5.530E-07 5.530E-07 2.030E-06
   1
1.800E-01       1.0       6.8       4.4     100.0     200.0       0.0       0.0       0.0       0.0
1.800E-01       1.0       6.8       4.4     100.0     200.0       0.0       0.0       0.0       0.0
     0.18       1.0      18.2      10.1     100.0     200.0       0.5       0.0       0.0       0.0
3.000E-02       1.0 7.280E+01 4.640E+01 4.000E+02 8.000E+02       0.0       0.0       0.0       0.0
1.800E-01       1.0      18.2      10.1     100.0     200.0       0.0       0.0       0.0       0.0
2.010E-11 3.180E-11 7.700E+03 2.000E+05 4.500E+06 1.750E-10 5.250E-10 1.110E-07 6.100E+02 7.060E-05
3.610E+00 1.400E-10 1.540E-08 1.540E-08 2.500E-06
   1
1.000E-03       1.0 3.400E+00      11.7     300.0     600.0       0.0       0.0       0.0       0.0
1.000E-03       1.0 3.400E+00      11.7     300.0     600.0       0.0       0.0       0.0       0.0
1.000E-03       1.0 9.100E+00      14.5     300.0     600.0       0.0       0.0       0.0       0.0
1.000E-03       1.0 9.100E+00 2.800E+02 5.800E+02 8.600E+02       0.0       0.0       0.0       0.0
1.000E-03       1.0 9.100E+00      14.5     300.0     600.0       0.0       0.0       0.0       0.0
2.640E-10 8.060E-11 7.700E+03 2.000E+05 4.500E+05 1.330E-11 3.990E-11 1.110E-07 6.000E+01 3.920E-05
6.670E+00 4.110E-11 7.950E-06 7.950E-06 6.840E-05
   1
1.000E+01 2.000E+01  2.54E+04 9.100E-11 3.330E-01 1.000E+00 2.960E+04 9.100E-11 3.330E-01      0.59
1.000E-10 2.000E-10 4.000E-10   1.7E-10  3.39E-10  6.78E-10      86.0      71.0      15.0 5.900E-01
      0.8      7.31 1.000E+00 1.000E+03       0.0   5.0E-05
1.000E+01 2.000E+01 4.280E+05 1.600E-13 3.330E-01 2.700E-01 2.960E+04 9.100E-11 3.330E-01 5.900E-01
3.700E-10 7.410E-10 1.480E-09 1.700E-10 3.390E-10 6.780E-10 8.600E+01 7.100E+01 1.500E+01 5.900E-01
8.000E-01 7.310E+00 1.000E+00 1.000E+03       0.0       0.0
1.000E+02 3.500E+01 2.540E+04 9.100E-11 3.330E-01       1.0 9.135E+04 9.100E-11 3.330E-01       1.0
1.000E-10 2.000E-10 4.000E-10 1.000E-10 2.000E-10 4.000E-10 3.840E+02 3.840E+02 1.710E+02 4.100E-01
     0.75      4.37       0.9 1.000E+03       0.0   5.0E-05
1.000E+02 3.500E+01 2.540E+04 1.600E-13 3.330E-01 1.000E+00 9.135E+04 9.100E-11 3.330E-01 1.000E+00
1.000E-10 2.000E-10 4.000E-10 1.000E-10 2.000E-10 4.000E-10 3.840E+02 3.840E+02 1.710E+02 4.100E-01
7.500E-01 4.370E+00 9.000E-01 1.000E+03       0.0       0.0
1.000E+02 3.500E+01 2.540E+04 1.600E-13 3.330E-01 1.000E+00 9.135E+04 9.100E-11 3.330E-01 1.000E+00
1.000E-10 2.000E-10 4.000E-10 1.000E-10 2.000E-10 4.000E-10 3.840E+02 3.840E+02 1.710E+02 4.100E-01
7.500E-01 4.370E+00 9.000E-01 1.000E+03       0.0       0.0
4.023E+03 3.440E+03 3.000E+00 0.000E+00
1.207E+04 2.051E+04 3.000E+00 0.000E+00
2.414E+04 7.364E+04 3.000E+00 3.300E-01
4.023E+04 1.216E+05 3.000E+00 3.300E-01
5.632E+04 5.566E+05 3.000E+00 0.000E+00
7.241E+04 1.015E+06 2.000E+00 3.300E-01
6.100E+01       0.0 3.000E+02 1.000E+02 3.300E-01 3.300E-01
    0.180       1.0       1.7      1.85      25.0      50.0       0.0       0.0      0.00     0.000
 2.64E-10  8.06E-11     110.0  2.00E+05  4.50E+06      6.67   1.4E-10  7.95E-06
   1
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APPENDIX C: TAPE5.DAT Input File for Sample Problem

SAMPLE PROBLEM INPUT FILE: TAPE5.DAT

```
  1  0  5  1  1 20 30  1
SEC-RESINS  8.00E+01  1.00E+00  8.00E+01
    2    1    1   50    1   -1   -1   10  100    0    5    0    0    0  100
H-3    * 1.150E-04  C-14   * 4.250E-06  CR-51  Y 1.330E-03  MN-54  W 2.360E-05  FE-55  W 2.080E-05
FE-59  W 6.620E-05  CO-58  Y 3.920E-05  CO-60  Y 4.030E-05  ZN-65  Y 9.120E-06  NI-59  W 2.490E-08
NI-63  W 7.660E-06  SR-90  Y 8.420E-06  NB-94  Y 7.860E-10  ZR-95  Y 2.690E-05  TC-99  W 3.580E-08
RU-103 Y 9.370E-05  AG-110 Y 5.880E-05  I-129  D 1.060E-07  CS-134 D 3.190E-04  CS-135 D 3.580E-08
CS-137 D 9.540E-04  CE-141 Y 1.330E-04  CE-144 Y 1.470E-04  PU-238 Y 7.290E-06  PU-239 Y 3.690E-06
PU-241 Y 1.610E-04  PU-242 Y 8.080E-09  AM-241 Y 8.540E-06  AM-243 Y 5.760E-07  CM-242 Y 1.610E-05
CM-243 Y 3.940E-09  CM-244 Y 4.420E-06                                                             5
  2  0  2  2  2 20  0  1
TRASH       1.00E+02  5.00E-01  2.00E+02
    2    1    0    0    5   -1   -1   32   10    4   16   50   20   20   10
H-3    * 1.150E-04  C-14   * 4.250E-06  CR-51  Y 1.330E-03  MN-54  W 2.360E-05  FE-55  W 2.080E-05
FE-59  W 6.620E-05  CO-58  Y 3.920E-05  CO-60  Y 4.030E-05  ZN-65  Y 9.120E-06  NI-59  W 2.490E-08
NI-63  W 7.660E-06  SR-90  Y 8.420E-06  NB-94  Y 7.860E-10  ZR-95  Y 2.690E-05  TC-99  W 3.580E-08
RU-103 Y 9.370E-05  AG-110 Y 5.880E-05  I-129  D 1.060E-07  CS-134 D 3.190E-04  CS-135 D 3.580E-08
CS-137 D 9.540E-04  CE-141 Y 1.330E-04  CE-144 Y 1.470E-04  PU-238 Y 7.290E-06  PU-239 Y 3.690E-06
PU-241 Y 1.610E-04  PU-242 Y 8.080E-09  AM-241 Y 8.540E-06  AM-243 Y 5.760E-07  CM-242 Y 1.610E-05
CM-243 Y 3.940E-09  CM-244 Y 4.420E-06                                                             5
CON-DIRT    5.00E+02  1.60E+00  3.13E+02
    3    1    0    0    1   -1   -1    3  100    0    1    0    0    0  100
U-238  Y 5.950E-07  U-234  Y 5.950E-07  TH-230 Y 5.950E-07  RA-226 W 5.950E-07  RN-222 * 5.950E-07
PO-210 W 5.950E-07  PB-210 D 5.950E-07  U-235  Y 2.750E-08  PA-231 Y 2.750E-08  AC-227 Y 2.750E-08
TH-232 Y 9.810E-07  TH-228 Y 9.810E-07  RA-228 W 9.810E-07                                         5
  1  2  1  1  2 20  5  1
WASTE OIL   8.00E+02  1.00E+00  8.00E+02
    1    1    1   50    2   -1   -1   30  100   30    1  100    0    0    0
AG-110 Y 2.400E-03  CE-141 Y 1.900E-01  CE-144 Y 6.500E-03  CO-58  Y 2.200E-02  CO-60  Y 3.900E-04
CR-51  Y 1.800E+00  CS-134 D 1.200E-03  CS-137 D 6.100E-04  FE-55  W 2.600E-01  FE-59  W 3.000E-02
MN-54  W 6.200E-03  NB-95  Y 6.100E-02  NI-63  W 2.100E-01  RB-86  D 6.800E-02  RU-103 Y 7.600E-02
RU-106 Y 5.900E-03  SR-89  Y 3.100E-02  SR-90  Y 7.100E-04  ZN-65  Y 1.000E-02  ZR-95  Y 3.400E-02
```

APPENDIX D: Output File for Sample Problem

SAMPLE PROBLEM OUTPUT FILE: TAPE 6.OUT

```
IMPACTS BRC - VERSION 2.1: Run on 10/03/91 at 11:48:28.48


HAZARDOUS WASTE II

LIFE= 10  OVFL=  1  NFTR=  1
REGN=  1  DATA=  0
IPOP=  1  INST= 30

WASTE: SEC-RESINS  WEIGHT: 6.00E+01 MT  DENSITY: 1.00E+00 MT/M3

ID= 2  IA= 1  IK1= 1  IK2= 50  PROCESS= 1
IXS=  10 100   0   5
ICS=   0   0   0 100

METAL PACKAGE RECYCLE IMPACTS   MAXIND = 5.71E-04 MREM/YR
                                POPULN = 4.81E+01 PERSON-MREM/30YRS

TRANSPORTATION IMPACTS          TR-MAX = 5.82E+00 MREM/YR
                                TR-OCC = 1.16E+02 PERSON-MREM/YR
                                TR-POP = 7.97E+02 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

  SCN   LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER    REL MAR    BONE   THYROID    ICRP
INT-CO 6.83E-03 6.78E-03 6.78E-03 6.78E-03 6.78E-03 6.88E-03 6.83E-03 7.33E-03 6.78E-03 6.82E-03
INT-AG 3.24E-02 3.22E-02 3.22E-02 3.21E-02 3.22E-02 3.26E-02 3.24E-02 3.41E-02 3.22E-02 3.23E-02

EXPOSED WASTE IMPACTS (MREM/YR):

  SCN   LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER    RED MAR    BONE   THYROID    ICRP
IN-AIR 1.03E-04 2.84E-05 3.34E-05 0.00E+00 2.81E-05 2.12E-03 9.45E-04 1.15E-02 3.83E-05 7.70E-04
ER-AIR 2.95E-01 9.15E-05 9.54E-04 0.00E+00 7.43E-05 4.69E-01 2.07E-01 2.59E+00 9.87E-03 1.76E-01
IN-WAT 5.69E-07 6.21E-07 6.81E-07 0.00E+00 6.12E-07 2.02E-06 1.22E-06 8.43E-06 5.73E-07 1.03E-06
ER-WAT 1.08E-05 1.[illegible]E-06 1.13E-05 0.00E+00 8.63E-07 3.62E-04 1.62E-04 2.02E-03 6.13E-06 1.11E-04

INCINERATION AND OPERATIONAL IMPACTS:   UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
                                               IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

  SCN   LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER    RED MAR    BONE   THYROID    ICRP
IC-POP 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
IC-IND 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
IC-WOR 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
IC-MWR 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
OP-POP 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
OP-IND 4.40E-11 1.97E-13 2.63E-13 0.00E+00 1.92E-13 6.41E-11 2.77E-11 3.44E-10 2.01E-13 2.42E-11
OP-WOR 1.52E+02 4.65E+01 4.67E+01 4.61E+01 4.65E+01 2.00E+02 1.13E+02 8.71E+02 4.66E+01 1.04E+02
OP-MWR 6.61E-01 2.98E-01 2.99E-01 2.97E-01 2.98E-01 8.27E-01 5.28E-01 3.14E+00 2.98E-01 4.97E-01

LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

  SCN   LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER    RED MAR    BONE   THYROID    ICRP
LA-OPS 1.49E-04 1.61E-04 3.88E-04 0.00E+00 1.55E-04 1.19E-03 6.18E-04 5.94E-03 3.09E-04 4.97E-04
LA-OVF 5.94E-05 6.18E-05 8.63E-05 0.00E+00 6.08E-05 1.04E-03 4.97E-04 5.51E-03 2.19E-04 3.62E-04
LA-AIR 2.98E-02 2.40E-02 2.41E-02 0.00E+00 2.40E-02 6.63E-02 4.28E-02 2.58E-01 4.32E-02 3.60E-02
1
GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL
  TIME  LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER    RED MAR    BONE   THYROID    ICRP
  20YR 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  40YR 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
  60YR 5.53E-05 5.69E-05 6.81E-05 0.00E+00 5.62E-05 5.61E-05 5.76E-05 5.97E-05 5.87E-04 7.32E-05
  80YR 4.73E-05 4.85E-05 5.42E-05 0.00E+00 4.78E-05 4.77E-05 4.88E-05 4.99E-05 5.50E-04 6.36E-05
 100YR 4.22E-05 4.31E-05 4.67E-05 0.00E+00 4.26E-05 4.25E-05 4.31E-05 4.39E-05 5.16E-04 5.72E-05
 120YR 3.85E-05 3.92E-05 4.15E-05 0.00E+00 3.87E-05 3.87E-05 3.91E-05 3.95E-05 4.86E-04 5.24E-05
 160YR 6.61E-05 6.71E-05 6.90E-05 0.00E+00 6.63E-05 6.63E-05 6.66E-05 6.69E-05 8.64E-04 9.05E-05
 200YR 5.82E-05 5.90E-05 5.98E-05 0.00E+00 5.83E-05 5.82E-05 5.84E-05 5.85E-05 7.69E-04 7.98E-05
 400YR 6.67E-05 6.75E-05 6.73E-05 0.00E+00 6.67E-05 6.67E-05 6.67E-05 6.67E-05 8.65E-04 9.07E-05
 600YR 6.79E-05 6.87E-05 6.96E-05 0.00E+00 6.79E-05 6.87E-05 6.83E-05 7.24E-05 8.52E-04 9.19E-05
 800YR 5.08E-05 5.14E-05 5.24E-05 0.00E+00 5.08E-05 5.16E-05 5.12E-05 5.52E-05 6.17E-04 6.82E-05
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1K YR	3.28E-05	3.32E-05	3.44E-05	0.00E+00	3.28E-05	3.36E-05	3.32E-05	3.72E-05	3.86E-04	4.39E-05
2K YR	2.28E-06	2.28E-06	4.74E-06	0.00E+00	2.21E-06	3.70E-06	2.88E-06	1.06E-05	2.18E-05	3.48E-06
5K YR	1.91E-07	1.49E-07	6.33E-06	0.00E+00	1.05E-08	4.86E-05	3.19E-05	2.73E-04	1.12E-08	1.53E-05
10K YR	3.00E-07	2.11E-07	9.23E-06	0.00E+00	4.73E-09	2.23E-05	9.29E-06	1.25E-04	3.85E-09	7.56E-06
20K YR	2.00E-07	1.38E-07	6.04E-06	0.00E+00	2.81E-09	8.32E-06	3.73E-06	4.60E-05	2.62E-09	3.06E-06

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	4.00E-06	4.05E-06	4.03E-06	0.00E+00	4.00E-06	4.00E-06	4.00E-06	4.00E-06	5.02E-05	5.39E-06
800YR	4.66E-06	4.71E-06	4.68E-06	0.00E+00	4.66E-06	4.66E-06	4.66E-06	4.66E-06	5.66E-05	6.22E-06
1K YR	4.07E-06	4.11E-06	4.09E-06	0.00E+00	4.07E-06	4.07E-06	4.07E-06	4.07E-06	4.78E-05	5.38E-06
2K YR	4.54E-07	4.[illegible]E-07	4.70E-07	0.00E+00	4.55E-07	4.54E-07	4.55E-07	4.55E-07	4.52E-06	5.78E-07
5K YR	8.39E-09	6.24E-08	2.31E-07	0.00E+00	1.15E-09	1.37E-07	6.25E-08	7.67E-07	1.67E-09	6.31E-08
10K YR	3.71E-08	2.54E-08	1.[illegible]0E-06	0.00E+00	5.94E-10	6.70E-07	3.02E-07	3.75E-06	5.57E-10	3.01E-07
20K YR	4.12E-08	2.80E-08	1.23E-06	0.00E+00	4.74E-10	7.46E-07	3.38E-07	4.18E-06	4.75E-10	3.35E-07

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	5.24E-08	5.28E-08	5.32E-08	0.00E+00	5.24E-08	5.24E-08	5.25E-08	5.25E-08	3.82E-07	6.24E-08
2K YR	3.52E-08	3.56E-08	3.98E-08	0.00E+00	3.54E-08	3.52E-08	3.54E-[illegible]	3.56E-08	2.19E-07	4.14E-08
5K YR	1.18E-10	2.06E-10	1.91E-09	0.00E+00	1.92E-10	1.33E-10	[illegible].99E-10	2.03E-10	1.45E-10	3.73E-10
10K YR	3.48E-10	2.94E-10	8.13E-09	0.00E+00	9.32E-11	5.36E-09	[illegible].47E-09	2.97E-08	7.65E-11	2.50E-09
20K YR	1.88E-09	1.38E-09	5.83E-08	0.00E+00	6.85E-11	3.54E-08	1.59E-08	1.98E-07	6.79E-11	1.59E-08

SANITARY LANDFILL

LIFE= 20 OVFL= 1 NSTR= 2
REGN= 2 DATA= 0
IPOP= 2 INST= 0

WASTE: TRASS WEIGHT: 1.00E+02 MT DENSITY: 5.00E-01 MT/M3

ID= 2 IA= 1 IK1= 0 IK2= 0 PROCESS= 5
IXS= 32 10 4 16
ICS= 50 20 20 10

METAL MATERIAL RECYCLE IMPACTS MAXIND = 3.21E-01 MREM/YR
POPULN = 2.1[illegible]E+04 PERSON-MREM/30YRS

GLASS MATERIAL RECYCLE IMPACTS MAXIND = 4.13E+00 MREM/YR
POPULN = 1.26E+04 PERSON-MREM/30YRS

TRANSPORTATION IMPACTS TR-MAX = 1.42E+00 MREM/YR
TR-OCC = 9.11E+01 PERSON-MREM/YR
TR-POP = 5.97E+01 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
INT-CO	6.72E-02	6.69E-02	6.69E-02	6.69E-02	6.69E-02	6.73E-02	6.70E-02	6.91E-02	6.69E-02	6.70E-02
INT-AG	3.17E-01	3.17E-01	3.17E-01	3.17E-01	3.17E-01	3.18E-01	3.17E-01	3.21E-01	3.17E-01	3.17E-01

EXPOSED WASTE IMPACTS (MREM/YR):

SCF	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IN-AIR	3.65E-02	2.28E-03	3.88E-03	0.00E+00	2.24E-03	5.52E-02	2.50E-02	2.87E-01	2.38E-03	2.20E-02
ER-AIR	1.99E-02	2.89E-06	6.11E-05	0.00E+00	1.72E-06	3.16E-02	1.40E-02	1.75E-01	6.60E-04	1.19E-02
IN-WAT	3.17E-06	3.48E-06	4.63E-06	0.00E+00	3.44E-06	5.73E-06	4.27E-06	1.55E-05	3.15E-06	4.17E-06
ER-WAT	6.25E-08	1.07E-07	2.30E-06	0.00E+00	5.82E-08	7.87E-05	3.52E-05	4.40E-04	1.61E-06	2.41E-05

INCINERATION AND OPERATIONAL IMPACTS: UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IC-POP	6.63E+01	5.15E+00	8.75E+00	0.00E+00	5.05E+00	9.98E+01	4.57E+01	5.14E+02	5.85E+00	4.06E+01
IC-IND	5.05E-04	3.82E-05	6.66E-05	0.00E+00	3.85E-05	7.60E-04	3.48E-04	3.91E-03	4.46E-05	3.09E-04
IC-WOR	5.88E+00	5.82E+00	5.82E+00	5.82E+00	5.82E+00	5.91E+00	5.86E+00	6.30E+00	5.82E+00	5.85E+00
IC-MWR	5.66E-02	5.52E-02	5.52E-02	5.51E-02	5.52E-02	5.73E-02	5.61E-02	6.65E-02	5.52E-02	5.59E-02
OP-POP	3.99E-01	2.50E-02	4.25E-02	0.00E+00	2.45E-02	6.04E-01	2.73E-01	3.14E+00	2.61E-02	2.41E-01
OP-IND	4.32E-04	2.70E-05	4.60E-05	0.00E+00	2.65E-05	6.53E-04	2.95E-04	3.39E-03	2.83E-05	2.61E-04
OP-WOR	3.66E+00	3.62E+00	3.62E+00	3.62E+00	3.62E+00	3.68E+00	3.65E+00	3.91E+00	3.62E+00	3.64E+00
OP-MWR	2.29E-01	2.27E-01	2.27E-01	2.27E-01	2.27E-01	2.30E-01	2.28E-01	2.44E-01	2.27E-01	2.28E-01

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	1.17E-05	1.36E-05	5.11E-05	0.00E+00	1.26E-05	1.84E-04	8.93E-05	9.71E-04	3.81E-05	6.93E-05
LA-OVF	1.17E-05	1.36E-05	5.11E-05	0.00E+00	1.26E-05	1.84E-04	8.93E-05	9.71E-04	3.81E-05	6.93E-05
LA-AIR	9.91E-02	5.63E-02	6.75E-02	0.00E+00	5.60E-02	3.23E-01	1.74E-01	1.53E+00	1.68E-01	1.46E-01

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GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	1.60E-04	1.71E-04	2.72E-04	0.00E+00	1.68E-04	1.08E-04	1.82E-04	1.98E-04	2.06E-03	2.36E-04
40YR	1.97E-04	2.11E-04	3.09E-04	0.00E+00	2.06E-04	2.05E-04	2.22E-04	2.42E-04	3.74E-03	3.23E-04
60YR	2.14E-04	2.29E-04	3.21E-04	0.00E+00	2.22E-04	2.22E-04	2.38E-04	2.66E-04	5.18E-03	3.81E-04
80YR	1.83E-04	1.95E-04	2.59E-04	0.00E+00	1.88E-04	1.89E-04	2.00E-04	2.21E-04	5.30E-03	3.50E-04
100YR	1.47E-04	1.56E-04	1.98E-04	0.00E+00	1.50E-04	1.51E-04	1.57E-04	1.73E-04	4.92E-03	2.99E-04
120YR	1.22E-04	1.29E-04	1.59E-04	0.00E+00	1.24E-04	1.27E-04	1.30E-04	1.49E-04	4.57E-03	2.62E-04
160YR	9.20E-05	9.70E-05	1.12E-04	0.00E+00	9.28E-05	9.53E-05	9.54E-05	1.11E-04	3.95E-03	2.11E-04
200YR	7.47E-05	7.85E-05	8.89E-05	0.00E+00	7.49E-05	7.84E-05	7.71E-05	9.60E-05	3.42E-03	1.78E-04
400YR	3.63E-05	3.78E-05	4.67E-05	0.00E+00	3.60E-05	4.15E-05	3.85E-05	6.71E-05	1.69E-03	8.82E-05
600YR	1.91E-05	2.00E-05	4.65E-05	0.00E+00	1.86E-05	8.33E-04	3.83E-04	4.57E-03	8.31E-04	2.91E-04
800YR	1.01E-05	1.06E-05	3.47E-05	0.00E+00	9.64E-06	6.18E-04	2.81E-04	3.41E-03	4.10E-04	2.08E-04
1K YR	5.47E-06	5.68E-06	2.71E-05	0.00E+00	5.00E-06	4.65E-04	2.11E-04	2.58E-03	2.02E-04	1.52E-04
2K YR	6.68E-07	6.91E-07	2.15E-05	0.00E+00	2.36E-07	4.45E-04	1.99E-04	2.49E-03	5.94E-06	1.37E-04
5K YR	4.25E-07	4.06E-07	1.74E-05	0.00E+00	3.76E-08	3.13E-04	1.40E-04	1.75E-03	2.44E-08	9.63E-05
10K YR	3.30E-07	2.79E-07	1.21E-05	0.00E+00	1.85E-08	1.50E-04	6.71E-05	8.38E-04	1.24E-08	4.64E-05
20K YR	2.06E-07	1.47E-07	6.39E-06	0.00E+00	4.15E-09	1.96E-05	8.79E-06	1.10E-04	3.49E-09	6.50E-06

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	1.34E-06	1.42E-06	1.77E-06	0.00E+00	1.37E-06	1.36E-06	1.43E-06	1.50E-06	4.48E-05	2.72E-06
120YR	3.33E-06	3.53E-06	4.21E-06	0.00E+00	3.40E-06	3.39E-06	3.50E-06	3.63E-06	1.25E-04	[illegible]
160YR	7.53E-06	7.94E-06	8.78E-06	0.00E+00	7.61E-06	7.60E-06	7.73E-06	7.87E-06	3.24E-04	1.72E-05
200YR	6.79E-06	7.14E-06	7.54E-06	0.00E+00	6.82E-06	6.82E-06	6.88E-06	6.94E-06	3.12E-04	1.61E-05
400YR	3.28E-06	3.43E-06	3.41E-06	0.00E+00	3.28E-06	3.28E-06	3.28E-06	3.28E-06	1.54E-04	7.81E-06
600YR	1.69E-06	1.77E-06	1.74E-06	0.00E+00	1.69E-06	1.69E-06	1.69E-06	1.70E-06	7.57E-05	3.92E-06
800YR	8.76E-07	9.12E-07	9.00E-07	0.00E+00	8.76E-07	8.76E-07	8.77E-07	8.77E-07	3.73E-05	1.98E-06
1K YR	4.58E-07	4.74E-07	5.94E-07	0.00E+00	4.54E-07	5.30E-07	4.89E-07	8.63E-07	1.84E-05	1.03E-06
2K YR	5.73E-08	4.52E-08	1.23E-06	0.00E+00	1.76E-08	7.48E-07	3.46E-07	4.12E-06	5.39E-07	3.62E-07
5K YR	3.54E-08	2.42E-08	1.06E-06	0.00E+00	4.17E-10	6.43E-07	2.89E-07	3.60E-06	3.68E-10	2.89E-07
10K YR	2.87E-08	2.00E-08	8.78E-07	0.00E+00	4.01E-10	1.83E-06	8.21E-07	1.02E-05	3.36E-10	6.32E-07
20K YR	1.88E-08	1.34E-08	5.62E-07	0.00E+00	3.78E-10	1.79E-06	8.00E-07	9.99E-06	3.18E-10	5.92E-07

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	5.51E-08	5.71E-08	5.97E-08	0.00E+00	5.56E-08	5.55E-08	5.57E-08	5.58E-08	1.44E-06	9.74E-08
400YR	2.53E-07	2.60E-07	2.63E-07	0.00E+00	2.53E-07	2.53E-07	2.54E-07	2.54E-07	7.06E-06	4.59E-07
600YR	1.31E-07	1.34E-07	1.36E-07	0.00E+00	1.31E-07	1.31E-07	1.31E-07	1.31E-07	3.48E-06	2.32E-07
800YR	6.77E-08	6.94E-08	7.14E-08	0.00E+00	6.78E-08	6.77E-08	6.79E-08	6.79E-08	1.72E-06	1.18E-07
1K YR	3.51E-08	3.60E-08	3.82E-08	0.00E+00	3.52E-08	3.51E-08	3.52E-08	3.52E-08	8.48E-07	6.00E-08
2K YR	1.55E-09	1.62E-09	9.01E-09	0.00E+00	1.45E-09	4.85E-09	3.02E-09	2.09E-08	2.50E-08	3.91E-09
5K YR	1.61E-09	1.20E-09	5.08E-08	0.00E+00	7.25E-11	3.05E-08	1.38E-08	1.71E-07	4.55E-11	1.38E-08
10K YR	1.20E-09	9.48E-10	4.06E-08	0.00E+00	3.91E-11	2.46E-08	1.11E-08	1.38E-07	3.50E-11	1.11E-08
20K YR	8.50E-10	6.29E-10	2.66E-08	0.00E+00	3.27E-11	2.64E-08	1.19E-08	1.48E-07	3.22E-11	1.04E-08

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WASTE: CON-DIRT WEIGHT: 5.00E+02 MT DENSITY: 1.60E+00 MT/M3

ID= 3 IA= 1 IK1= 0 IK2= 0 PROCESS= 1
IXS= 3 100 0 1
ICS= 0 0 0 100

TRANSPORTATION IMPACTS
TR-MAX = 1.18E-01 MREM/YR
TR-OCC = 7.10E-01 PERSON-MREM/YR
TR-POP = 4.65E-01 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
INT-CD	2.48E-02	1.43E-02	1.43E-02	1.43E-02	1.43E-02	1.45E-02	1.65E-02	4.21E-02	1.43E-02	1.67E-02
INT-AG	8.44E-02	6.78E-02	6.78E-02	6.77E-02	6.81E-02	6.85E-02	7.18E-02	1.16E-01	6.78E-02	7.18E-02

EXPOSED WASTE IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IN-AIR	8.12E-02	1.65E-04	2.78E-04	0.00E+00	1.44E-03	2.98E-03	1.87E-02	2.33E-01	1.62E-04	1.94E-02
ER-AIR	1.79E-01	3.62E-04	6.11E-04	0.00E+00	3.17E-03	6.57E-03	4.12E-02	5.14E-01	3.57E-04	4.27E-02
IN-WAT	1.89E-06	1.89E-06	3.37E-06	0.00E+00	3.50E-05	2.09E-05	1.53E-05	1.78E-04	1.86E-06	1.50E-05
ER-WAT	2.26E-04	2.25E-04	4.02E-04	0.00E+00	4.17E-03	2.49E-03	1.83E-03	2.12E-02	2.22E-04	1.78E-03

INCINERATION AND OPERATIONAL IMPACTS: UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IC-POP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IC-IND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IC-WOR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IC-MWR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OP-POP	8.89E-01	1.80E-03	3.04E-03	0.00E+00	1.58E-02	3.26E-02	2.05E-01	2.55E+00	1.78E-03	2.12E-01
OP-IND	1.54E-02	3.12E-05	5.26E-05	0.00E+00	2.73E-04	5.65E-04	3.55E-03	4.42E-02	3.07E-05	3.68E-03
OP-WOR	1.34E-01	4.85E-02	4.85E-02	4.84E-02	4.87E-02	4.98E-02	6.66E-02	2.75E-01	4.85E-02	6.78E-02
OP-MWR	1.34E-01	4.85E-02	4.85E-02	4.84E-02	4.87E-02	4.98E-02	6.66E-02	2.75E-01	4.85E-02	6.78E-02

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	9.86E-04	9.69E-04	1.65E-03	0.00E+00	9.65E-03	1.87E-02	1.79E-02	2.24E-01	9.56E-04	1.16E-02
LA-OVF	9.86E-04	9.69E-04	1.65E-03	0.00E+00	9.65E-03	1.87E-02	1.79E-02	2.24E-01	9.56E-04	1.16E-02
LA-AIR	4.23E-01	8.52E-04	1.24E-03	0.00E+00	5.63E-03	1.94E-02	1.59E-01	1.98E+00	8.43E-04	1.31E-01

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GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	2.68E-04	2.70E-04	3.83E-04	0.00E+00	2.68E-04	2.68E-04	1.74E-03	2.00E-02	2.68E-04	1.04E-03
200YR	2.62E-04	2.64E-04	3.74E-04	0.00E+00	2.62E-04	2.62E-04	1.71E-03	1.95E-02	2.62E-04	1.02E-03
400YR	4.68E-04	4.72E-04	6.69E-04	0.00E+00	4.68E-04	4.68E-04	3.05E-03	3.49E-02	4.68E-04	1.82E-03
600YR	6.65E-04	6.48E-04	1.24E-03	0.00E+00	6.35E-04	6.93E-04	1.19E-02	1.45E-01	6.35E-04	6.36E-03

600YR	7.84E-04	7.69E-04	1.40E-03	0.00E+00	7.56E-04	8.12E-04	1.25E-02	1.51E-01	7.56E-04	6.73E-03
1K YR	8.72E-04	8.58E-04	1.52E-03	0.00E+00	8.44E-04	6.98E-04	1.29E-02	1.55E-01	8.43E-04	6.98E-03
2K YR	1.05E-03	1.00E-03	2.22E-03	0.00E+00	9.75E-04	1.12E-03	2.59E-02	3.17E-01	9.75E-04	1.35E-02
5K YR	3.25E-04	2.41E-04	1.62E-03	0.00E+00	2.14E-04	4.38E-04	3.36E-02	4.18E-01	2.09E-04	1.69E-02
10K YR	1.21E-04	5.66E-05	1.05E-03	0.00E+00	4.22E-05	2.06E-04	2.48E-02	3.09E-01	3.38E-05	1.24E-02
20K YR	3.15E-05	1.31E-05	3.03E-04	0.00E+00	1.63E-05	5.41E-05	6.99E-03	8.72E-02	[illegible].44E-06	3.50E-03

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+[illegible]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	1.63E-05	1.64E-05	2.32E-05	0.00E+00	1.63E-05	1.63E-05	1.05E-04	1.21E-03	1.63E-05	6.33E-05
10K YR	1.98E-06	1.41E-06	1.06E-05	0.00E+00	1.20E-06	2.76E-06	2.22E-04	2.76E-03	1.20E-06	1.12E-04
20K YR	2.78E-06	1.13E-06	2.50E-05	0.00E+00	5.95E-07	4.90E-06	6.03E-04	7.52E-03	5.81E-07	3.01E-04

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	5.03E-08	5.07E-08	7.20E-08	0.00E+00	5.03E-08	5.03E-08	3.28E-07	3.75E-06	5.03E-08	1.96E-07
20K YR	1.30E-08	6.08E-09	1.31E-07	0.00E+00	3.27E-09	2.5[illegible]E-08	3.15E-06	3.93E-05	3.20E-09	1.57E-06

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CUMULATIVE IMPACTS

INTRUDER IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
INT-CO	9.19E-02	8.12E-02	8.12E-02	8.12E-02	8.12E-02	8.17E-02	8.36E-02	1.11E-01	8.12E-02	8.37E-02
INT-AG	4.02E-01	3.85E-01	3.85E-01	3.84E-01	3.85E-01	3.86E-01	3.89E-01	4.38E-01	3.85E-01	3.89E-01

EXPOSED WASTE IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IN-AIR	1.18E-01	2.45E-03	4.17E-03	0.00E+00	3.68E-03	5.82E-02	4.37E-02	3.20E-01	2.55E-03	4.14E-02
ER-AIR	1.99E-01	3.65E-04	6.73E-04	0.00E+00	3.17E-03	3.82E-02	5.52E-02	6.88E-01	1.02E-03	5.46E-02
IN-WAT	5.07E-06	5.37E-06	8.00E-06	0.00E+00	3.84E-05	2.66E-05	1.96E-05	1.93E-04	5.01E-06	1.91E-05
ER-WAT	2.26E-04	2.25E-04	4.04E-04	0.00E+00	4.17E-03	2.56E-03	1.86E-03	2.1[illegible]E-02	2.23E-04	1.61E-03

INCINERATION AND OPERATIONAL IMPACTS: UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IC-POP	6.63E+01	5.15E+00	8.75E+00	0.00E+00	5.05E+00	9.98E+01	4.57E+01	5.14E+02	5.85E+00	4.06E+01
IC-IND	5.05E-04	3.92E-05	6.66E-05	0.00E+00	3.85E-05	7.60E-04	3.48E-04	3.91E-03	4.46E-05	3.09E-04
IC-WOR	5.88E+00	5.82E+00	5.82E+00	5.82E+00	5.82E+00	5.81E+00	5.86E+00	6.30E+00	5.82E+00	5.85E+00
IC-MWR	5.66E-02	5.52E-02	5.52E-02	5.51E-02	5.52E-02	5.73E-02	5.61E-02	6.65E-02	5.52E-02	5.59E-02
OP-POP	1.29E+00	2.68E-02	4.56E-02	0.00E+00	4.03E-02	6.36E-01	4.78E-01	5.69E+00	2.79E-02	4.53E-01
OP-IND	1.58E-02	5.82E-05	9.86E-05	0.00E+00	2.[illegible]E-04	1.22E-03	3.84E-03	4.76E-02	5.90E-05	3.34E-03
OP-WOR	3.79E+00	3.67E+00	3.67E+00	3.67E+00	3.67E+[illegible]	[illegible]73E+00	3.71E+00	4.18E+00	3.67E+00	3.71E+00

OP-MWR	2.62E-01	2.75E-01	2.75E-01	2.75E-01	2.75E-01	2.80E-01	2.95E-01	5.19E-01	2.75E-01	2.96E-01

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	9.97E-04	9.82E-06	1.70E-03	0.00E+00	9.87E-03	1.89E-02	1.80E-02	2.25E-01	9.94E-04	1.17E-02
LA-OVF	9.97E-04	9.82E-04	1.70E-03	0.00E+00	9.87E-03	1.89E-02	1.80E-02	2.25E-01	9.94E-04	1.17E-02
LA-AIR	5.22E-01	5.72E-02	6.87E-02	0.00E+00	6.16E-02	3.42E-01	3.33E-01	3.51E+00	1.69E-01	2.77E-01

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GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	1.60E-04	1.71E-04	2.72E-04	0.00E+00	1.68E-04	1.69E-04	1.82E-04	1.98E-04	2.06E-03	2.38E-04
40YR	1.97E-04	2.11E-04	3.09E-04	0.00E+00	2.06E-04	2.05E-04	2.22E-04	2.42E-04	3.74E-03	3.23E-04
60YR	2.14E-04	2.29E-04	3.21E-04	0.00E+00	2.22E-04	2.22E-04	2.38E-04	2.66E-04	5.16E-03	3.81E-04
80YR	1.83E-04	1.95E-04	2.59E-04	0.00E+00	1.88E-04	1.89E-04	2.00E-04	2.21E-04	5.30E-03	3.50E-04
100YR	1.47E-04	1.56E-04	1.98E-04	0.00E+00	1.50E-04	1.51E-04	1.57E-04	1.73E-04	4.92E-03	2.99E-04
120YR	1.22E-04	1.29E-04	1.59E-04	0.00E+00	1.24E-04	1.27E-04	1.30E-04	1.49E-04	4.57E-03	2.62E-04
160YR	3.60E-04	3.67E-04	4.94E-04	0.00E+00	3.60E-04	3.63E-04	1.84E-03	2.01E-02	4.22E-03	1.25E-03
200YR	3.37E-04	3.42E-04	4.63E-04	0.00E+00	3.36E-04	3.40E-04	1.78E-03	1.96E-02	3.68E-03	1.20E-03
400YR	5.03E-04	5.10E-04	7.16E-04	0.00E+00	5.04E-04	5.09E-04	3.09E-03	3.55E-02	2.15E-03	1.91E-03
600YR	6.84E-04	6.68E-04	1.29E-03	0.00E+00	6.54E-04	1.53E-03	1.23E-02	1.49E-01	1.47E-03	6.65E-03
800YR	7.95E-04	7.80E-04	1.44E-03	0.00E+00	7.65E-04	1.43E-03	1.28E-02	1.54E-01	1.17E-03	6.94E-03
1K YR	8.77E-04	8.64E-04	1.55E-03	0.00E+00	8.47E-04	1.36E-03	1.31E-02	1.58E-01	1.05E-03	7.13E-03
2K YR	1.05E-03	1.00E-03	2.24E-03	0.00E+00	9.76E-04	1.56E-03	2.61E-02	3.19E-01	9.81E-04	1.37E-02
5K YR	3.25E-04	[illegible].41E-04	1.64E-03	0.00E+00	2.14E-04	7.51E-04	3.37E-02	4.20E-01	2.09E-04	1.70E-02
10K YR	1.22E-04	5.69E-05	1.06E-03	0.00E+00	4.22E-05	3.56E-04	2.49E-02	3.10E-01	3.39E-05	1.25E-02
20K YR	3.17E-05	1.32E-05	3.10E-04	0.00E+00	1.63E-05	7.37E-05	7.00E-03	8.73E-02	6.44E-06	3.50E-03

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	1.34E-06	1.42E-06	1.77E-06	0.00E+00	1.37E-06	1.36E-06	1.43E-06	1.50E-06	4.48E-05	2.72E-06
120YR	3.33E-06	3.53E-06	4.21E-06	0.00E+00	3.40E-06	3.39E-06	3.50E-06	3.83E-06	1.25E-04	7.13E-06
160YR	7.53E-06	7.64E-06	8.78E-06	0.00E+00	7.61E-06	7.60E-06	7.73E-06	7.87E-06	3.24E-04	1.72E-05
200YR	6.79E-06	7.14E-06	7.54E-06	0.00E+00	6.82E-06	6.82E-06	6.88E-06	6.94E-06	3.12E-04	1.61E-05
400YR	3.28E-06	3.43E-06	3.41E-06	0.00E+00	3.28E-06	3.28E-06	3.28E-06	3.28E-06	1.54E-04	7.81E-06
600YR	1.69E-06	1.77E-06	1.71E-06	0.00E+00	1.69E-06	1.69E-06	1.69E-06	1.70E-06	7.57E-05	3.92E-06
800YR	8.76E-07	9.12E-07	9.00E-07	0.00E+00	8.76E-07	8.76E-07	8.77E-07	8.77E-07	3.73E-05	1.98E-06
1K YR	4.58E-07	4.74E-07	5.94E-07	0.00E+00	4.51E-07	5.30E-07	4.89E-07	8.83E-07	1.84E-05	1.03E-06
2K YR	5.73E-08	4.52E-08	1.23E-06	0.00E+00	1.76E-03	7.48E-07	3.46E-07	4.12E-06	5.39E-07	3.62E-07
5K YR	1.63E-05	1.64E-05	2.43E-05	0.00E+00	1.63E-05	1.69E-05	1.06E-04	1.22E-03	1.63E-05	6.38E-05
10K YR	2.02E-06	1.43E-06	1.15E-05	0.00E+00	1.20E-06	4.59E-06	2.23E-04	2.77E-03	1.20E-06	1.12E-04
20K YR	2.80E-06	1.14E-06	2.56E-05	0.00E+00	5.95E-07	6.68E-06	6.04E-04	7.53E-03	5.81E-07	3.02E-04

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	5.51E-08	5.71E-08	5.97E-08	0.00E+00	5.56E-08	5.55E-08	5.57E-08	5.58E-08	1.44E-06	9.74E-08
400YR	2.53E-07	2.60E-07	2.63E-07	0.00E+00	2.53E-07	2.53E-07	2.54E-07	2.54E-07	7.06E-06	4.59E-07
600YR	1.31E-07	1.34E-07	1.36E-07	0.00E+00	1.31E-07	1.31E-07	1.31E-07	1.31E-07	3.48E-06	2.32E-07
800YR	6.77E-08	6.94E-08	7.14E-08	0.00E+00	6.78E-08	6.77E-08	6.79E-08	6.79E-08	1.72E-06	1.18E-07
1K YR	3.51E-08	3.60E-08	3.82E-08	0.00E+00	3.52E-08	3.51E-08	3.52E-08	3.52E-08	8.48E-07	6.00E-08
2K YR	1.55E-09	1.62E-09	9.01E-09	0.00E+00	1.45E-09	4.85E-09	3.02E-09	2.09E-08	2.50E-08	3.91E-09
5K YR	1.61E-09	1.20E-09	5.08E-08	0.00E+00	7.25E-11	3.05E-08	1.38E-08	1.71E-07	4.55E-11	1.38E-08
10K YR	5.16E-08	5.17E-08	1.13E-07	0.00E+00	5.03E-08	7.49E-08	3.39E-07	3.89E-06	5.03E-08	2.07E-07
20K YR	1.39E-08	6.69E-09	1.57E-07	0.00E+00	3.30E-09	5.21E-08	3.16E-06	3.84E-05	3.23E-09	1.58E-06

ONSITE INC, S. LANDF

LIFE= 20 OVFL= 1 NSTR= 1
REGN= 1 DATA= 2

IPOP= 2 INST= 5

OPTIONAL ENVIRONMENTAL PARAMETERS
PRC = 1.60E-01 TXC = 1.00E+00 QFC = 1.10E+02 2.00E+05 4.50E+06
FSC = 2.64E-10 DTTM= 1.70E+00 TTM = 1.83E+00 2.50E+01 5.00E+01
FSA = 8.06E-11 DTPC= 0.00E+00 TPC = 0.00E+00 0.00E+00 0.00E+00
WVEL= 6.67E+00 AXOQ= 1.40E-10 EFAC= 7.95E-08

WASTE: WASTE OIL WEIGHT: 8.00E+02 MT DENSITY: 1.20E+00 MT/M3

ID= 1 IA= 1 IK1= 1 IK2= 50 PROCESS= 2
IXS= 30 100 30 1
ICS= 100 0 0 0

METAL PACKAGE RECYCLE IMPACTS MAXIND = 9.64E-01 MREM/YR
POPULN = 3.83E+03 PERSON-MREM/30YRS

TRANSPORTATION IMPACTS TR-MAX = 1.49E+03 MREM/YR
TR-OCC = 8.93E+04 PERSON-MREM/YR
TR-POP = 2.19E+05 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
INT-CO	8.24E+00	7.97E+00	7.98E+00	7.96E+00	7.97E+00	7.97E+00	7.97E+00	7.97E+00	7.97E+00	8.00E+00
INT-AG	3.78E+01	3.78E+01	3.81E+01	3.77E+01	3.77E+01	3.78E+01	3.78E+01	3.79E+01	3.77E+01	3.78E+01

EXPOSED WASTE IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IN-AIR	4.58E-01	9.14E-02	5.41E-01	0.00E+00	8.06E-02	1.16E-01	8.81E-02	1.09E-01	7.94E-02	1.73E-01
ER-AIR	1.06E-02	3.40E-03	2.54E-02	0.00E+00	2.86E-03	2.86E-03	2.86E-03	2.86E-03	2.86E-03	5.70E-03
IN-WAT	5.19E-04	5.73E-04	2.41E-03	0.00E+00	5.29E-04	7.18E-04	5.40E-04	6.57E-04	5.02E-04	7.25E-04
ER-WAT	1.17E-05	1.44E-05	1.26E-04	0.00E+00	1.17E-05	1.17E-05	1.17E-05	1.17E-05	1.17E-05	2.14E-05

INCINERATION AND OPERATIONAL IMPACTS: UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IC-POP	1.96E+04	9.68E+03	1.25E+05	0.00E+00	6.31E+03	6.54E+03	7.61E+03	1.37E+04	5.90E+03	2.05E+04
IC-IND	3.93E+00	1.94E+00	2.50E+01	0.00E+00	1.26E+00	1.31E+00	1.52E+00	2.74E+00	1.18E+00	4.09E+00
IC-WOR	5.18E+04	5.17E+04	5.18E+04	5.17E+04	5.17E+04	5.17E+04	5.17E+04	5.18E+04	5.18E+04	5.18E+04
IC-MWR	8.32E+01	8.31E+01	8.31E+01	8.31E+01	8.31E+01	8.31E+01	8.31E+01	8.31E+01	8.31E+01	8.31E+01
OP-POP	1.61E+01	7.86E+00	6.71E+01	0.00E+00	5.87E+00	6.39E+00	7.35E+00	1.66E+01	5.70E+00	1.42E+01
OP-IND	9.65E-02	4.71E-02	4.03E-01	0.00E+00	3.52E-02	3.84E-02	4.41E-02	9.95E-02	3.42E-02	8.51E-02
OP-WOR	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03
OP-MWR	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03	4.55E+03

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	4.93E+00	9.71E+00	1.56E+02	0.00E+00	5.87E+00	6.34E+00	6.61E+00	1.45E+01	5.03E+00	2.10E+01
LA-OVF	6.77E-01	8.69E-01	8.69E+00	0.00E+00	6.81E-01	9.04E-01	7.46E-01	8.63E-01	6.66E-01	1.42E+00
LA-AIR	1.15E+01	1.95E+00	2.13E+01	0.00E+00	1.48E+00	1.76E+00	1.65E+00	1.89E+00	1.46E+00	4.40E+00

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GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	5.1[illegible]E+00	6.37E+00	5.70E+01	0.00E+00	5.17E+00	5.33E+00	5.79E+00	6.50E+00	5.17E+00	9.70E+00
40YR	4.35E+00	5.38E+00	4.82E+01	0.00E+00	4.35E+00	4.35E+00	4.73E+00	5.17E+00	4.35E+00	8.13E+00
60YR	3.74E+00	[illegible]3E+00	4.12E+01	0.00E+00	3.74E+00	3.74E+00	3.98E+00	4.24E+00	3.74E+00	6.96E+00
80YR	3.23E+00	[illegible]	3.53E+01	0.00E+00	3.23E+00	3.23E+00	3.37E+00	3.53E+00	3.22E+00	5.97E+00
100YR	2.78E+00	3.43E+00	3.03E+01	0.00E+00	2.78E+00	2.78E+00	2.87E+00	2.97E+00	2.78E+00	5.13E+00
120YR	2.40E+00	2.96E+00	2.60E+01	0.00E+00	2.40E+00	2.40E+00	2.45E+00	2.51E+00	2.40E+00	4.41E+00
160YR	1.78E+00	2.20E+00	1.93E+01	0.00E+00	1.78E+00	1.78E+00	1.80E+00	1.83E+00	1.78E+00	3.27E+00
200YR	1.33E+00	1.64E+00	1.43E+01	0.00E+00	1.33E+00	1.33E+00	1.33E+00	1.34E+00	1.33E+00	2.43E+00
400YR	3.03E-01	3.74E-01	3.27E+00	0.00E+00	3.03E-01	3.03E-01	3.03E-01	3.03E-01	3.03E-01	5.54E-01
600YR	6.91E-02	8.53E-02	7.45E-01	0.00E+00	6.91E-02	6.91E-02	6.91E-02	6.91E-02	6.91E-02	1.27E-01
800YR	1.58E-02	1.95E-02	1.70E-01	0.00E+00	1.58E-02	1.58E-02	1.58E-02	1.58E-02	1.58E-02	2.89E-02
1K YR	3.60E-03	4.45E-03	3.89E-02	0.00E+00	3.60E-03	3.60E-03	3.60E-03	3.60E-03	3.60E-03	6.59E-03
2K YR	2.23E-06	2.76E-06	2.41E-05	0.00E+00	2.23E-06	2.23E-06	2.23E-06	2.23E-06	2.23E-06	4.09E-06
5K YR	5.33E-16	6.58E-16	5.75E-15	0.00E+00	5.32E-16	5.32E-16	5.32E-16	5.32E-16	5.32E-16	9.75E-16

10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	3.57E-01	4.41E-01	3.85E+00	0.00E+00	3.57E-01	3.57E-01	3.88E-01	4.24E-01	3.57E-01	6.67E-01
60YR	3.41E-01	4.22E-01	3.75E+00	0.00E+00	3.41E-01	3.41E-01	3.62E-01	3.87E-01	3.41E-01	6.34E-01
80YR	2.94E-01	3.63E-01	3.22E+00	0.00E+00	2.94E-01	2.94E-01	3.07E-01	3.22E-01	2.94E-01	5.44E-01
100YR	2.53E-01	3.13E-01	2.76E+00	0.00E+00	2.53E-01	2.53E-01	2.61E-01	2.70E-01	2.53E-01	4.67E-01
120YR	2.18E-01	2.70E-01	2.37E+00	0.00E+00	2.18E-01	2.18E-01	2.23E-01	2.29E-01	2.18E-01	4.02E-01
160YR	1.62E-01	2.01E-01	1.76E+00	0.00E+00	1.62E-01	1.62E-01	1.64E-01	1.66E-01	1.62E-01	2.98E-01
200YR	1.21E-01	1.49E-01	1.31E+00	0.00E+00	1.21E-01	1.21E-01	1.21E-01	1.22E-01	1.21E-01	2.22E-01
400YR	2.76E-02	3.40E-02	2.98E-01	0.00E+00	2.76E-02	2.76E-02	2.76E-02	2.76E-02	2.76E-02	5.05E-02
600YR	6.29E-03	7.77E-03	6.79E-02	0.00E+00	6.29E-03	6.29E-03	6.29E-03	6.29E-03	6.29E-03	1.15E-02
800YR	1.44E-03	1.77E-03	1.55E-02	0.00E+00	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03	2.63E-03
1K YR	3.28E-04	4.05E-04	3.54E-03	0.00E+00	3.28E-04	3.28E-04	3.28E-04	3.28E-04	3.28E-04	6.01E-04
2K YR	2.03E-07	2.51E-07	2.20E-06	0.00E+00	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07	3.73E-07
5K YR	4.85E-17	5.99E-17	5.24E-16	0.00E+00	4.85E-17	4.85E-17	4.85E-17	4.85E-17	4.85E-17	8.89E-17
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	1.08E-02	1.33E-02	1.18E-01	0.00E+00	1.08E-02	1.08E-02	1.14E-02	1.21E-02	1.08E-02	2.00E-02
80YR	1.55E-02	1.91E-02	1.68E-01	0.00E+00	1.55E-02	1.55E-02	1.61E-02	1.68E-02	1.55E-02	2.86E-02
100YR	1.33E-02	1.65E-02	1.45E-01	0.00E+00	1.33E-02	1.33E-02	1.37E-02	1.41E-02	1.33E-02	2.45E-02
120YR	1.15E-02	1.42E-02	1.24E-01	0.00E+00	1.15E-02	1.15E-02	1.17E-02	1.20E-02	1.15E-02	2.11E-02
160YR	8.52E-03	1.05E-02	9.27E-02	0.00E+00	8.52E-03	8.52E-03	8.61E-03	8.71E-03	8.52E-03	1.56E-02
200YR	6.34E-03	7.83E-03	6.85E-02	0.00E+00	6.34E-03	6.34E-03	6.37E-03	6.41E-03	6.34E-03	1.16E-02
400YR	1.45E-03	1.78E-03	1.56E-02	0.00E+00	1.45E-03	1.45E-03	1.45E-03	1.45E-03	1.45E-03	2.65E-03
600YR	3.30E-04	4.07E-04	3.56E-03	0.00E+00	3.30E-04	3.30E-04	3.30E-04	3.30E-04	3.30E-04	6.04E-04
800YR	7.53E-05	9.30E-05	8.13E-04	0.00E+00	7.53E-05	7.53E-05	7.53E-05	7.53E-05	7.53E-05	1.38E-04
1K YR	1.72E-05	2.12E-05	1.86E-04	0.00E+00	1.72E-05	1.72E-05	1.72E-05	1.72E-05	1.72E-05	3.15E-05
2K YR	1.07E-08	1.32E-08	1.15E-07	0.00E+00	1.07E-08	1.07E-08	1.07E-08	1.07E-08	1.07E-08	1.95E-08
5K YR	2.54E-18	3.14E-18	2.75E-17	0.00E+00	2.54E-18	2.54E-18	2.54E-18	2.54E-18	2.54E-18	4.66E-18
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Total Run Time = 0.7050E-01 Minute(s)

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SAMPLE PROBLEM OUTPUT FILE: TAPE10.OUT

IMPACTS BRC - VERSION 2.1: Run on 10/03/91 at 11:48:28.46

HAZARDOUS WASTE II

SEC-RESINS

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	MAX INDIVIDUAL
H-3	0.000E+00
C-14	0.000E+00
CR-51	1.328E-01
MN-54	6.896E-02
FE-55	0.000E+00
FE-59	2.710E-01
CO-58	1.356E-01
CO-60	3.489E-01
NI-59	0.000E+00
NI-63	0.000E+00

ZN-65	1.844E-02
SR-90	0.000E+00
ZR-95	7.225E-02
NB-94	4.408E-06
TC-99	0.000E+00
RU-103	1.892E-01
AG-110	5.843E-01
I-129	8.396E-07
CS-134	1.820E+00
CS-135	0.000E+00
CS-137	2.159E+00
CE-141	1.937E-02
CE-144	2.047E-02
PU-238	3.909E-07
PU-239	3.631E-07
PU-241	1.085E-07
PU-242	5.128E-10
AM-241	3.114E-04
AM-243	1.938E-04
CM-242	3.810E-06
CM-243	1.008E-06
CM-244	1.292E-07

TOTAL TRANSPORTATION IMPACTS = 5.821E+00

METAL PACKAGE RECYCLE ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	DOSIND
H-3	7.185E-09
C-14	4.251E-12
CR-51	4.174E-04
MN-54	1.523E-06
FE-55	4.454E-11
FE-59	5.049E-06
CO-58	2.070E-06
CO-60	9.693E-06
NI-59	1.118E-13
NI-63	8.538E-11
ZN-65	3.745E-07
SR-90	1.544E-08
ZR-95	4.419E-06
NB-94	1.176E-10
TC-99	4.802E-14
RU-103	2.336E-06
AG-110	1.533E-05
I-129	3.047E-11
CS-134	4.304E-05
CS-135	2.520E-11
CS-137	5.317E-05
CE-141	2.134E-07
CE-144	6.640E-07
PU-238	2.502E-06
PU-239	1.191E-06
PU-241	5.920E-10
PU-242	2.465E-09
AM-241	2.255E-06
AM-243	1.556E-06
CM-242	6.139E-06
CM-243	5.686E-09
CM-244	1.608E-06

TOTAL RECYCLE IMPACT = 5.706E-04

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	CONSTRUCTION	AGRICULTURE
H-3	2.681E-11	2.038E-04

C-14	1.750E-10	1.770E-04
CR-51	0.000E+00	0.000E+00
MN-54	6.201E-14	2.937E-13
FE-55	2.478E-13	6.181E-11
FE-59	0.000E+00	0.000E+00
CO-58	0.000E+00	0.000E+00
CO-60	2.075E-04	9.832E-04
NI-59	4.557E-13	3.206E-11
NI-63	2.830E-10	2.231E-08
ZN-65	2.188E-17	1.043E-16
SR-90	1.047E-07	9.778E-07
ZR-95	0.000E+00	0.000E+00
NB-94	1.374E-07	6.510E-07
TC-99	5.890E-12	1.590E-07
RU-103	0.000E+00	0.000E+00
AG-110	1.264E-15	5.987E-15
I-129	2.657E-08	7.696E-07
CS-134	2.380E-06	1.128E-05
CS-135	3.221E-12	2.298E-10
CS-137	3.369E-02	1.598E-01
CE-141	0.000E+00	0.000E+00
CE-144	1.575E-15	7.450E-15
PU-238	3.277E-05	1.058E-04
PU-239	2.247E-05	7.257E-05
PU-241	4.327E-05	1.611E-04
PU-242	4.683E-08	1.513E-07
AM-241	8.104E-05	3.055E-04
AM-243	1.103E-05	4.678E-05
CM-242	3.684E-07	1.190E-06
CM-243	2.573E-08	1.118E-07
CM-244	6.923E-06	2.392E-05
RADON		0.000E+00

TOTAL NON-NORMALIZED INTRUDER IMPACTS
3.409E-02 1.617E-01

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
H-3	9.426E-09	0.000E+00	3.189E-10	0.000E+00
C-14	8.915E-08	6.503E-05	5.256E-09	4.707E-06
CR-51	0.000E+00	0.000E+00	0.000E+00	0.000E+00
MN-54	5.211E-18	0.000E+00	1.248E-18	0.000E+00
FE-55	6.595E-12	0.000E+00	3.419E-13	0.000E+00
FE-59	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CO-58	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CO-60	3.049E-08	0.000E+00	6.771E-10	0.000E+00
NI-59	5.701E-12	4.635E-09	1.699E-13	1.696E-10
NI-63	3.765E-09	3.718E-09	1.153E-10	1.398E-10
ZN-65	1.764E-20	0.000E+00	1.343E-21	0.000E+00
SR-90	4.530E-07	2.374E-14	1.462E-09	9.407E-17
ZR-95	0.000E+00	0.000E+00	0.000E+00	0.000E+00
NB-94	6.253E-11	4.962E-08	8.490E-12	8.271E-09
TC-99	1.364E-10	1.116E-07	4.004E-12	4.020E-09
RU-103	0.000E+00	0.000E+00	0.000E+00	0.000E+00
AG-110	1.451E-19	0.000E+00	4.361E-21	0.000E+00
I-129	3.596E-07	2.950E-04	1.071E-09	1.079E-06
CS-134	1.196E-09	0.000E+00	1.259E-10	0.000E+00
CS-135	2.767E-10	2.269E-07	3.143E-11	3.165E-08
CS-137	2.780E-05	4.235E-12	3.020E-06	5.648E-13
CE-141	0.000E+00	0.000E+00	0.000E+00	0.000E+00
CE-144	1.597E-17	0.000E+00	2.453E-19	0.000E+00
PU-238	1.303E-04	7.264E-05	7.853E-09	7.626E-09
PU-239	8.929E-05	7.124E-02	5.260E-09	5.152E-06
PU-241	1.639E-04	3.448E-02	6.391E-07	1.811E-04
PU-242	1.861E-07	1.524E-04	1.095E-11	1.101E-08
AM-241	3.056E-04	5.315E-02	1.308E-06	2.793E-04
AM-243	2.139E-05	1.632E-02	9.181E-08	8.444E-05
CM-242	1.454E-06	8.175E-07	8.828E-11	8.547E-11

CM-243	4.808E-08	8.994E-08	1.540E-10	6.505E-12
CM-244	2.958E-05	2.173E-04	9.133E-08	1.572E-08

TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS

	7.703E-04	1.760E-01	5.173E-00	5.559E-04

OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	TREATMENT	OVERFLOW	EVAPORATOR
H-3	3.167E-04	3.869E-05	1.118E-02
C-14	1.408E-04	1.403E-04	1.279E-02
CR-51	3.183E-07	0.000E+00	0.000E+00
MN-54	1.277E-06	3.679E-17	5.501E-18
FE-55	6.423E-07	2.880E-10	1.990E-10
FE-59	7.955E-08	0.000E+00	0.000E+00
CO-58	2.350E-06	0.000E+00	0.000E+00
CO-60	4.743E-05	9.043E-07	1.575E-06
NI-59	6.526E-10	6.524E-10	7.842E-10
NI-63	5.106E-07	4.168E-07	4.852E-07
ZN-65	1.054E-05	4.011E-19	1.887E-19
SR-90	6.204E-06	3.002E-06	3.331E-05
ZR-95	1.019E-06	0.000E+00	0.000E+00
NB-94	2.448E-08	2.443E-08	6.440E-09
TC-99	1.184E-07	1.184E-07	2.890E-07
RU-103	1.269E-04	0.000E+00	0.000E+00
AG-110	2.080E-07	1.442E-20	1.718E-20
I-129	2.398E-05	2.398E-05	5.765E-04
CS-134	2.210E-05	9.262E-10	3.152E-10
CS-135	1.334E-09	1.334E-09	4.207E-10
CS-137	2.057E-04	1.029E-04	3.391E-05
CE-141	6.841E-08	0.000E+00	0.000E+00
CE-144	1.023E-06	2.520E-18	5.876E-18
PU-238	1.120E-06	8.837E-07	5.250E-04
PU-239	6.384E-07	6.379E-07	3.878E-04
PU-241	2.715E-07	6.413E-08	4.235E-05
PU-242	1.314E-09	1.314E-09	8.001E-07
AM-241	1.442E-03	1.374E-03	1.150E-02
AM-243	9.812E-05	9.784E-05	8.160E-04
CM-242	4.584E-07	2.169E-27	3.005E-28
CM-243	3.101E-08	1.496E-08	1.706E-07
CM-244	2.486E-05	7.879E-06	9.020E-05

TOTAL NON-NORMALIZED OVERFLOW IMPACTS

	2.485E-03	1.812E-03	3.798E-02

GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

FIRST ROW IS INTRUDER WELL
SECOND ROW IS POPULATION WELL
THIRD ROW IS SURFACE WATER

20YR 40YR 60YR 80YR 100YR 120YR 160YR 200YR 400YR 600YR 800YR 1K YR 2K YR 5K YR
10K YR 20K YR

H-3
0.0E+00 0.0E+00 9.4E-06 1.7E-06 3.1E-07 5.6E-08 3.7E-09 1.2E-10 9.7E-18 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
C-14
0.0E+00 0.0E+00 2.1E-04 2.0E-04 1.9E-04 1.8E-04 3.2E-04 2.9E-04 3.3E-04 3.4E-04 2.5E-04 1.6E-04 1.1E-05 3.3E-09
4.4E-15 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.0E-05 2.3E-05 2.0E-05 2.3E-06 6.8E-10
9.1E-16 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.6E-07 1.8E-07 5.2E-11

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7.0E-17 0.0E+00
  CR-51
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  MN-54
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  FE-55
 0.0E+00 0.0E+00 1.0E-12 6.1E-15 3.5E-17 2.1E-19 1.4E-23 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  FE-59
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CO-58
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CO-60
 0.0E+00 0.0E+00 1.3E-07 9.2E-09 6.5E-10 4.8E-11 4.6E-13 2.3E-15 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  NI-59
 0.0E+00 0.0E+00 1.6E-09 1.6E-09 1.6E-09 1.6E-09 3.2E-09 3.1E-09 5.8E-09 9.4E-09 1.1E-08 1.1E-08 7.8E-09 2.5E-09
3.7E-10 8.3E-12
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.5E-10 1.0E-09 1.4E-09 1.6E-09 5.2E-10
7.7E-11 1.7E-12
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.2E-11 8.5E-11 2.7E-11
4.0E-12 8.0E-14
  NI-63
 0.0E+00 0.0E+00 9.0E-07 7.8E-07 6.7E-07 5.8E-07 8.7E-07 8.5E-07 3.0E-07 1.2E-07 3.7E-08 9.4E-09 6.4E-12 2.0E-21
0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  ZN-65
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  SR-90
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0.0E+00 0.0E+00
  ZR-95
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  NB-94
 0.0E+00 0.0E+00 1.1E-08 1.1E-08 1.1E-08 1.1E-08 2.2E-08 2.1E-08 4.0E-08 6.6E-08 8.0E-08 8.3E-08 6.1E-08 2.4E-08
5.0E-09 2.2E-10
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.9E-09 7.3E-09 1.0E-08 1.3E-08 4.9E-09
1.0E-09 4.5E-11
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.0E-10 3.6E-09 1.4E-09
3.0E-10 1.3E-11
  TC-99
 0.0E+00 0.0E+00 3.0E-07 2.8E-07 2.7E-07 2.5E-07 4.5E-07 4.0E-07 4.5E-07 4.4E-07 3.2E-07 2.0E-07 1.1E-08 1.9E-12
1.0E-18 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.6E-08 2.9E-08 2.5E-08 2.3E-09 4.0E-13
2.1E-19 0.0E+00
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9.5E-21 0.0E+00
  RU-103
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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  AG-110
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  I-128
 0.0E+00 0.0E+00 8.0E-05 7.5E-05 7.1E-05 6.7E-05 1.2E-04 1.1E-04 1.2E-04 1.2E-04 8.5E-05 5.3E-05 3.0E-06 5.2E-10
2.8E-16 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.9E-06 7.8E-06 6.6E-06 6.1E-07 1.1E-10
5.8E-17 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.0E-08 2.8E-08 4.8E-12
2.6E-18 0.0E+00
  CS-134
 0.0E+00 0.0E+00 2.2E-13 2.7E-16 3.2E-19 3.8E-22 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CS-135
 0.0E+00 0.0E+00 1.2E-09 1.2E-09 1.2E-09 1.2E-09 2.5E-09 2.5E-09 4.9E-09 6.6E-09 1.1E-08 1.2E-08 1.2E-08 1.2E-08
1.2E-08 1.1E-08
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.1E-10 1.0E-09 1.5E-09 2.5E-09 2.5E-09
2.4E-09 2.3E-09
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.7E-11 3.6E-10 3.6E-10
3.5E-10 3.4E-10
  CS-137
 0.0E+00 0.0E+00 6.2E-05 3.9E-05 2.4E-05 1.5E-05 1.2E-05 4.8E-06 9.6E-08 1.6E-08 2.1E-11 2.3E-13 2.1E-23 0.0E+00
0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CE-141
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CE-144
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  PU-238
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.0E-08 8.1E-09 1.3E-09 9.2E-13 1.1E-22
0.0E+00 0.0E+00
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0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  PU-239
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1.2E-05 8.1E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.1E-07
1.5E-06 1.7E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
1.2E-08 7.9E-08
  PU-241
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.4E-19 2.3E-23 1.5E-2[illegible] 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  PU-242
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.7E-09 3.7E-09 3.7E-09 7.3E-09 1.8E-08
3.3E-08 2.9E-08
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 7.3E-10
4.1E-09 5.9E-09
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
3.2E-11 2.8E-10
  AM-241
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.5E-07
1.1E-10 8.8E-18
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0.0E+00 0.0E+00
  AM-243
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.9E-05
2.6E-05 7.2E-06
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  CM-242
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  CM-243
 [illegible]+00 [illegible] 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
[illegible]+00 [illegible]
 [illegible]+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
[illegible]+00 0.0E+00
 [illegible]+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
[illegible]+00 0.0E+00
  CM-244
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 [illegible]MALIZED GROUNDWATER IMPACTS
 [illegible] 3.7E-04 3.2E-04 2.9E-04 2.8E-04 4.5E-04 4.0E-04 4.5E-04 4.6E-04 3.4E-04 2.2E-04 1.7E-05 7.7E-05
3.6E-[illegible]
 [illegible]+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.7E-05 3.1E-05 2.7E-05 2.9E-06 3.2E-07
1.5E-08 [illegible].7E-06
 [illegible] 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.1E-07 2.1E-07 1.9E-09
1.3E-08 8.0E-08
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SANITARY LANDFILL

TRASH

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	MAX INDIVIDUAL
H-3	0.000E+00
C-14	0.000E+00
CR-51	3.249E-02
MN-54	1.687E-02
FE-55	0.000E+00
FE-59	6.628E-02
CO-58	3.316E-02
CO-60	8.536E-02
NI-59	0.000E+00
NI-63	0.000E+00
ZN-65	4.511E-03
SR-90	0.000E+00
ZR-95	1.768E-02
NB-94	1.078E-06
TC-99	0.000E+00
RU-103	4.139E-02
AG-110	1.429E-01
I-129	2.054E-07
CS-134	4.453E-01
CS-135	0.000E+00
CS-137	5.281E-01
CE-141	4.738E-03
CE-144	5.007E-03
PU-238	9.583E-08
PU-239	8.393E-08
PU-241	2.655E-08
PU-242	1.254E-10
AM-241	7.862E-05
AM-243	4.742E-05
CM-242	9.320E-07
CM-243	2.466E-07
CM-244	3.160E-08

TOTAL TRANSPORTATION IMPACTS = 1.424E+00

INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIES ****

NUC	MAXIMUM OFF-SITE INDIVIDUAL
H-3	1.263E-05
C-14	1.840E-05
CR-51	6.494E-07
MN-54	2.479E-07
FE-55	2.016E-08
FE-59	1.284E-06
CO-58	5.031E-07
CO-60	2.193E-05
NI-59	7.817E-12
NI-63	6.353E-09
ZN-65	6.355E-07
SR-90	1.283E-06
ZR-95	3.733E-07
NB-94	8.560E-11
TC-99	3.741E-10
RU-103	6.704E-06
AG-110	2.869E-06
I-129	9.858E-07
CS-134	3.912E-05
CS-135	3.783E-10

CS-137	7.621E-05
CE-141	5.872E-07
CE-144	8.891E-06
PU-238	[illegible].263E-04
PU-239	1.225E-04
PU-241	8.606E-05
PU-242	2.552E-07
AM-241	4.395E-04
AM-243	2.938E-05
CM-242	3.169E-05
CM-243	1.393E-07
CM-244	1.282E-04

TOTAL NON-NORMALIZED INCINERATOR IMPACT = 1.236E-03

WORKER INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIES ****

NUC	RESIDUE HANDLERS	MAINTENANCE
H-3	2.637E-09	1.340E-09
C-14	2.841E-09	1.618E-09
CR-51	5.034E-03	5.033E-03
MN-54	2.614E-03	2.613E-03
FE-55	9.343E-09	5.139E-09
FE-59	1.027E-02	1.027E-02
CO-58	5.158E-03	5.1[illegible]7E-03
CO-60	1.3[illegible]3E-02	1.322E-02
NI-59	7.827E-12	4.305E-12
NI-63	5.833E-09	3.208E-09
ZN-65	6.989E-04	6.988E-04
SR-90	3.624E-06	1.993E-06
ZR-95	2.738E-03	2.738E-03
NB-94	1.672E-07	1.671E-07
TC-99	9.862E-11	5.424E-11
RU-103	6.411E-03	6.411E-03
AG-110	2.215E-02	2.214E-02
I-129	3.86[illegible]E-08	3.557E-08
CS-134	6.899E-02	6.899E-02
CS-135	5.393E-11	2.966E-11
CS-137	8.183E-02	8.181E-02
CE-141	7.345E-04	7.342E-04
CE-144	7.938E-04	7.856E-04
PU-238	6.952E-04	3.824E-04
PU-239	3.763E-04	2.070E-04
PU-241	2.644E-04	1.454E-04
PU-242	7.839E-07	4.312E-07
AM-241	1.238E-03	7.027E-04
AM-243	9.126E-05	5.350E-05
CM-242	9.237E-05	5.087E-05
CM-243	4.387E-07	2.565E-07
CM-244	3.630E-04	1.996E-04

TOTAL NON-NORMALIZED WORKER IMPACTS
2.238E-01 2.223E-01

METAL AND GLASS RECYCLE ICRP IMPACTS BY NUCLIDE

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF FACILITIES ****

NUC	METAL IND	GLASS IND
H-3	4.042E-06	0.000E+00
C-14	2.391E-09	0.000E+00
CR-51	2.348E-01	9.424E-02
MN-54	8.567E-04	4.893E-02
FE-55	2.505E-08	0.000E+00
FE-59	2.840E-03	1.923E-01
CO-58	1.164E-03	9.619E-02
CO-60	5.453E-03	2.476E-01

NI-59	6.286E-11	0.000E+00
NI-63	4.803E-08	0.000E+00
ZN-65	2.107E-04	1.308E-02
SR-90	6.583E-06	0.000E+00
ZR-95	2.466E-03	5.127E-02
[illegible]-94	6.614E-08	3.128E-06
[illegible]	2.735[illegible]-11	0.000E+00
R[illegible]-103	1.314E-03	1.200E-01
AG-110	8.625E-03	4.146E-01
I-129	1.714E-08	5.957E-07
CS-134	2.421E-02	1.282E+00
CS-135	1.416E-08	0.000E+00
CS-137	2.991E-02	1.532E+00
CE-141	1.200E-04	1.374E-02
CE-144	3.735E-04	1.452E-02
PU-238	1.407E-03	2.774E-07
PU-239	6.697E-0[illegible]	2.434[illegible]-07
PU-241	3.161E-07	7.699E-08
PU-242	1.387E-06	3.636E-10
AM-241	1.268E-03	2.280E-04
AM-243	8.753[illegible]-04	1.375E-04
CM-242	3.453E-03	2.703E-06
CM-243	3.198E-06	7.152E-07
CM-244	9.043E-04	9.165E-08

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIE[illegible] ****

NUC	CONSTRUCTION	AGRICULTURE
H-3	1.887E-10	6.553E-04
C-14	5.694E-1[illegible]	2.630E-04
CR-51	2.442E-02	1.157E-01
MN-54	1.268E-02	6.005E-02
FE-55	7.132E-09	8.659E-08
FE-59	4.981E-02	2.360E-01
CO-58	2.492E-02	1.181E-01
CO-60	6.415E-02	3.039E-01
NI-59	5.880E-12	1.945E-10
NI-63	4.495E-09	1.634E-07
ZN-65	3.390E-03	1.615E-02
SR-90	2.793E-06	1.224E-05
ZR-95	1.328E-02	6.292E-02
NB-94	8.104E-07	3.839E-06
TC-99	7.561E-11	9.320E-07
RU-103	3.094E-02	1.466E-01
AG-110	1.074E-01	5.088E-01
I-129	1.584E-07	4.639E-06
CS-134	3.347E-01	[illegible].585E+00
[illegible]S-135	4.156E-11	1.452E-09
CS-137	3.969E-01	1.880E+00
CE-141	3.561E-03	1.687E-02
CE-144	3.776E-03	1.785E-02
PU-238	5.357E-04	8.491E-04
PU-239	2.000E-04	4.587E-04
PU-241	2.038E-04	3.229E-04
PU-242	6.041E-07	9.575E-07
AM-241	1.026E-03	2.002E-03
AM-243	1.003E-04	2.839E-04
CM-242	7.176E-05	1.224E-04
CM-243	4.939E-07	1.401E-06
CM-244	2.787E-04	4.744E-04
RADON		0.000E+00

TOTAL NON-NORMALIZED INTRUDER IMPACTS
1.072E+00 5.074E+00

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
H-3	1.294E-07	0.000E+00	1.026E-09	0.000E+00
C-14	5.653E-07	1.103E-06	7.808E-09	8.243E-07
CR-51	1.181E-05	0.000E+00	1.140E-07	0.000E+00
MN-54	4.547E-06	0.000E+00	2.552E-07	0.000E+00
FE-55	3.899E-07	0.000E+00	4.483E-09	0.000E+00
FE-59	2.356E-05	0.000E+00	2.433E-07	0.000E+00
CO-58	9.228E-06	0.000E+00	7.008E-08	0.000E+00
CO-60	4.022E-05	0.000E+00	1.938E-07	0.000E+00
NI-59	1.434E-10	9.128E-10	1.001E-12	1.182E-10
NI-63	1.165E-07	2.509E-10	8.360E-10	9.742E-11
ZN-65	1.166E-05	0.000E+00	2.080E-07	0.000E+00
SR-90	2.354E-05	1.602E-15	1.780E-06	6 [illegible]57E-17
ZR-95	6.847E-06	0.000E+00	4.601E-08	0.000E+00
NB-94	1.574E-08	3.349E-08	5.007E-11	5.765E-09
TC-99	3.413E-09	7.492E-09	2.348E-11	2.788E-09
RU-103	6.118E-05	0.000E+00	4.877E-07	0.000E+00
AG-110	5.262E-05	0.000E+00	3.707E-07	0.000E+00
I-129	8.996E-06	1.981E-05	6.280E-09	7.483E-07
CS-134	7.176E-04	0.000E+00	1.770E-05	0.000E+00
CS-135	6.957E-09	1.531E-08	1.852E-10	3.206E-08
CS-137	1.398E-03	2.858E-13	3.559E-05	3.937E-13
CE-141	1.077E-05	0.000E+00	8.594E-08	0.000E+00
CE-144	1.631E-04	0.000E+00	5.869E-07	0.000E+00
PU-238	4.151E-03	4.916E-06	5.864E-08	5.316E-09
PU-239	2.247E-03	4.808E-03	3.102E-06	3.591E-06
PU-241	1.570E-03	2.327E-03	2.003E-08	1.263E-04
PU-242	4.881E-06	1.029E-05	6.452E-11	7.673E-09
AM-241	8.062E-03	3.587E-03	6.087E-06	1.947E-04
AM-243	5.390E-04	1.101E-03	5.424E-07	5.886E-05
CM-242	5.812E-04	5.518E-08	3.521E-07	5.958E-11
CM-243	2.555E-06	6.070E-09	1.881E-09	4.334E-12
CM-244	2.315E-03	1.467E-02	1.697E-06	1.096E-08

TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS
2.203E-02 1.187E-02 6.679E-05 3.850E-04

OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	TREATMENT	OVERFLOW	EVAPORATOR
H-3	1.697E-05	1.697E-05	3.586E-02
C-14	1.875E-05	1.875E-05	1.895E-02
CR-51	1.676E-07	1.676E-07	1.630E-06
MN-54	6.765E-07	6.765E-07	1.122E-06
FE-55	3.403E-07	3.403E-07	2.608E-06
FE-59	4.215E-06	4.215E-06	3.789E-03
CO-58	1.245E-06	1.245E-06	1.526E-05
CO-60	2.513E-05	2.513E-05	4.854E-04
NI-59	3.458E-10	3.458E-10	4.608E-09
NI-63	2.705E-07	2.705E-07	3.510E-06
ZN-65	5.586E-06	5.586E-06	2.914E-05
SR-90	3.287E-06	3.287E-06	4.045E-04
ZR-95	5.397E-07	5.397E-07	7.476E-06
NB-94	1.296E-08	1.296E-08	3.791E-08
TC-99	6.243E-08	6.243E-08	1.690E-06
RU-103	6.689E-05	6.689E-05	1.530E-03
AG-110	1.102E-07	1.102E-07	1.456E-06
I-129	1.264E-05	1.264E-05	3.370E-03
CS-134	1.171E-05	1.171E-05	4.418E-05
CS-135	7.071E-10	7.071E-10	2.472E-09
CS-137	1.090E-04	1.090E-04	3.984E-0[illegible]
CE-141	4.685E-08	4.685E-08	5.465E-07
CE-144	5.422E-07	5.422E-07	1.402E-05
PU-238	5.935E-07	5.935E-07	3.910E-03
PU-239	3.383E-07	3.383E-07	2.281E-03
PU-241	1.438E-07	1.438E-07	1.053E-03
PU-242	6.963E-10	6.963E-10	4.702E-06
AM-241	7.639E-04	7.639E-04	7.086E-02

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AM-243      5.199E-05   5.199E-05   4.808E-03
CM-242      2.429E-07   2.429E-07   3.732E-05
CM-243      1.843E-08   1.843E-08   2.078E-06
CM-244      1.317E-05   1.317E-05   1.872E-03

TOTAL NON-NORMALIZED OVERFLOW IMPACTS
             109E-03   1.109E-03   1.458E-01


GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME
****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

FIRST ROW IS INTRUDER WELL
SECOND ROW IS POPULATION WELL
THIRD ROW IS SURFACE WATER

   20YR    40YR    60YR    80YR   100YR   120YR   160YR   200YR   400YR   600YR   800YR   1K YR   2K YR   5K YR
10K YR  20K YR

  H-3
 2.6E-04 8.3E-05 2.0E-05 3.5E-06 5.6E-07 8.9E-08 2.3E-09 5.8E-11 6.1E-19 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.1E-09 2.4E-09 1.9E-10 5.3E-12 5.6E-20 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.3E-14 2.5E-21 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
  C-14
 6.0E-04 1.1E-03 1.6E-03 1.6E-03 1.5E-03 1.4E-03 1.3E-03 1.1E-03 5.7E-04 3.0E-04 1.5E-04 7.9E-05 2.9E-06 1.5E-10
1.1E-17 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.4E-05 3.9E-05 1.0E-04 [illegible] 5.2E-05 2.7E-05 1.4E-05 7.2E-06 2.7E-07 1.4E-11
9.9E-19 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 7.6E-07 4.0E-06 2.1E-06 1.1E-06 5.6E-07 2.1E-08 1.1E-12
7.6E-20 0.0E+00
  CR-51
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  MN-54
 0.0E+00 0.0E+00 1.6E-26 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  FE-55
 3.2E-07 3.7E-09 3.2E-11 2.1E-13 1.2E-15 7.1E-18 2.4E-22 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.1E-17 1.9E-19 1.0E-23 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  FE-59
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CO-58
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
  CO-60
 2.7E-04 3.8E-05 4.0E-06 3.2E-07 2.2E-08 1.6E-09 7.0E-12 4.0E-14 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.0E-10 4.3E-11 6.5E-13 3.6E-15 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
```

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 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.7E-17 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
  NI-59
 1.7E-08 3.4E-08 5.1E-08 5.6E-08 5.5E-08 5.5E-08 5.4E-08 5.2E-08 4.8E-08 4.4E-08 4.0E-08 3.6E-08 2.3E-08 5.7E-09
5.6E-10 5.3E-12
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.0E-10 1.5E-09 4.4E-09 4.8E-09 4.4E-09 4.0E-09 3.6E-09 3.3E-09 2.1E-09 5.2E-10
5.1E-11 4.9E-13
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.5E-11 2.3E-10 2.1E-10 1.9E-10 1.7E-10 1.1E-10 2.7E-11
2.7E-12 2.5E-14
  NI-63
 1.3E-05 2.2E-05 2.8E-05 2.7E-05 2.3E-05 2.0E-05 1.5E-05 1.1E-05 2.5E-06 5.8E-07 1.5E-07 3.0E-08 1.9E-11 4.4E-21
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.1E-07 5.4E-07 1.2E-06 1.0E-06 2.3E-07 5.2E-08 1.2E-08 2.7E-09 1.7E-12 4.0E-22
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.3E-09 1.2E-08 2.7E-09 6.3E-10 1.4E-10 8.9E-14 2.1E-23
0.0E+00 0.0E+00
  ZN-65
 2.2E-12 4.8E-21 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  SR-90
 1.4E-04 1.7E-04 1.6E-04 1.1E-04 6.5E-05 4.0E-05 1.5E-05 5.6E-06 4.2E-08 3.1E-10 2.3E-12 1.7E-14 3.9E-25 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.0E-07 1.1E-06 1.7E-06 5.1E-07 3.8E-09 2.8E-11 2.1E-13 1.6E-15 3.6E-26 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.4E-09 1.8E-10 1.3E-12 1.0E-14 7.5E-17 1.7E-27 0.0E+00
0.0E+00 0.0E+00
  ZR-95
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  NB-94
 1.2E-07 2.3E-07 3.5E-07 3.8E-07 3.8E-07 3.8E-07 3.7E-07 3.7E-07 3.4E-07 3.1E-07 2.9E-07 2.7E-07 1.9E-07 6.0E-08
9.2E-09 2.1E-10
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.5E-09 1.0E-08 3.0E-08 3.3E-08 3.1E-08 2.9E-08 2.7E-08 2.5E-08 1.7E-08 5.5E-09
8.4E-10 2.0E-11
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 9.6E-10 8.9E-09 8.3E-09 7.7E-09 7.1E-09 4.9E-09 1.6E-09
2.4E-10 5.6E-12
  TC-99
 3.4E-06 6.4E-06 9.0E-06 9.3E-06 8.7E-06 8.1E-06 7.0E-06 6.1E-06 3.0E-06 1.5E-06 7.2E-07 3.6E-07 1.0E-08 2.5E-13
5.1E-21 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 7.9E-08 2.2E-07 5.7E-07 5.5E-07 2.7E-07 1.3E-07 6.6E-08 3.3E-08 9.4E-10 2.3E-14
4.8E-22 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.5E-09 1.2E-08 6.0E-09 3.0E-09 1.5E-09 4.2E-11 1.0E-15
2.1E-23 0.0E+00
  RU-103
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  AG-110
* 1.3E-13 4.5E-22 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  I-129
 9.1E-04 1.7E-03 2.4E-03 2.5E-03 2.3E-03 2.1E-03 1.9E-03 1.6E-03 7.9E-04 3.9E-04 1.9E-04 9.5E-05 2.8E-06 6.7E-11
1.4E-18 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.1E-05 5.8E-05 1.5E-04 1.5E-04 7.2E-05 3.6E-05 1.8E-05 8.8E-06 2.5E-07 6.1E-12
1.3E-19 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.6E-07 3.3E-06 1.6E-06 7.9E-07 3.9E-07 1.1E-08 2.0E-13
5.7E-21 0.0E+00
  CS-134
```

1.[illegible] 3.8E-09 6.9E-12 9.3E-15 1.1E-17 1.3E-20 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.0E-19 3.7E-22 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
CS-135
1.3E-08 2.6E-08 3.8E-08 4.3E-08 4.2E-08 4.2E-08 4.2E-08 4.2E-08 4.2E-08 4.2E-08 4.2E-08 4.2E-08 4.2E-08 4.1E-08
4.0E-08 3.8E-08
0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.9E-10 1.2E-09 3.5E-09 3.9E-09 3.9E-09 3.9E-09 3.9E-09 3.9E-09 3.8E-09 3.8E-09
3.7E-09 3.5E-09
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.6E-11 5.6E-10 5.6E-10 5.6E-10 5.6E-10 5.5E-10 5.5E-10
5.3E-10 5.0E-10
CS-137
1.6E-03 2.0E-03 1.9E-03 1.3E-03 8.5E-04 5.3E-04 2.1E-04 8.4E-05 8.3E-07 8.1E-09 8.0E-11 7.9E-13 7.3E-23 0.0E+00
0.[illegible]+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 7.7E-06 1.5E-05 1.7E-05 7.6E-06 7.5E-08 7.4E-10 7.3E-12 7.2E-14 6.6E-24 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.1E-07 1.0E-08 1.0E-10 1.0E-12 9.9E-15 9.2E-25 [illegible].0E+00
0.0E+00 0.0E+00
CE-141
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.[illegible]00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
CE-144
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
PU-238
0.0E+00 0.0E+00 7.4E-06 6.3E-06 5.4E-06 9.2E-06 6.7E-06 7.3E-06 3.0E-0[illegible] 9.2E-07 2.1E-07 4.3E-08 1.6E-11 7.7E-22
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.[illegible]-10 1.4E-12 7.0E-23
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.8E-15 3.3E-24
0.0E+00 0.0E+00
PU-239
0.0E+00 0.0E+00 6.3E-06 6.2E-06 6.2E-06 1.2E-05 1.2E-05 1.9E-05 3.7E-05 5.5E-05 6.1E-05 6.0E-05 5.8E-05 5.1E-05
4.1E-05 2.6[illegible]
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.5E-07 5.2E-06 4.6E-06
3.7E-06 2.4E-06
0.0E+00 0.0E+00 0.[illegible]+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.5E-08 2.2E-07
1.8E-07 1.1E-07
PU-241
0.0E+00 0.0E+00 2.3[illegible] [illegible].6E-0[illegible] 3.3E-08 2.5E-08 3.7E-09 8.1E-10 1.1E-13 1.1E-17 7.8E-22 5.2E-26 0.0E+00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+[illegible] 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 4.7E-28 0.0E+00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
PU-242
0.0E+00 0.0E+00 1.3E-08 1.3E-08 1.3E-08 2.6E-08 2.6E-08 3.9E-08 7.8E-08 1.2E-07 1.3E-07 1.3E-07 1.3E-07 1.2E-07
1.1E-07 9.4E-08
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.2E-09 1.2E-08 1.1E-08
1.0E-08 8.6E-09
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.4E-11 5.2E-10
4.8E-10 4.1E-10
AM-241
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.4E-03 2.4E-03 1.7E-03 9.0E-04 1.2E-05
3.0E-09 9.8E-17
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
2.7E-11 8.7E-18
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 6.3E-20
AM-243
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.6E-04 5.3E-04 5.1E-04 1.2E-03 1.5E-03
7.0E-04 7.7E-05
0.0E+00 0.0E+00 0.0E+00 0.0E+[illegible] 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00

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6.4E-06 7.0E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 5.1E-08
  CM-242
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CM-243
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 2.4E-28 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  CM-244
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
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0.0E+00 0.0E+00
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0.0E+00 0.0E+00

  TOTAL NON-NORMALIZED GROUNDWATER IMPACTS
 3.8E-03 5.2E-03 6.1E-03 5.6E-03 4.8E-03 4.2E-03 3.4E-03 2.8E-03 1.4E-03 4.7E-03 3.3E-03 2.4E-03 2.2E-03 1.5E-03
7.4E-04 1.0E-04
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 4.3E-05 1.1E-04 2.8E-04 2.6E-04 1.2E-04 6.3E-05 3.2E-05 1.6E-05 5.8E-06 4.6E-06
1.0E-05 9.5E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.6E-06 7.3E-06 3.7E-06 1.9E-06 9.6E-07 6.3E-08 2.2E-07
1.8E-07 1.7E-07


   ON-DIRT


   ANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

   NUC    MAX INDIVIDUAL

   PB-210       2.305E-05
   PO-210       1.372E-07
   RN-222       2.753E-02
   RA-226       2.775E-02
   RA-228       2.387E-02
   AC-227       1.479E-04
   TH-228       3.874E-02
   TH-230       1.101E-06
   TH-232       9.483E-07
   PA-231       1.758E-05
   U-234        3.558E-07
   U-235        6.630E-05
   U-238        1.797E-04

   TOTAL TRANSPORTATION IMPACTS =   1.[illegible]93E-01


   INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

   ****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

   NUC      CONSTRUCTION  AGRICULTURE

   PB-210      1.318E-05   1.113E-04
   PO-210      6.562E-06   3.270E-05
   RN-222      3.326E-03   1.575E-02
   RA-226      3.360E-03   1.593E-02
   RA-228      2.890E-03   1.374E-02
   AC-227      6.335E-05   1.781E-04
   TH-228      5.111E-03   2.286E-02
   TH-230      2.000E-04   3.252E-04
   TH-232      1.446E-03   2.358E-03
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PA-231	1.238E-05	7.729E-05
U-234	1.007E-04	1.598E-04
U-235	1.235E-05	4.482E-05
U-238	1.117E-04	2.455E-04
RADON		1.222E-05

TOTAL NON-NORMALIZED INTRUDER IMPACTS
1.667E-02 7.183E-02

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
PB-210	3.560E-04	3.533E-17	2.880E-06	3.242E-17
PO-210	1.564E-04	0.000E+00	5.774E-06	0.000E+00
RN-222	1.801E-10	1.661E-20	1.413E-12	1.524E-20
RA-226	1.198E-04	9.133E-04	6.869E-07	7.299E-04
RA-228	1.708E-04	0.000E+00	1.235E-06	0.000E+00
AC-227	4.339E-04	1.478E-17	7.780E-07	1.434E-18
TH-228	3.362E-03	0.000E+00	3.395E-07	0.000E+00
TH-230	1.574E-03	3.912E-03	2.845E-07	4.126E-04
TH-232	1.142E-02	3.292E-02	2.336E-06	4.660E-04
PA-231	3.080E-04	1.600E-03	6.346E-07	1.648E-04
U-234	7.805E-04	1.747E-03	1.225E-08	3.531E-06
U-235	3.362E-05	1.078E-04	6.053E-10	3.558E-06
U-238	6.978E-04	1.541E-03	1.116E-08	1.336E-06

TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS
1.941E-02 4.275E-02 1.495E-05 1.782E-03

OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	TREATMENT	OVERFLOW	EVAPORATOR
PB-210	3.319E-03	3.319E-03	2.403E-03
PO-210	5.277E-04	5.277E-04	8.316E-05
RN-222	2.638E-08	2.638E-08	1.956E-08
RA-226	1.050E-03	1.050E-03	1.065E-03
RA-228	7.577E-04	7.577E-04	6.096E-04
AC-227	8.975E-04	8.975E-04	2.912E-03
TH-228	8.552E-05	8.552E-05	4.925E-03
TH-230	4.365E-04	4.365E-04	1.405E-02
TH-232	3.584E-03	3.584E-03	1.019E-01
PA-231	9.746E-04	9.746E-04	2.752E-03
U-234	5.674E-07	5.674E-07	2.104E-04
U-235	2.825E-08	2.825E-08	8.128E-06
U-238	5.209E-07	5.209E-07	1.894E-04

TOTAL NON-NORMALIZED OVERFLOW IMPACTS
1.163E-02 1.163E-02 1.312E-01

GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME
**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

FIRST ROW IS INTRUDER WELL
SECOND ROW IS POPULATION WELL
THIRD ROW IS SURFACE WATER

20YR 40YR 60YR 80YR 100YR 120YR 160YR 200YR 400YR 600YR 800YR 1K YR 2K YR 5K YR 10K YR 20K YR

PB-210
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00

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 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
  PO-210
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  RN-222
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  RA-226
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.0E-03 1.0E-03 1.8E-03 2.4E-03 2.9E-03 3.3E-03 3.7E-03 6.9E-04
4.2E-05 1.6E-07
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.3E-05
3.9E-06 1.4E-08
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
2.0E-07 7.3E-10
  RA-228
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 7.8E-12 6.2E-14 3.7E-24 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  AC-227
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  TH-228
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  TH-230
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 4.2E-04 4.1E-04 4.0E-04 1.1E-03 1.6E-03
1.2E-03 3.1E-04
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
1.1E-[illegible] 1.8E-05
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 1.5E-07
  TH-232
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.5E-03 3.4E-03 3.3E-03 8.8E-03 1.4E-02
1.1E-02 3.0E-03
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
9.7E-05 2.7E-04
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 1.4E-06
  PA-231
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 5.7E-04
5.4E-04 1.8E-04
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  U-234
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.7E-07
1.0E-06 1.8E-08
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
  U-235
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0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 3.4E-08
6.6E-08 9.5E-08
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
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0.0E+00 0.0E+00

U-238

0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.2E-07
1.2E-06 1.8E-06
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00

TOTAL NON-NORMALIZED GROUNDWATER IMPACTS

0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.0E-03 1.0E-03 1.8E-03 6.4E-03 6.7E-03 7.0E-03 1.4E-02 1.7E-02
1.2E-02 3.5E-03
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 6.3E-05
1.1E-04 3.0E-04
0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
2.0E-07 1.6E-06

ONSITE INC. S. LANDF

WASTE OIL

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	MAX INDIVIDUAL
CR-51	2.932E+02
MN-54	2.955E+01
FE-55	0.000E+00
FE-59	2.003E+02
CO-58	1.241E+02
CO-60	5.508E+00
NI-63	0.000E+00
ZN-65	3.298E+01
RB-86	4.710E+01
SR-89	2.438E-02
SR-90	0.000E+00
ZR-95	1.490E+02
NB-95	2.761E+02
RU-103	2.238E+02
RU-106	7.433E+00
AG-110	3.890E+01
CS-134	1.117E+01
CS-137	2.990E+00
CE-141	4.513E+01
CE-144	1.476E+00

TOTAL TRANSPORTATION IMPACTS = 1.489E+03

METAL PACKAGE RECYCLE ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	DOSIND
CR-51	9.416E-01
MN-54	6.668E-04
FE-55	8.279E-07
FE-59	3.813E-03
CO-58	1.936E-03
CO-60	1.563E-04
NI-63	3.901E-06
ZN-65	6.844E-04
RB-86	8.734E-04
SR-89	1.743E-05
SR-90	2.169E-06
ZR-95	9.308E-03

NB-95	5.457E-05
RU-103	3.156E-03
RU-106	1.760E-04
AG-110	1.043E-0[illegible]
CS-134	2.699E-04
CS-137	7.524E-05
CE-141	5.081E-04
CE-144	4.89[illegible]E-05

TOTAL RECYCLE IMPACT = 9.644E-01

INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIES ****

NUC	MAXIMUM OFF-SITE INDIVIDUAL
CR-51	3.960E+00
MN-54	2.934E-01
FE-55	1.136E+00
FE-59	2.622E+00
CO-58	1.272E+00
CO-60	9.559E-02
NI-63	7.846E-01
ZN-65	3.139E+00
RB-86	6.826E+00
SR-89	1.967E+00
SR-90	4.875E-01
ZR-95	2.128E+00
NB-95	7.019E+00
RU-103	4.899E+01
RU-106	3.499E+01
AG-110	5.275E-01
CS-134	6.630E-01
CS-137	2.915E-01
CE-141	3.779E+00
CE-144	1.771E+00

TOTAL NON-NORMALIZED INCINERATOR IMPACT = 1.227E+02

WORKER INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIES ****

NUC	RESIDUE HANDLERS	MAINTENANCE
CR-51	4.910E+02	4.910E+02
MN-54	4.949E+01	4.948E+01
FE-55	8.426E-03	4.255E-03
FE-59	3.354E+02	3.354E+02
CO-58	2.078E+02	2.078E+02
CO-60	9.225E+00	9.223E+00
NI-63	1.154E-02	5.827E-03
ZN-65	5.523E+01	5.522E+01
RB-86	7.888E+01	7.887E+01
SR-89	7.148E-02	5.630E-02
SR-90	2.205E-02	1.113E-02
ZR-95	2.495E+02	2.494E+02
NB-95	4.623E+02	4.623E+02
RU-103	3.748E+02	3.748E+02
RU-106	1.251E+01	1.248E+01
AG-110	6.515E+01	6.514E+01
CS-134	1.871E+01	1.870E+01
CS-137	5.007E+00	5.007E+00
CE-141	7.563E+01	7.559E+01
CE-144	2.530E+00	2.501E+00

TOTAL NON-NORMALIZED WORKER IMPACTS
2.493E+03 2.493E+03

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	CONSTRUCTION	AGRICULTURE
CR-51	3.961E-18	1.876E-17
MN-54	4.678E-01	2.216E+00
FE-55	2.598E-03	5.620E-03
FE-59	8.822E-11	4.179E-10
CO-58	1.985E-06	9.403E-06
CO-60	2.575E+00	1.219E+01
NI-63	1.254E-02	4.248E-02
ZN-65	1.729E-01	8.236E-01
RB-86	0.000E+00	0.000E+00
SR-89	7.468E-13	4.052E-12
SR-90	2.198E-02	1.176E-02
ZR-95	3.564E-07	1.688E-06
NB-95	4.983E-14	2.360E-13
RU-103	2.301E-12	1.090E-11
RU-106	2.184E-01	1.035E+00
AG-110	2.254E-01	1.068E+00
CS-134	1.882E+00	8.915E+00
CS-137	2.409E+00	1.141E+01
CE-141	4.959E-16	2.347E-15
CE-144	1.627E-02	7.379E-02
RADON		0.000E+00
TOTAL NON-NORMALIZED INTRUDER IMPACTS	8.003E+00	3.779E+01

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
CR-51	4.528E-21	0.000E+00	1.849E-23	0.000E+00
MN-54	3.930E-04	0.000E+00	9.416E-06	0.000E+00
FE-55	2.404E-02	0.000E+00	1.246E-04	0.000E+00
FE-59	9.775E-14	0.000E+00	4.308E-16	0.000E+00
CO-58	1.722E-09	0.000E+00	5.582E-12	0.000E+00
CO-60	3.780E-03	0.000E+00	7.775E-06	0.000E+00
NI-63	5.799E-02	5.699E-03	1.776E-04	2.142E-05
ZN-65	1.393E-03	0.000E+00	1.061E-05	0.000E+00
RB-86	0.000E+00	0.000E+00	0.000E+00	0.000E+00
SR-89	1.089E-12	0.000E+00	5.352E-15	0.000E+00
SR-90	3.305E-02	1.119E-10	1.067E-05	4.434E-14
ZR-95	4.304E-10	0.000E+00	1.234E-12	0.000E+00
NB-95	1.072E-16	0.000E+00	2.263E-18	0.000E+00
RU-103	1.066E-14	0.000E+00	3.701E-17	0.000E+00
RU-106	2.151E-02	0.000E+00	6.529E-05	0.000E+00
AG-110	2.587E-04	0.000E+00	7.777E-07	0.000E+00
CS-134	9.455E-03	0.000E+00	9.953E-05	0.000E+00
CS-137	1.987E-02	2.010E-10	2.159E-04	2.687E-12
CE-141	3.511E-18	0.000E+00	1.195E-20	0.000E+00
CE-144	1.575E-03	0.000E+00	2.418E-08	0.000E+00
TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS	1.733E-01	5.699E-03	7.245E-04	2.142E-05

OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	TREATMENT	OVERFLOW	EVAPORATOR
CR-51	2.910E-02	4.349E-22	7.630E-22
MN-54	2.281E-02	3.993E-04	1.194E-04
FE-55	5.459E-01	1.510E-01	2.087E-01
FE-59	2.451E-01	1.194E-13	1.941E-13

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CO-58        8.968E-02   1.587E-09   3.508E-09
CO-60        3.121E-02   1.613E-02   5.619E-02
NI-63        9.518E-01   9.194E-01   2.151E+00
ZN-65        7.859E-01   4.558E-03   4.288E-03
RB-86        1.625E-02   0.000E+00   0.000E+00
SR-89        7.507E-02   9.917E-13   2.640E-12
SR-90        3.557E-02   3.151E-02   6.894E-01
ZR-95        8.754E-02   2.317E-10   5.788E-10
NB-95        2.350E+00   4.693E-16   1.593E-16
RU-103       6.944E+00   7.957E-14   3.284E-13
RU-106       8.718E+00   2.823E-01   1.333E+00
AG-110       5.772E-04   3.698E-06   8.816E-06
CS-134       5.652E-03   1.053E-03   7.169E-04
CS-137       1.187E-02   1.058E-02   6.975E-03
CE-141       8.588E-03   1.043E-19   2.193E-19
CE-144       3.077E-03   3.575E-05   1.668E-04

TOTAL NON-NORMALIZED OVERFLOW IMPACTS
             2.096E+01   1.417E+00   4.461E+00


GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME
****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

FIRST ROW IS INTRUDER WELL
SECOND ROW IS POPULATION WELL
THIRD ROW IS SURFACE WATER

   20YR    40YR    60YR    80YR   100YR   120YR   160YR   200YR   400YR   600YR   800YR   1K YR   2K YR   5K YR
10K YR  20K YR

 CR-51
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
 MN-54
 3.9E-09 7.4E-16 1.0E-22 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 FE-55
 1.1E-01 6.2E-04 3.6E-06 2.1E-08 1.2E-10 7.1E-13 2.4E-17 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 5.1E-05 3.3E-07 1.9E-09 1.1E-11 6.4E-14 2.2E-18 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 FE-59
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 CO-58
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 CO-60
 7.0E-02 4.9E-03 3.5E-04 2.5E-05 1.7E-06 1.2E-07 6.1E-10 3.1E-12 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 4.0E-04 3.2E-05 2.2E-06 1.6E-07 1.1E-08 5.6E-11 2.8E-13 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00 0.0E+00
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 NI-63
 9.2E+00 7.9E+00 6.6E+00 5.9E+00 5.1E+00 4.4E+00 3.3E+00 2.4E+00 5.5E-01 1.3E-01 2.9E-02 6.6E-03 4.1E-06 9.8E-16
0.0E+00 0.0E+00
 0.0E+00 6.5E-01 6.2E-01 5.4E-01 4.6E-01 4.0E-01 3.0E-01 2.2E-01 5.0E-02 1.2E-02 2.6E-03 6.0E-04 3.7E-07 8.9E-17
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 2.0E-02 2.8E-02 2.4E-02 2.1E-02 1.6E-02 1.2E-02 2.6E-03 6.0E-04 1.4E-04 3.1E-05 2.0E-08 4.7E-18
0.0E+00 0.0E+00
 ZN-65
 6.3E-08 7.1E-17 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 RB-86
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 SR-89
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 SR-90
 3.1E-01 1.9E-01 1.2E-01 7.2E-02 4.4E-02 2.7E-02 1.0E-02 3.8E-03 2.8E-05 2.1E-07 1.5E-09 1.2E-11 2.7E-22 0.0E+00
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0.0E+00 0.0E+00
 ZR-95
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 NB-95
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 RU-103
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 RU-106
 1.1E-03 1.1E-09 1.1E-15 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 AG-110
 1.5E-10 2.5E-19 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 CS-134
 1.6E-04 1.9E-07 2.3E-10 2.8E-13 3.4E-16 4.1E-19 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 0.0E+00 1.6E-08 2.1E-11 2.5E-14 3.1E-17 3.7E-20 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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 0.0E+00 0.0E+00 1.7E-12 3.4E-15 4.1E-18 5.0E-21 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
  CS-137
 3.7E-02 2.3E-02 1.5E-02 9.1E-03 5.6E-03 3.6E-03 1.4E-03 5.7E-04 5.6E-06 5.5E-08 5.4E-10 5.4E-12 5.0E-22 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 1.9E-03 1.2E-03 8.3E-04 5.2E-04 3.3E-04 1.3E-04 5.2E-05 5.1E-07 5.0E-09 5.0E-11 4.9E-13 4.5E-23 0.0E+00
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0.0E+00 0.0E+00
  CE-141
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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  CE-144
 6.6E-10 2.4E-17 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00 0.0E+00

  TOTAL NON-NORMALIZED GROUNDWATER IMPACTS
 9.7E+00 8.1E+00 7.0E+00 6.0E+00 5.1E+00 4.4E+00 3.3E+00 2.4E+00 5.5E-01 1.3E-01 2.9E-02 6.6E-03 4.1E-06 9.8E-16
0.0E+00 0.0E+00
 0.0E+00 6.7E-01 6.3E-01 5.4E-01 4.7E-01 4.0E-01 3.0E-01 2.2E-01 5.0E-02 1.2E-02 2.6E-03 6.0E-04 3.7E-07 8.9E-17
0.0E+00 0.0E+00
 0.0E+00 0.0E+00 2.0E-02 2.9E-02 2.5E-02 2.1E-02 1.6E-02 1.2E-02 2.6E-03 6.0E-04 1.4E-04 3.1E-05 2.0E-08 4.7E-18
0.0E+00 0.0E+00
----------------------------------------------------------------
 Total Run Time =   0.7050E-01 Minute(s)

***********************************************************************************************  ******
***********************************************************************************************  ******
```

SAMPLE PROBLEM OUTPUT FILE: TAPE11.OUT

```
 IMPACTS-BRC - VERSION 2.1: Run on 10/03/91 at 11:48:28.48


 HAZARDOUS WASTE II

 LIFE= 20  OVFL=  1  NSTR=  1
 REGN=  1  DATA=  0
 IPOP=  1  INST= 30

 WASTE: SEC-RESINS  WEIGHT: 8.00E+01 MT  DENSITY: 1.00E+00 MT/M3

 ID= 2  IA= 1  IK1= 1  IK2= 50  PROCESS= 1
 IXS=  10 100   0   5
 ICS=   0   0   0 100

 METAL PACKAGE RECYCLE IMPACTS    MAXIND = 5.71E-04 MREM/YR
                                  POPULN = 4.81E+01 PERSON-MREM/30YRS

 TRANSPORTATION IMPACTS           TR-MAX = 5.82E+00 MREM/YR
                                  TR-OCC = 1.16E+02 PERSON-MREM/YR
                                  TR-POP = 7.97E+02 PERSON-MREM/YR

 INTRUDER IMPACTS (MREM/YR):

   SCN   ICRP
 INT-CO 6.82E-03
 INT-AG 3.23E-02

 EXPOSED WASTE IMPACTS (MREM/YR):
```

```
   SCN   ICRP
 IN-AIR 7.70E-04
 ER-AIR 1.76E-01
 IN-WAT 1.03E-06
 ER-WAT 1.11E-04

 INCINERATION AND OPERATIONAL IMPACTS:
  UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
         IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

   SCN   ICRP
 IC-POP 0.00E+00
 IC-IND 0.00E+00
 IC-WOR 0.00E+00
 IC-MWR 0.00E+00
 OP-POP 0.00E+00
 OP-IND 2.42E-11
 OP-WOR 1.04E+02
 OP-MWR 4.97E-01

 LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

   SCN   ICRP
 LA-OPS 4.97E-04
 LA-OVF 3.62E-04
 LA-AIR 3.80E-02
1
 GROUND WATER IMPACTS (MREM/YR):

 INTRUDER-WELL
   TIME  ICRP
   20YR 0.00E+00
   40YR 0.00E+00
   60YR 7.32E-05
   80YR 6.36E-05
  100YR 5.72E-05
  120YR 5.24E-05
  160YR 9.05E-05
  200YR 7.98E-05
  400YR 9.07E-05
  600YR 9.19E-05
  800YR 6.82E-05
  1K YR 4.39E-05
  2K YR 3.48E-06
  5K YR 1.53E-05
 10K YR 7.56E-06
 20K YR 3.06E-06

 POPULATION-WELL
   TIME  ICRP
   20YR 0.00E+00
   40YR 0.00E+00
   60YR 0.00E+00
   80YR 0.00E+00
  100YR 0.00E+00
  120YR 0.00E+[illegible]
  160YR 0.00[illegible]
  200YR 0.00E+00
  400YR 0.[illegible]0E+00
  600YR 5.39E-06
  800YR 6.22E-06
  1K YR 5.38E-06
  2K YR 5.79E-07
  5K YR 6.31E-08
 10K YR 3.01E-07
 20K YR 3.35E-07

 POPULATION-SURFACE WATER
   TIME  ICRP
   20YR 0.00E+00
   40YR 0.00E+00
   60YR 0.00E+00
   80YR 0.00E+00
```

```
100YR 0.00E+00
120YR 0.00E+00
160YR 0.00E+00
200YR 0.00E+00
400YR 0.00E+00
500YR 0.00E+00
800YR 0.00E+00
 1K YR 6.24E-08
 2K YR 4.14E-08
 5K YR 3.73E-10
10K YR 2.50E-09
20K YR 1.59E-08


SANITARY LANDFILL

LIFE= 20  OVFL=  1  NSTR=  2
REGN=  2  DATA=  0
IPOP=  2  INST=  0

WASTE: TRASH        WEIGHT: 1.00E+02 MT  DENSITY: 5.00E-01 MT/M3

ID= 2  IA= 1  IK1= 0  IK2=  0  PROCESS= 5
IXS=  32  10   4  16
ICS=  50  20  20  10

METAL MATERIAL RECYCLE IMPACTS  MAXIND = 3.21E-01 MREM/YR
                                POPULN = 2.16E+04 PERSON-MREM/30YRS

GLASS MATERIAL RECYCLE IMPACTS  MAXIND = 4.13E+00 MREM/YR
                                POPULN = 1.28E+04 PERSON-MREM/30YRS

TRANSPORTATION IMPACTS          TR-MAX = 1.42E+00 MREM/YR
                                TR-OCC = 9.11E+01 PERSON-MREM/YR
                                TR-POP = 5.07E+01 PERSON-MREM/YR

 INTRUDER IMPACTS (MREM/YR):

   SCN   ICRP
 INT-CO 6.70E-02
 INT-AG 3.17E-01

 EXPOSED WASTE IMPACTS (MREM/YR):

   SCN   ICRP
 IN-AIR 2.20E-02
 ER-AIR 1.19E-02
 IN-WAT 4.17E-06
 ER-WAT 2.41E-05

 INCINERATION AND OPERATIONAL IMPACTS:
  UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
         IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

   SCN   ICRP
 IC-POP 4.06E+01
 IC-IND 3.09E-04
 IC-WOR 5.85E+00
 IC-MWR 5.59E-02
 OP-POP 2.41E-01
 OP-IND 2.61E-04
 OP-WOR 3.64E+00
 OP-MWR 2.28E-01

 LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

   SCN   ICRP
 LA-OPS 6.93E-05
 LA-OVF 6.93E-05
 LA-AIR 1.46E-01
1
 GROUND WATER IMPACTS (MREM/YR):
```

INTRUDER-WELL

TIME	ICRP
20YR	2.38E-04
40YR	3.23E-04
60YR	3.81E-04
80YR	3.50E-04
100YR	2.99E-04
120YR	2.62E-04
160YR	2.11E-04
200YR	1.78E-04
400YR	8.82E-05
600YR	2.91E-04
800YR	2.08E-04
1K YR	1.52E-04
2K YR	1.37E-04
5K YR	9.63E-05
10K YR	4.64E-05
20K YR	6.50E-06

POPULATION-WELL

TIME	ICRP
20YR	0.00E+00
40YR	0.00E+00
60YR	0.00E+00
80YR	0.00E+00
100YR	2.72E-06
120YR	7.13E-06
160YR	1.72E-05
200YR	1.61E-05
400YR	7.81E-06
600YR	3.92E-06
800YR	1.98E-06
1K YR	1.03E-06
2K YR	3.62E-07
5K YR	2.89E-07
10K YR	6.32E-07
20K YR	5.92E-07

POPULATION-SURFACE WATER

TIME	ICRP
20YR	0.00E+00
40YR	0.00E+00
60YR	0.00E+00
80YR	0.00E+00
100YR	0.00E+00
120YR	0.00E+00
160YR	0.00E+00
200YR	9.74E-08
400YR	4.59E-07
600YR	2.32E-07
800YR	1.18E-07
1K YR	6.00E-08
2K YR	3.91E-09
5K YR	1.38E-08
10K YR	1.11E-08
20K YR	1.04E-08

1

WASTE: CON-DIRT   WEIGHT: 5.00E+02 MT   DENSITY: 1.60E+00 MT/M3

```
ID= 3  IA= 1  IK1= 0  IK2=  0  PROCESS= 1
IXS=   3 100   0   1
ICS=   0   0   0 100
```

```
TRANSPORTATION IMPACTS           TR-MAX = 1.18E-01 MREM/YR
                                 TR-OCC = 7.10E-01 PERSON-MREM/YR
                                 TR-POP = 4.65E-01 PERSON-MREM/YR
```

INTRUDER IMPACTS (MREM/YR):

SCN	ICRP
INT-CO	1.67E-02
INT-AG	7.18E-02

EXPOSED WASTE IMPACTS (MREM/YR):

SCN	ICRP
IN-AIR	1.84E-02
ER-AIR	4.27E-02
IN-WAT	1.50E-05
ER-WAT	1.78E-03

INCINERATION AND OPERATIONAL IMPACTS:
UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	ICRP
IC-POP	0.00E+00
IC-IND	0.00E+00
IC-WOR	0.00E+00
IC-MWR	0.00E+00
OP-POP	2.12E-01
OP-IND	3.68E-03
OP-WOR	6.78E-02
OP-MWR	6.78E-02

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	ICRP
LA-OPS	1.16E-02
LA-OVF	1.16E-02
LA-AIR	1.31E-01

1

GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	ICRP
20YR	0.00E+00
40YR	0.00E+00
60YR	0.00E+00
80YR	0.00E+00
100YR	0.00E+00
120YR	0.00E+00
160YR	1.04E-03
200YR	1.02E-03
400YR	1.82E-03
600YR	6.36E-03
800YR	6.73E-03
1K YR	6.98E-03
2K YR	1.35E-02
5K YR	1.69E-02
10K YR	1.24E-02
20K YR	3.50E-03

POPULATION-WELL

TIME	ICRP
20YR	0.00E+00
40YR	0.00E+00
60YR	0.00E+00
80YR	0.00E+00
100YR	0.00E+00
120YR	0.00E+00
160YR	0.00E+00
200YR	0.00E+00
400YR	0.00E+00
600YR	0.00E+00
800YR	0.00E+00
1K YR	0.00E+00
2K YR	0.00E+00
5K YR	6.33E-05
10K YR	1.12E-04
20K YR	3.01E-04

POPULATION-SURFACE WATER

TIME	ICRP
20YR	0.00E+00
40YR	0.00E+00

```
   60YR 0.00E+00
   80YR 0.00E+00
  100YR 0.00E+00
  120YR 0.00E+00
  160YR 0.00E+00
  200YR 0.00E+00
  400YR 0.00E+00
  600YR 0.00E+00
  800YR 0.00E+00
  1K YR 0.00E+00
  2K YR 0.00E+00
  5K YR 0.00E+00
 10K YR 1.98E-07
 20K YR 1.57E-06
1
 CUMULATIVE IMPACTS


 INTRUDER IMPACTS (MREM/YR):

   SCN   ICRP
 INT-CO 8.37E-02
 INT-AG 3.89E-01

 EXPOSED WASTE IMPACTS (MREM/YR):

   SCN   ICRP
 IN-AIR 4.14E-02
 ER-AIR 5.46E-02
 IN-WAT 1.91E-05
 ER-WAT 1.81E-03

 INCINERATION AND OPERATIONAL IMPACTS:
  UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
         IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

   SCN   ICRP
 IC-POP 4.06E+01
 IC-IND 3.09E-04
 IC-WOR 5.85E+00
 IC-MWR 5.59E-02
 OP-POP 4.53E-01
 OP-IND 3.94E-03
 OP-WOR 3.71E+00
 OP-MWR 2.96E-01

 LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

   SCN   ICRP
 LA-OPS 1.17E-02
 LA-OVF 1.17E-02
 LA-AIR 2.77E-01
1
 GROUND WATER IMPACTS (MREM/YR):

 INTRUDER-WELL
   TIME  ICRP
   20YR 2.[illegible]8E-04
   40YR 3.23E-04
   60YR 3.81E-04
   80YR 3.50E-04
  100YR 2.99E-04
  120YR 2.62E-04
  160YR 1.25E-03
  200YR [illegible]70E-03
  400YR [illegible]E-03
  600YR 6[illegible]E-03
  800YR 6.94E-03
  1K YR 7.13E-03
  2K YR 1.37E-02
  5K YR 1.70E-02
 10K YR 1.25E-02
 20K YR 3.50E-03
```

```
POPULATION-WELL
  TIME  ICRP
  20YR 0.00E+00
  40YR 0.00E+00
  60YR 0.00E+00
  80YR 0.00E+00
 100YR 2.72E-06
 120YR 7.13E-06
 160YR 1.72E-05
 200YR 1.61E-05
 400YR 7.81E-06
 600YR 3.92E-06
 800YR 1.98E-06
  1K YR 1.03E-06
  2K YR 3.62E-07
  5K YR 6.36E-05
 10K YR 1.12E-04
 20K YR 3.02E-04

POPULATION-SURFACE WATER
  TIME  ICRP
  20YR 0.00E+00
  40YR 0.00E+00
  60YR 0.00E+00
  80YR 0.00E+00
 100YR 0.00E+00
 120YR 0.00E+00
 160YR 0.00E+00
 200YR 9.74E-08
 400YR 4.59E-07
 600YR 2.32E-07
 800YR 1.18E-07
  1K YR 6.00E-08
  2K YR 3.91E-09
  5K YR 1.36E-08
 10K YR 2.07E-07
 20K YR 1.58E-06


ONSITE INC, S. LANDF

LIFE= 20  OVFL=  1  NSTR=  1
REGN=  1  DATA=  2
IPOP=  2  INST=  5

OPTIONAL ENVIRONMENTAL PARAMETERS
PRC = 1.80E-01  TXC = 1.00E+00  QFC = 1.10E+02 2.00E+05 4.50E+06
FSC = 2.64E-10  DTTM= 1.70E+00  TTM = 1.85E+00 2.50E+01 5.00E+01
FSA = 8.06E-11  DTPC= 0.00E+00  TPC = 0.00E+00 0.00E+00 0.00E+00
WVEL= 6.67E+00  AXOQ= 1.40E-10  EFAC= 7.95E-06

WASTE: WASTE OIL   WEIGHT: 8.00E+02 MT  DENSITY: 1.00E+00 MT/M3

ID= 1  IA= 1  IK1= 1  IK2= 50  PROCESS= 2
IXS=  30 100  30   1
ICS= 100   0   0   0

METAL PACKAGE RECYCLE IMPACTS   MAXIND = 9.64E-01 MREM/YR
                                POPULN = 3.83E+03 PERSON-MREM/30YRS

TRANSPORTATION IMPACTS          TR-MAX = 1.49E+03 MREM/YR
                                TR-OCC = 8.93E+04 PERSON-MREM/YR
                                TR-POP = 2.19E+05 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

  SCN   ICRP
INT-CO 8.00E+00
INT-AG 3.78E+01

EXPOSED WASTE IMPACTS (MREM/YR):

  SCN   ICRP
```

```
IN-AIR 1.73E-01
ER-AIR 5.70E-03
IN-WAT 7.25E-04
ER-WAT 2.14E-05

INCINERATION AND OPERATIONAL IMPACTS:
 UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
        IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

  SCN   ICRP
IC-POP 2.05E+04
IC-IND 4.09E+00
IC-WOR 5.18E+04
IC-MWR 8.31E+01
OP-POP 1.42E+01
OP-IND 8.51E-02
OP-WOR 4.55E+03
OP-MWR 4.55E+03

LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

  SCN   ICRP
LA-OPS 2.10E+01
LA-OVF 1.42E+00
LA-AIR 4.46E+00
1
GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL
  TIME  ICRP
  20YR 9.70E+00
  40YR 8.13E+00
  60YR 6.96E+00
  80YR 5.97E+00
 100YR 5.13E+00
 120YR 4.41E+00
 160YR 3.27E+00
 200YR 2.43E+00
 400YR 5.54E-01
 600YR 1.27E-01
 800YR 2.89E-02
 1K YR 6.59E-03
 2K YR 4.09E-06
 5K YR 9.75E-16
10K YR 0.00E+00
20K YR 0.00E+00

POPULATION-WELL
  TIME  ICRP
  20YR 0.00E+00
  40YR 6.67E-01
  60YR 6.34E-01
  80YR 5.44E-01
 100YR 4.67E-01
 120YR 4.02E-01
 160YR 2.98E-01
 200YR 2.22E-01
 400YR 5.05E-02
 600YR 1.15E-02
 800YR 2.63E-03
 1K YR 6.01E-04
 2K YR 3.73E-07
 5K YR 8.89E-17
10K YR 0.00E+00
20K YR 0.00E+00

POPULATION-SURFACE WATER
  TIME  ICRP
  20YR 0.00E+00
  40YR 0.00E+00
  60YR 2.00E-02
  80YR 2.86E-02
 100YR 2.45E-02
```

```
  120YR 2.11E-02
  160YR 1.56E-02
  200YR 1.16E-02
  400YR 2.65E-03
  600YR 6.04E-04
  800YR 1.38E-04
   1K YR 3.15E-05
   2K YR 1.95E-08
   5K YR 4.86E-18
  10K YR 0.00E+00
  20K YR 0.00E+00
------------------------------------------------------------
 Total Run Time =    0.7050E-01 Minute(s)
```

APPENDIX E: Parameter History for the TAPE1.DAT Input File

Appendix E consists of a history of the parameter values as found on the TAPE1.DAT input file.

Abbreviations used in Appendix E

DMI = De Minimus documentation Vol. I
DMII = De Minimus documentation Vol. II
BRC = IMPACTS-BRC Version 2.0 User's Manual

CARD 1 DATA

NUC(N)

There were no changes in the current isotope list from DMI Table D-4 page D-10 to the current TAPE1.DAT file.

JJ(N)

Each value of JJ was noted to be consistent with the number of solubility classes for each isotope on the TAPE1.DAT file, but there is a discrepancy between the various documents as to the number of classes which are in fact to be included. This discrepancy will be addressed in the discussion for SOLB(N).

SOLB(N)

There was no change in the expected number of solubility classes in going from DMI Table D-5 pages D-11,12 to DMII Table 16, pages 24,25. However, the following changes were noted between the following sources:

DMII Table 16 pages 24,25
TAPE1.DAT file DMII pages B-1 to B-10
BRC Table 5.3 pages 5 to 7
Current TAPE1.DAT file

Codes: * = no change for either the current TAPE1.DAT file or BRC documentation
** = change for BRC documentation
*** = change for TAPE1.DAT input file

Isotope	DMII table	DMII TAPE1.DAT	BRC	TAPE1.DAT (Version 2.0)	Code
Cr-51	Y, D	Y, W, D	Y, W, D	Y, W, D	*
Sr-85,89,90	Y, W	Y, D	Y, D	Y, D	*
Zn-65	Y, W, D	Y, W, D	Y	Y, Y, Y	**
Nb-95	Y, W	Y, W	Y, W	Y	***
Ru-103,106	Y, W, D	Y	Y	Y	*
La-140	Y, W	W	W	W	*
Ce-141,144	Y, W	Y, W, D	Y, W	Y, W, W	**
Eu-152,154	Y, W	W	W	W	*
Ac-227	W	Y, W	Y, W	Y, W	*
Pa-231	W	Y, W	Y, W	Y, W	*
Np-237	W	Y, W	W	W, W	**
Am-241,243	W	Y, W	W	W, W	**
Cm-242,243, 244,248	W	Y, W	W	W, W	**

DCF3(N)

The values for this dose conversion factor were derived by using the MICROSHIELD code. The resulting dose conversion factors are listed in Table 7.6 on pages 7-19 and 7-20 of the BRC User's Manual. A comparison was made between the values in this table and the values on the current TAPE1.DAT file.

The following discrepancy was noted:

Eu-154	BRC = 8.63E-06
	TAPE1.DAT = 6.91E-06

This is the number found in DMI Table D-8 page D-18 and it may have been unchanged when the new values were entered into the updated TAPE1.DAT file. The error was acknowledged in the O'Neal letter and the change was made to TAPE1.DAT.

FF(N,1): Soil-to-plant transfer factor

The following sources were compared:

DMI Table D-11 page D-25
DMII TAPE1.DAT sample
BRC Table 7-9 pages 7-27,28
Current TAPE1.DAT

Isotope	DMI	DMII (TAPE1.DAT)	BRC	TAPE1.DAT (Version 2.0)
Ra-226,228	1.4E-3	1.4E-2	1.4E-2	1.4E-2

The originial citation of the transfer factor was in opposition to all subsequent documentation, so it was desirable to return to the original source of that datum. The original reference is USNRC "Calculational Models for Estimating Radiation Doses to Man from Airborne Radioactive Materials Resulting from Uranium Milling Operations," Regulatory Guide 3.51 (Task RH 802-4), Office of Standards Development, Feb. 1982.

The transfer factor given in the regulatory guide is 1.4E-2; therefore no change was made in the TAPE1.DAT input file.

FF(N,2): Feed and water-to-meat transfer factor

The following sources were compared:

DMI Table D-12 page D-26
DMII TAPE1.DAT sample
BRC Table 7-9 pages 7-27,28
Current TAPE1.DAT

Isotope	DMI	DMII (TAPE1.DAT)	BRC	TAPE1.DAT (Version 2.0)
Am-241,243	3.9E-3	3.9E-3	3.9E-4	3.9E-3

There is a typographical error in the IMPACTS-BRC User's Manual.

FF(N,3): Feed and water-to-milk transfer factor

The following sources were compared:

DMI Table D-13 page D-27
DMII TAPE1.DAT sample
BRC Table 7-9 pages 7-27,28

Isotope	DMI	DMII (TAPE1.DAT)	BRC	TAPE1.DAT (Version 2.0)
Yb-169	2.0E-5	5.0E-6	5.0E-6	5.0E-6
Am-241,243	4.1E-7 2.05E-5	4.1E-7	4.1E-7	4.1E-7

For Yb-169, Oztunali and Roles [1984] indicated that the value 2.0E-5 was to be used as the parameter value, but this value was not incorporated into the sample input file in Forstom and Goode [1986]. The parameter value was changed to the more conservative value, 2.0E-5, as originially selected. For Am-241,243, two selected values were indicated in the DMI document but the less conservative value has been used subsequently.

In the interest of conservatism it was decided to use the following transfer factors:

Yb-169	2.0E-5
Am-241,243	2.05E-5

FF(N,4): Water-to-freshwater fish transfer factor

The following sources were compared:

DMI Table D-14 page D-28
DMII TAPE1.DAT sample
BRC Table 7-9 pages 7-27,28
Current TAPE1.DAT

Isotope	DMI	DMII (TAPE1.DAT)	BRC	TAPE1.DAT (Version 2.0)
S-35	7.5E+2	7.5E+2	7.5E-2	7.5E+2

There is a typographical error in the IMPACTS-BRC Version 2.0 User's Manual.

FF(N,5): Water-to-freshwater seafood transfer factor

The following sources were compared:

DMI Table D-14 page D-28
DMII TAPE1.DAT sample
BRC Table 7-9 pages 7-27,28
Current TAPE1.DAT

Isotope	DMI	DMII (TAPE1.DAT)	BRC	TAPE1.DAT (Version 2.0)
S-35	1.0E+2	1.0E+2	1.0E-2	1.0E+2

There is a typographical error in the IMPACTS-BRC User's Manual.

AL(N): Decay constant

By using Dose-Rate Conversion Factors for External Exposure to Photons and Electrons by Kocher and Eckerman [1988] as the as the source for the half-lives of the isotopes, the following discrepancies were found in the decay constants.

	DEVELOPED FROM KOCHER, 1988		TAPE1.DAT (VERSION 2.0)	
ISOTOPE	HALF LIFE (yr)	AL(N)	Roundoff	Nonroundoff
H-3	1.228E+01	5.645E-02	5.64E-02	
Na-22	2.602E+00	2.664E-01	2.65E-01	
P-33	6.959E-02	9.961E+00		1.04E+01
S-35	2.396E-01	2.893E+00	2.88E+00	
Cl-36	3.010E+05	2.303E-06		2.25E-06
Ca-45	4.458E-01	1.555E+00		1.53E+00
Sc-46	2.296E-01	3.019E+00	3.01E+00	
Cr-51	7.590E-02	9.132E+00		9.10E+00
Mn-54	8.567E-01	8.091E-01		8.35E-01
Fe-55	2.700E+00	2.567E-01		2.67E-01
Fe-59	1.223E-01	5.669E+00		5.55E+00
Co-57	7.422E-01	9.339E-01		9.37E-01
Co-58	1.940E-01	3.573E+00		3.55E+00
Ni-59	7.500E+04	9.242E-06		8.66E-06
Ni-63	1.001E+02	6.925E-03		7.53E-03
Zn-65	6.696E-01	1.035E+00	1.03E+00	
Se-75	3.282E-01	2.112E+00	2.10E+00	
Sr-85	1.776E-01	3.902E+00		3.96E+00
Sr-89	1.385E-01	5.005E+00		4.81E+00
Sr-90	2.860E+01	2.424E-02		2.47E-02
Zr-95	1.754E-01	3.952E+00		3.87E+00
Nb-94	2.030E+04	3.415E-05		3.47E-05
Nb-95	9.605E-02	7.216E+00	7.23E+00	
Mo-99	7.537E-03	9.197E+01		9.11E+01
Tc-99	2.103E+05	3.254E-06		3.27E-06
Tc-99m	6.872E-04	1.009E+03	1.00E+03	
Ru-103	1.078E-01	6.429E+00	6.42E+00	
Ru-106	1.009E+00	6.871E-01	6.86E-01	
Ag-108m	1.270E+02	5.458E-03		5.39E-01
Ag-110m	6.845E-01	1.013E+00		9.92E-01
Cd-109	1.271E+00	5.453E-01		5.59E-01
Sn-126	1.000E+05	6.931E-06		6.60E-06
Sb-125	2.770E+00	2.502E-01		2.56E-01
I-125	1.648E-01	4.207E+00	4.20E+00	
I-129	1.570E+07	4.415E-08		5.92E-08
I-131	2.203E-02	3.147E+01	3.14E+01	
Cs-134	2.062E+00	3.362E-01		3.38E-01
Cs-135	2.300E+06	3.014E-07		2.31E-07
Cs-136	3.605E-02	1.922E+01		1.85E+01
Cs-137	3.017E+01	2.297E-02	2.31E-02	
Ba-140	3.504E-02	1.978E+01	1.97E+01	
Ce-144	7.789E-01	8.899E-01	8.91E-01	
Eu-152	1.360E+01	5.097E-02		5.46E-02
Eu-154	8.800E+00	7.877E-02		4.33E-02
Yb-169	8.759E-02	7.914E+00		7.96E+00
Pb-210	2.226E+01	3.114E-02		3.40E-02

ISOTOPE	DEVELOPED FROM KOCHER, 1988 HALF LIFE (yr)	AL(N)	TAPE1.DAT (VERSION 2.0) Roundoff	Nonroundoff
Rn-222	1.048E-02	6.617E+01		6.60E+01
Ra-228	5.750E+00	1.205E-01		1.03E-01
Ac-227	2.177E+01	3.184E-02		2.73E-03
Th-228	1.913E+00	3.623E-01	3.63E-01	
Th-230	7.700E+04	9.002E-06		8.66E-06
Th-232	1.405E+10	4.933E-11	4.92E-11	
Pa-231	3.276E+04	2.116E-05	2.13E-05	
U-233	1.592E+05	4.354E-06		4.28E-06
U-234	2.445E+05	2.835E-06		2.81E-06
U-235	7.038E+08	9.849E-10		9.76E-10
U-236	2.342E+07	2.960E-08		2.90E-08
U-238	4.468E+09	1.551E-10	1.54E-10	
Pu-238	8.775E+01	7.899E-03		8.02E-03
Pu-239	2.413E+03	2.872E-05		2.84E-05
Pu-240	6.537E+03	1.060E-04	1.05E-04	
Pu-241	1.440E+01	4.814E-02		5.25E-02
Pu-242	3.758E+05	1.844E-06	1.83E-06	
Pu-244	8.260E+07	8.392E-09		9.12E-09
Am-241	4.322E+02	1.604E-03		1.51E-03
Am-243	7.380E+03	9.392E-05		8.72E-05
Cm-242	4.471E-01	1.550E+00	1.56E+00	
Cm-243	2.850E+01	2.432E-02		2.17E-02
Cm-244	1.811E+01	3.827E-02		3.94E-02
Cm-248	3.390E+05	2.045E-06		1.47E-06
Cf-252	2.639E+00	2.627E-01	2.62E-01	

Round-off errors in the table of AL(N) values are considered to be 1 in the 3rd significant digit

The half-lives cited in Kocher and Eckermann [1988] served as the basis for the establishment of the dose conversion factors. The older half-lives were never referenced in the background documentation, so they were untraceable. Therefore, the decay constants were changed to be the same as those in Kocher for consistency and traceability.

FMF(N): Waste-to-leachate partition ratio

The following sources were compared:

DMI Table 6-5 page 6-24
DMII TAPE1.DAT sample
BRC Table 9-3 pages 9-34
Current TAPE1.DAT

The following conflicting values were given:

Isotope	DMI	DMII (TAPE1.DAT)	BRC	TAPE1.DAT (Version 2.0)
C-14 Rn-222	5.76E-3	.103 1.00E+0	1.03E-1	.103 1.00E+0

The original source value was not repeated. This source is Oztunali, O.I., Data Base for Radioactive Waste Management, Vol. 3, Impacts Methodology report, NUREG/CR-1759, U.S. Nuclear Regulatory Commission, 1981.

The value of 1.03E-01 was adopted for C-14 in the interest of conservatism when the IMPACTS-BRC input files were developed. That value will be retained for the same reason. The value of 1.00E+00 will be retained for Rn-222 since it is a gas. **No changes to the data file were necessary.**

RET(N,1): Retardation coefficient Set 1

Inconsistencies were found comparing the following sources:

DMI Table 6-7 page 6-30 DMII Table 28 page 52 DMII sample TAPE1.DAT BRC Table 9-1 page 9-20 Letter from Bill O'Neal to Chad Glenn (12/16/91) Current TAPE1.DAT file

Isotope	DMI	DMII	TAPE1.DAT (DMII)	BRC	letter	TAPE1.DAT (Version 2.0)
Na-22	85.0		1.0	1.0		1.0
S-35	9.0	1.0	1.0		1.0	1.0
Cl-36	2.0		1.0	1.0		1.0
Ca-45	9.0		1.0	1.0		1.0
Cr-51	43.0		10.0	1.0	10.0	10.0
Mn-54	43.0	10.0	10.0	1.0	10.0	10.0
Rb-86	85.0		1.0	1.0		1.0
Zr-95	1000.0		1.0	1.0		1.0
Nb-94	1000.0		1.0	1.0		1.0
Nb-95	1000.0		1.0	1.0		1.0
Ru-103	2.0		1.0	1.0		1.0
Ru-106	2.0		1.0	1.0		1.0
Ag-108m	85.0		1.0	1.0		1.0
Ag-110m	85.0		1.0	1.0		1.0
Ce-141	840.0	100.0	10.0	10.0		10.0
Ce-144	840.0	100.0	10.0	10.0		10.0

This table summarizes the discrepancies noted in tracing history of the RET(N,1) values. Several types of discrepancies were noted and can be summarized as follows:

The values for Na-22, Ca-45, Rb-86, Nb-94, Nb-95, Ag-108m, Ag-110m, Cl-36, Cr-51, Zr-95, Ru-103, and Ru-106 were unchanged in the DMII documentation but changed in going to the TAPE1.DAT published in DMII without justification. New values for Ce-141 and Ce-144 were indicated to be 100.0 in the DMII document, but that value did not appear on the sample TAPE1.DAT file published in that document. There was no justification given for that change. The value for S-35 was inadvertently omitted from the IMPACTS-BRC User's Manual [O'Neal, 1990], but the current parameter value used on the TAPE1.DAT input file is correct. No numerical changes were made to RET(N,1) to produce Version 2.1; some values were rewritten in consistent format, and these are summarized in Appendix G.

RET(N,4): Retardation Coefficient 4

Inconsistencies were found comparing the following sources:

DMI Table 6-7 page 6-30 BRC Table 9-1 page 9-20 Letter from Bill O'Neal to Chad Glenn (12/16/91) Current TAPE1.DAT file

Isotope	DMI	BRC	LETTER	TAPE1.DAT (Version 2.0)
P-32, P-33	360.0	42.0	360.0	360.0
S-35	42.0		42.0	42.0

<u>DCF1(N,I): Dose Conversion Factors for Exposure Due to Ingestion</u>

Inconsistencies were found comparing the following sources:

DFINGEST.DAT data file received from Keith Eckerman (ORNL) for all radionuclide-organ pairs except as noted below.
Tables of dose conversion factors in Eckerman et al. [1988] (Ag-108m, Ag-110m, and Rn-222 for lung, red marrow, bone surface, thyroid, and effective dose equivalent)
Version 2.0 of the TAPE1.DAT input file
Sample TAPE1.DAT input file in IMPACTS-BRC User's Manual (Ag-108m, Ag-110m, and Rn-222 for stomach wall, LLI wall, kidney, and liver)

Isotope	Class/ Parameter	TAPE1.DAT (Version 2.0)	Corrected Value
S-35	W/DCF1(N,10)	4.84E-7	4.48E-7
I-131	D/DCF1(N,2)	1.13E-07	1.13E-06
Cs-136	D/DCF1(N,1)	9.69E-05	9.69E-06
Ce-141	D/DCF1(N,1)	5.29E-08	5.29E-09
Ac-227	W/DCF1(N,1)	8.41E-07	8.14E-07
Pa-241	W/DCF1(N,5)	1.18E-09	1.81E-09

<u>DCF2(N,I): Dose Conversion Factors for Exposure Due to Inhalation</u>

Inconsistencies were found comparing the following sources:

DFINHALE.DAT data file received from Keith Eckerman (ORNL) (for all radionuclide-organ pairs except as noted below)
Tables of dose conversion factors in Eckerman et al. [1988] (Ag-108m, Ag-110m, and Rn-222 for lung, red marrow, bone surface, thyroid, and effective dose equivalent)
Version 2.0 of the TAPE1.DAT input file
Sample TAPE1.DAT input file in IMPACTS-BRC User's Manual (Ag-108m, Ag-110m, and Rn-222 for stomach wall, LLI wall, kidney, and liver)

Isotope	Class/ Parameter	TAPE1.DAT (Version 2.0)	Corrected Value
Na-22	D/DCF2(N,5)	6.07E-06	6.70E-06
Ca-45	W/DCF2(N,6)	1.66E-06	1.66E-07
Sn-126	D/DCF2(N,10)	8.66E-05	8.73E-05
I-129	D/DCF2(N,1)	1.16E-07	1.16E-06
U-236	Y/DCF2(N,3)	1.00E-04	1.09E-04
Cm-244	W/DCF2(N,6)	8.84E-04	8.84E-01
Cf-252	W/DCF2(N,6)	2.48E-01	2.45E-01

<u>DCF3(N,I): Dose Conversion Factors for Exposure due to Contaminated Ground</u>

Inconsistencies were found comparing the following sources:

Version 2.0 of the TAPE1.DAT input file Sample TAPE1.DAT input file in IMPACTS-BRC User's Manual

Isotope	Parameter	TAPE1.DAT (Version 2.0)	Corrected Value
Eu-154	DCF3	6.91E-06	8.63E-06

<u>DCF4(N,I): Dose Conversion Factors for Exposure due to Surface Contamination</u>

Inconsistencies were found comparing the following sources:

Version 2.0 of the TAPE1.DAT input file
TAPE1.DAT input file in IMPACTS-BRC User's Manual
Kocher and Eckermann [1988]

Isotope	Parameter	TAPE1.DAT (Version 2.0)	Corrected Value
Cl-36	DCF4(N,1)	2.41E-12	2.65E-13
	DCF4(N,2)	6.21E-13	6.84E-14
	DCF4(N,3)	1.25E-12	1.38E-13
	DCF4(N,5)	3.65E-12	4.02E-16
	DCF4(N,6)	2.96E-14	3.26E-15
	DCF4(N,7)	7.91E-13	8.70E-14
	DCF4(N,8)	3.91E-12	4.30E-13
	DCF4(N,9)	1.52E-12	1.68E-13
	DCF4(N,10)	4.24E-[illegible]	4.66E-12
Mn-54	DCF4(N,1)	7.44E-05	7.42E-05
Sn-126	DCF4(N,1)	2.52E-04	1.46E-04
	DCF4(N,2)	2.32E-04	1.34E-04
	DCF4(N,3)	2.27E-04	1.32E-04
	DCF4(N,5)	2.46E-04	1.43E-04
	DCF4(N,6)	2.34E-04	1.36E-04
	DCF4(N,7)	2.55E-04	1.47E-04
	DCF4(N,8)	2.88E-04	1.70E-04
	DCF4(N,9)	3.17E-04	1.84E-04
	DCF4(N,10)	2.87E-04	1.68E-04
Pu-244	DCF4(N,10)	5.80E-09	5.80E-08

<u>DCF5(N,I): Dose Conversion Factors for Exposure due to Air Immersion</u>

Inconsistencies were found comparing the following sources:

Version 2.0 of the TAPE1.DAT input file
TAPE1.DAT input file in IMPACTS-BRC User's Manual
Kocher and Eckerman [1988]

Isotope	Parameter	TAPE1.DAT (Version 2.0)	Corrected Value
Cl-36	DCF5(N,10)	1.47E-11	4.24E-11
Ca-45	DCF5(N,6)	3.00E-25	3.00E-16
Sc-46	DCF5(N,8)	1.01E-03	1.01E-02
Fe-55	DCF5(N,6)	8.04E-11	8.02E-11
Cd-109	DCF5(N,10)	2.36E-05	3.35E-05
Sn-126	DCF5(N,1)	1.26E-02	7.23E-03
	DCF5(N,2)	1.17E-0[illegible]	6.66E-03
	DCF5(N,3)	1.14E-02	6.51E-03
	DCF5(N,5)	1.24E-02	7.06E-03
	DCF5(N,6)	1.18E-02	6.74E-03
	DCF5(N,7)	1.27E-02	7.32E-03
	DCF5(N,8)	1.44E-02	8.38E-03
	DCF5(N,9)	1.59E-02	9.11E-03
	DCF5(N,10)	1.43E-02	8.28E-03
I-125	DCF5(N,7)	8.921-06	8.91E-06
Ra-228	DCF5(N,1)	1.84E-14	1.82E-14
Th-228	DCF5(N,8)	1.26E-06	1.26E-05

References for Appendix E

Forstom, J. M., and D. J. Goode, De Minimis Waste Impacts Analysis Methodology, NUREG/CR-3585, Volume 2, U.S. Nuclear Regulatory Commission, 1986.

Kocher, D. C., and K. F. Eckerman, External Dose-Rate Conversion Factors for Calculation of Dose to the Public U.S. Department of Energy, DOE/EH--0070, July 1988.

O'Neal, B., letter to Chad Glenn, NRC Office of Research, December 16, 1991.

APPENDIX F: Parameter History for the TAPE2.DAT Input File

Appendix F contains a history of the parameter values contained in the TAPE2.DAT input file for the IMPACTS-BRC computer code.

Abbreviations used in Appendix F

IR	1 = NE 2 = SE 3 = SW
Incinerators	M = municipal HW = hazardous waste O = onsite
IQ: incinerator/landfill	1 = O/MS 2 = M/MS 3 = O/HW(II) 4 = HW/HW(I) 5 = HW/HW(II)
Landfills	MS = municipal sanitary HW(I) = hazardous waste type I HW(II) = hazardous waste type II

Sources: DMI = de Minimis documentation Vol I
DMII = de Minimis documentation Vol II
BRC = BRC-IMPACTS User's Manual

Note: When giving a parameter value on the current TAPE2.DAT (Version 2.0) file for which there is an incomplete historical record, the value will be underlined in the appropriate table of parameter values.

CARD TYPE 1

PRC(IR,IQ) = Average annual infiltration rate (m/yr)

Source	Scenario	NE	SE	SW
DMI page C-86	MS HW(I) HW(II)	0.074 0.036 0.074	0.180 0.030 0.180	0.001 0.001 0.001
TAPE2.DAT (Version 2.0)	MS HW(I) HW(II)	**0.074 0.036 0.074**	**0.180 0.030 0.180**	**0.001 0.001 0.001**

Worst case: DMII Table 26 page 50 PRC = 0.18

TSC(IR,IQ) = Contact time fraction between sectors of facility (yr)

Source	Scenario	NE	SE	SW
DMI page C-86	MS HW(I) HW(II)	2.66E-3 1.29E-3 2.66E-3	6.47E-3 1.08E-3 6.47E-3	3.60E-5 3.60E-5 3.60E-5
TAPE2.DAT (Version 2.0)	MS HW(I) HW(II)	**1.0** **1.0** **1.0**	**1.0** **1.0** **1.0**	**1.0** **1.0** **1.0**

DMII page 51: all contact fractions equal 1.0

DTTM(IR,IQ) = Groundwater travel time between sectors of facility (yr)

Source	Scenario	NE	SE	SW
DMI page C-85	MS HW(I+II)	170 455	27.2 72.8	3.4 9.1
DMII page 50	MS HW(II)	34 91	6.8 18.2	3.4 9.1
TAPE2.DAT (Version 2.0)	MS HW(I) HW(II)	**34** **455** **91**	**6.8** **72.8** **18.2**	**3.4** **9.1** **9.1**

Worst case: DMII Table 26 page 50 DTTM = 1.7

TTM(IR,1,IQ) = Groundwater travel time from facility to intruder well (yrs from mid first sector to well)

Source	Scenario	NE	SE	SW
DMI page C-85	MS HW(I+II)	95 237.5	23.6 46.4	280 280
DMII page 50	MS HW(II)	18 46.5	4.4 10.1	11.7 14.5
TAPE2.DAT (Version 2.0)	MS HW(I) HW(II)	**18** **237.5** **46.5**	**4.4** **46.4** **10.1**	**11.7** **280** **14.5**

Worst case: DMII Table 26 page 50 TTM(1) = **1.85**

TTM(IR,2,IQ) = Groundwater travel time from facility to population well (yrs from mid first sector to well)

Source	Scenario	NE	SE	SW
DMI page C-85	MS	2500	400	580
	HW(I+II)	2500	400	580
DMII page 50	MS	500	100	300
	HW(II)	500	100	300
TAPE2.DAT (Version 2.0)	MS	**500**	**100**	**300**
	HW(I)	**2500**	**400**	**580**
	HW(II)	**500**	**100**	**300**

Worst case: DMII Table 26 page 50 TTM(2) = **25.0**

TTM(IR,3,IQ) = Groundwater travel time from facility to surface stream (yrs from mid first sector to stream)

Source	Scenario	NE	SE	SW
DMI page C-85	MS	5000	800	NA
	HW(I+II)	5000	800	NA
DMII page 50	MS	1000	200	
	HW(II)	1000	200	
TAPE2.DAT (DMII)	MS	1000	200	0
	HW(I)	5000	800	880
	HW(II)	1000	200	0
BRC pg. EXEC-2	MS			600
	HW(II)			600
TAPE2.DAT (Version 2.0)	MS	**1000**	**200**	**600**
	HW(I)	**5000**	**800**	**880**
	HW(II)	**1000**	**200**	**600**

Worst case: DMII Table 26 page 50 TTM(3) = **50**

DPTC(IR,IQ) = Peclet number between sectors

Source	Scenario	NE	SE	SW
DMI page C-85	MS	340	680	340
	HW(I+II)	910	1820	910
TAPE2.DAT (Version 2.0)	MS	**0.0**	**0.0**	**0.0**
	HW(I)	**0.0**	**0.0**	**0.0**
	HW(II)	**0.0**	**0.0**	**0.0**

Note: DMII page 53 Peclet numbers are not needed -- all values = 0.0

TPC(IR,1,IQ) = Peclet number to intruder well

Source	Scenario	NE	SE	SW
DMI page C-85	MS HW(I+II)	170 455	340 910	170 455
TAPE2.DAT (Version 2.0)	MS HW(I) HW(II)	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0

Note: DMII page 53 Peclet numbers are not needed -- all values = 0.0

TPC(IR,2,IQ) = Peclet number t[illegible] popula[illegible]

Source	S[illegible]	[illegible]	SE	SW
DMI page C-85	MS HW(I+II)	10000 10000	10000 10000	30000 30000
TAPE2.DAT (Version 2.0)	MS HW(I) HW(II)	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0

Note: DMII page 53 Peclet numbers are not needed -- all values = 0.0

TPC(IR,3,IQ) = Peclet number to surface stream

Source	Scenario	NE	SE	SW
DMI page C-85	MS HW(I+II)	20000 20000	20000 20000	NA NA
TAPE2.DAT (Version 2.0)	MS HW(I) HW(II)	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0

Note: DMII page 53 Peclet numbers are not needed -- all values = 0.0

CARD TYPE 2

FSC(IR) = Soil-to-air transfer factor for intruder construction (unitless)

Source	NE	SE	SW
DMI page C-80	9.18E-12	2.01E-11	2.64E-10
TAPE2.DAT (Version 2.0)	**9.18E-12**	**2.01E-11**	**2.64E-10**

Worst case: DMII Table 26 page 50 FSC = **2.64E-10**

FSA(IR) = Soil-to-air transfer factor for intruder agriculture (unitless)

Source	NE	SE	SW
DMI page C-80	2.96E-11	3.18E-11	8.06E-11
TAPE2.DAT (Version 2.0)	**2.96E-11**	**3.18E-11**	**8.06E-11**

Worst case: DMII Table 26 page 50 FSA = **8.06E-11**

QFC(IR,1) = Groundwater dilution factor for intruder well (m^3/yr)

Source	NE	SE	SW
DMI page C-80	7.7E+3	7.7E+3	7.7E+3
TAPE2.DAT (Version 2.0)	**7.7E+3**	**7.7E+3**	**7.7E+3**

Worst case: DMII Table 26 page 50 QFC(1) = **110**

QFC(IR,2) = Groundwater dilution factor for population well (m^3/yr)

Source	NE	SE	SW
DMI page C-80	2.0E+5	2.0E+5	2.0E+5
TAPE2.DAT (Version 2.0)	**2.0E+5**	**2.0E+5**	**2.0E+5**

Worst case: DMII Table 26 page 50 QFC(1) = **2.0e+5**

QFC(IR,2) = Groundwater dilution factor for surface stream (m^3/yr)

Source	NE	SE	SW
DMI page C-80	4.5e+6	4.5e+6	NA
BRC page 9-17			4.5e+6
TAPE2.DAT (Version 2.0)	**4.5E+6**	**4.5E+6**	**4.5E+6**

Worst case: DMII Table 26 page 50 QFC(3) = **4.5E+6**

POP(IR) = Population factor for airborne exposed waste for operations/intrusion (person-yr/m^3)

Source	NE	SE	SW
DMI page C-80	5.05E-10	1.75E-10	1.33E-11
TAPE2.DAT (Version 2.0)	**5.05E-10**	**1.75E-10**	**1.33E-11**

POPE(IR) = Population factor for airborne exposed waste from erosion (person-yr/m^3)

Source	NE	SE	SW
DMI page C-80	1.51E-9	5.25E-10	3.99E-11
TAPE2.DAT (Version 2.0)	**1.51E-9**	**5.25E-10**	**3.99E-11**

POPW(IR) = Site selection factor for waterborne exposed waste from erosion/intrusion (yr/m^3)

Source	NE	SE	SW
DMI page C-80	1.11E-7	1.11E-7	NA
BRC page EXEC-2			1.11E-7
TAPE2.DAT (Version 2.0)	**1.11E-7**	**1.11E-7**	**1.11E-7**

TPOP(IR) = Population density around transportation route (persons/mi^2)

Source	NE	SE	SW
DMI page C-80	2280	610	60
TAPE2.DAT (Version 2.0)	**2280**	**610**	**60**

TDOZ(IR) = Distance dependent dose factor for transportation population exposure calculations (mi^2/ft^2)

Source	NE	SE	SW
DMI page C-80	7.06E-5	7.06E-5	3.92E-5
TAPE2.DAT (Version 2.0)	**7.06E-5**	**7.06E-5**	**3.92E-5**

CARD TYPE 3

WVEL(IR) = Average windspeed at the site (m/sec)

Source	NE	SE	SW
DMI page C-80	4.61	3.61	6.67
TAPE2.DAT (Version 2.0)	**4.61**	**3.61**	**6.67**

Worst case: DMII Table 26 page 50 WVEL = **6.67**

AXOQ(IR) = Accident atmospheric dispersion factor (yr/m³)

Source	NE	SE	SW
DMI page C-80	9.68E-11	1.40E-10	4.11E-11
TAPE2.DAT (Version 2.0)	**9.68E-11**	**1.40E-10**	**4.11E-11**

Worst case: DMII Table 26 page 50 AXOQ = **1.4E-10**

EFAC(IR) = Dust mobilization rate for HW facility operations (g/m²-sec)

Source	NE	SE	SW
DMI page C-80	5.53E-7	1.54E-8	7.95E-6
TAPE2.DAT (Version 2.0)	**5.53E-7**	**1.54E-8**	**7.95E-6**

Worst case: DMII Table 26 page 50 EFAC = **7.95E-6**

EERO(IR) = Dust mobilization rate for erosion exposed waste (g/m²-sec)

Source	NE	SE	SW
DMI page C-80	5.53E-7	1.54E-8	7.95E-6
TAPE2.DAT (Version 2.0)	**5.53E-7**	**1.54E-8**	**7.95E-6**

EREC(IR) = Dust mobilization rate for intruder exposed waste (g/m²-sec)

Source	NE	SE	SW
DMI page C-80	2.03E-6	2.50E-6	6.84E-5
TAPE2.DAT (Version 2.0)	**2.03E-6**	**2.50E-6**	**6.84E-5**

CARD TYPE 4

NREC(IR) = Soil retardation index

Source	NE	SE	SW
DMI page C-80	3	2	1
TAPE2.DAT (DMII)	1	1	1
TAPE2.DAT (Version 2.0)	1	1	1

CARD TYPE 5

TDIS(IQ) = Transportation distance to facility (mi)

Source	MS	HW
DMI page 3-13	10	100
BRC page EXEC-2	10	
TAPE2.DAT (Version 2.0)	**10**	**100**

TVEL(IQ) = Transportation velocity to the facility (mi/hr)

Source	MS	HW
DMI page 3-13	20	35
BRC page EXEC-2		35 (IQ = 3)
TAPE2.DAT (Version 2.0)	**20**	**35**

VINC(IQ) = Annual volume for non-BRC waste incinerated (m^3)

Source	O	M	HW
DMI page C-29		4.28E+5	
DMI page C-58	2.54E+4		2.54E+4
TAPE2.DAT (Version 2.0)	**2.54E+4**	**4.28E+5**	**2.54E+4**

XOQI(IQ) = Off-site atmospheric dispersion factor for elevated release (yr/m^3)

Source	O	M	HW
DMI page 4-12	9.1E-11		
DMI page 4-14		1.6E-13	
DMI page 4-24			1.6E-13
TAPE2.DAT (Version 2.0)	**9.1E-11**	**1.6E-13**	**1.6E-13**

EDFI(IQ) = Exposure duration factor for incineration (unitless)

Source	O	M	HW
DMI page 4-9	0.333	0.333	0.333
TAPE2.DAT (Version 2.0)	**0.333**	**0.333**	**0.333**

DEN1(IQ) = Average density of the waste during shipment and incineration (g/cm^3)

Source	O	M	HW
DMI page 4-17		0.27	
DMI page 4-26			1.0
TAPE2.DAT (Version 2.0)	**1.0**	**0.27**	**1.0**

VANN(IQ) = Annual volume for non-BRC waste disposed (m^3)

Source	MS	HW
DMI page 5-14	29,610	
DMI page 5-29		91,350
TAPE2.DAT (Version 2.0)	**29,610**	**91,350**

XOQO(IQ) = Off-site atmospheric dispersion factor for ground level release (yr/m^3)

Source	MS	HW
DMI page 4-9	9.1E-11	9.1E-11
TAPE2.DAT (Version 2.0)	**9.1E-11**	**9.1E-11**

EDFO(IQ) = Exposure duration factor for disposal operations (unitless)

Source	MS	HW
DMI page 5-12	0.237	
DMI page 5-29		0.237
TAPE2.DAT (Version 2.0)	**0.333**	**0.333**

DEN2(IQ) = Average density of the waste during disposal (g/cm^3)

Source	MS	HW
DMI page 5-14	0.59	
DMI page 5-29		1.0
TAPE2.DAT (Version 2.0)	**0.59**	**1.0**

CARD TYPE 6

TWI(IQ,1) = Waste-to-air transfer factor for incineration operations (low)

Source	O	M	HW
DMI page 4-16		3.70E-10	
DMI page 4-26			1.0E-10
TAPE2.DAT (Version 2.0)	1.0E-10	**3.70E-10**	**1.0E-10**

TWI(IQ,2) = Waste-to-air transfer factor for incineration operations (med)

Source	O	M	HW
DMI page 4-16		7.41E-10	
DMI page 4-26			2.0E-10
TAPE2.DAT (Version 2.0)	2.0E-10	**7.14E-10**	**2.0E-10**

TWI(IQ,3) = Waste-to-air transfer factor for incineration operations (high)

Source	O	M	HW
DMI page 4-16		1.48E-9	
DMI page 4-26			4.0E-10
TAPE2.DAT (Version 2.0)	4.0E-10	**1.48E-9**	**4.0E-10**

TWO(IQ,1) = Waste-to-air transfer factor for disposal operations (low)

Source	MS	HW
DMI page 5-12	1.7E-10	
DMI page 5-5		1.0E-10
TAPE2.DAT (Version 2.0)	**1.7E-10**	**1.0E-10**

TWO(IQ,2) = Waste-to-air transfer factor for disposal operations (med)

Source	MS	HW
DMI page 5-12	3.39E-10	
DMI page 5-5		2.0E-10
TAPE2.DAT (Version 2.0)	**3.39E-10**	**2.0E-10**

TWO(IQ,3) = Waste-to-air transfer factor for disposal operations (high)

Source	MS	HW
DMI page 5-12	6.78E-10	
DMI page 5-5		4.0E-10
TAPE2.DAT (Version 2.0)	**6.7E-10**	**4.0E-10**

ADAY(IQ,1) = Daily exposed area of the disposal facility (m^2)

Source	MS (offsite)	HW (offsite)
DMI page 5-14	86	
DMI page 5-30		384
TAPE2.DAT (Version 2.0)	**86**	**384**

ADAY(IQ,2) = Daily exposed area of the disposal facility (m^2)

Source	MS (equipment operators)	HW (unpackaged waste)
DMI page 5-13	70.8	
DMI page 5-29		384
TAPE2.DAT (Version 2.0)	**71**	**384**

ADAY(IQ,3) = Daily exposed area of the disposal facility (m^2)

Source	MS (other personnel)	HW (packaged waste)
DMI page 5-13	15	
DMI page 5-29		171
BRC page EXEC-2		171 (IQ=3)
TAPE2.DAT (Version 2.0)	**15**	**171**

RMIX(IQ) = Cover mixing efficiency (unitless)

Source	MS	HW
DMI page 6-9	0.59	0.41
TAPE2.DAT (Version 2.0)	**0.59**	**0.41**

CARD TYPE 7

EMP(IQ) = Waste emplacement efficiency (unitless)

Source	MS	HW
DMI page 5-1	0.8	0.75
TAPE2.DAT (Version 2.0)	**0.8**	**0.75**

EFF(IQ) = Volumetric disposal efficiency (m^3/m^2)

Source	MS	HW
DMI page 6-21	7.31	4.37
TAPE2.DAT (Version 2.0)	**7.31**	**4.37**

SEFF(IQ) = Surface utilization efficiency (unitless)

Source	MS	HW
DMI page 6-38	1.0	0.9
TAPE2.DAT (Version 2.0)	**1.0**	**0.9**

GERO(IQ) = Erosion time delay (yr)

Source	MS	HW
DMI page 6-38	1000	1000
TAPE2.DAT (Version 2.0)	**1000**	**1000**

OSWR(IQ) = On-site incinerator weight reduction factor (unitless)

Source	O	M	HW
None (Default)		0.0	0.0
TAPE2.DAT (Version 2.0)	**0.0**	**0.0**	**0.0**

OSDL(IQ) = On-site incinerator dust loading factor (g/m^3)

Source	O	M	HW
None (Default)		0.0	0.0
TAPE2.DAT (Version 2.0)	**5.0E-5**	**0.0**	**0.0**

CARD TYPE 8

DSP(I) = Distance to center of population ring (m)

Ring	miles	DMI page C-78 (m)	TAPE2.DAT, Version 2.0 (m)
1	2.5	4.023E+3	**4.023E+3**
2	7.5	1.207E+4	**1.207E+4**
3	15.0	2.414E+4	**2.414E+4**
4	25.0	4.023E+4	**4.023E+4**
5	35.0	9.623E+4	**5.632E+4**
6	45.0	7.241E+4	**7.241E+4**

*** The currently used value is correct**

PDS(I) = Population within the population ring (persons)

Ring	DMI page C-78			TAPE2.DAT (Version 2.0)
	NE	SE	SW	
1	3,440	2,024	59	**3.440E+03**
2	20,513	8,115	180	**2.051E+04**
3	73,636	36,000	3,529	**7.364E+04**
4	121,559	124,995	9,062	**1.216E+05**
5	556,639	203,435	4,888	**5.566E+05**
6	1,012,788	104,933	27,158	**1.013E+06**

WSP(I) = Average wind speed for stability class (m/sec)

Class	DMI page 4-9	TAPE2.DAT (Version 2.0)
A		**3.0**
B		**3.0**
C	3.0	**3.0**
D	3.0	**3.0**
E		**3.0**
F	2.0	**2.0**

STB(I) = Stability class duration factor (unitless)

Class	DMI page 4-9	TAPE2.DAT (Version 2.0)
A		**0.0**
B		**0.0**
C	0.333	**0.333**
D	0.333	**0.333**
E		**0.0**
F	0.333	**0.333**

CARD TYPE 9: Note: Card Type 9 was an addition to TAPE2.DAT for version 2.0; it did not exist in earlier TAPE2.DAT files.

HYTI = Incineration release height (m)

Source	O	M	HW
DMI page 4-9			
DMI page 4-12	0.0		
DMI page 4-14		61.0	
DMI page 4-24			61.0
TAPE2.DAT (Version 2.0)		**61.0**	

HYTO = Disposal operations release height (m)

Source	MS	HW
DMI page 4-9	0.0	0.0
TAPE2.DAT (Version 2.0)	**0.0**	

DISTI = Distance to off-site individual from incineration (m)

Source	O	M	HW
DMI page 4-9			
DMI page 4-12	100		
DMI page 4-14		300	
DMI page 4-24			300
TAPE2.DAT (Version 2.0)		**320**	

DISTO = Distance to off-site individual (operations) (m)

Source	MS	HW
DMI page 4-9	100.0	100.0
TAPE2.DAT (Version 2.0)	**100.0**	

EDFID = Exposure duration factor for incineration (unitless)

Source	O	M	HW
DMI page 4-9	0.333	0.333	0.333
TAPE2.DAT (Version 2.0)		**0.333**	

EDFOD = Exposure duration factor for disposal operations (unitless)

Source	MS	HW
DMI page 5-12	0.237	
DMI page 5-29		0.237
TAPE2.DAT (Version 2.0)	0.333	

CARD TYPE 10 (repeat of variables for worst case)

FSC(IR) = Soil-to-air transfer factor for intruder construction (unitless)

Source	Value
DMII Table 26 page 50	2.64E-10
TAPE2.DAT (Version 2.0)	**2.64E-10**

FSA(IR) = Soil-to-air transfer factor for intruder agriculture (unitless)

Source	Value
DMII Table 26 page 50	8.06E-11
TAPE2.DAT (Version 2.0)	**8.06E-11**

QFC(IR,1) = Groundwater dilution factor for intruder well (m^3/yr)

Source	Value
DMII Table 26 page 50	110
TAPE2.DAT (Version 2.0)	**110**

QFC(IR,2) = Groundwater dilution factor for population well (m^3/yr)

Source	Value
DMII Table 26 page 50	2.0E+5
TAPE2.DAT (Version 2.0)	**2.0E+5**

QFC(IR,3) = Groundwater dilution factor for surface stream (m^3/yr)

Source	Value
DMII Table 26 page 50	4.5E+6
TAPE2.DAT (Version 2.0)	**4.5E+6**

WVEL(IR) = Average windspeed at the site (m/sec)

Source	Value
DMII Table 26 page 50	6.67
TAPE2.DAT (Version 2.0)	**6.67**

AXOQ(IR) = Accident atmospheric dispersion factor (yr/m^3)

Source	Value
DMII Table 26 page 50	1.4E-10
TAPE2.DAT (Version 2.0)	**1.4E-10**

EFAC(IR) = Dust mobilization rate for HW facility operations (g/m^2-sec)

Source	Value
DMII Table 26 page 50	7.95E-6
TAPE2.DAT (Version 2.0)	**7.95E-6**

APPENDIX G: Summary of Changes to Version 2.0 Data to Create Version 2.1

Errors found on the Version 2.0 TAPE1.DAT input file are summarized in Table G-1. The new AL(N) resulted from the recalculation of decay constants from a cited reference. The primary result of this change is to use a referenced set of values. Table G-2 summarizes errors found in sample TAPE1.DAT input file in the IMPACTS-BRC Version 2.0 user's guide, but for which the correct value is being used on the current TAPE1.DAT input file. Table G-3 summarizes parameter values in the Version 2.0 TAPE1.DAT input file that are correct, but are not written in the exponential form used for the remainder of the input file. This is entirely an aesthetic issue, with no effect on the output from IMPACTS-BRC. Table G-4 summarizes "round-off" errors in parameter values in the TAPE1.DAT input file. Changing these values would not substantially affect the output from the IMPACTS-BRC computer code, and these changes were not be made at this time.

Changes to TAPE2.DAT are identified on page G-7.

Table G-1: Changes for Both TAPE1.DAT and BRC User's Gr[illegible]

ISOTOPE	PARAMETER	Version 2.0 value	Corrected value
Na-22	D/DCF2(N,5)	6.07E-06	6.70E-06
P-33	AL(N)	1.04E+01	9.96E+00
S-35	W/DCF1(N,10)	4.84E-07	4.48E-07
Cl-36	AL(N)	2.25E-06	2.30E-06
	DCF4(N,1)	2.41E-12	2.65E-13
	DCF4(N,2)	6.21E-13	6.84E-14
	DCF4(N,3)	1.25E-12	1.38E-13
	DCF4(N,5)	3.65E-12	4.02E-16
	DCF4(N,6)	2.96E-14	3.26E-15
	DCF4(N,7)	7.91E-13	8.70E-14
	DCF4(N,8)	3.91E-12	4.30E-13
	DCF4(N,9)	1.52E-12	1.68E-13
	DCF4(N,10)	4.24E-11	4.66E-12
	DCF5(N,10)	1.47E-11	4.24E-11
Ca-45	AL(N)	1.53E+00	1.56E+00
	DC[illegible](N,6)	3.00E-25	3.00E-16
	W/DCF2(N,6)	1.66E-06	1.66E-07
Sc-46	DCF5(N,8)	1.01E-03	1.01E-02
Cr-51	AL(N)	9.10E+00	9.13E+00
Mn-54	AL(N)	8.35E-01	8.09E-01
	DCF4(N,1)	7.44E-05	7.42E-05
Fe-55	AL(N)	2.67E-01	2.57E-01
	DCF5(N,6)	8.04E-11	8.02E-11
Fe-59	AL(N)	5.55E+00	5.67E+00
Co-57	AL(N)	9.37E-01	9.34E-01
Co-58	AL(N)	3.55E+00	3.57E+00
Ni-59	AL(N)	8.66E-06	9.24E-06
Ni-63	AL(N)	7.53E-03	6.93E-03
Sr-85	AL(N)	3.96E+00	3.90E+00
Sr-89	AL(N)	4.81E+00	5.01E+00
Sr-90	AL(N)	2.47E-02	2.42E-02
Zr-95	AL(N)	3.87E+00	3.95E+00
Nb-94	AL(N)	3.47E-05	3.42E-05
Mo-99	AL(N)	9.11E+01	9.20E+01
Tc-99	AL(N)	3.27E-06	3.25E-06
Ag-108m	AL(N)	1.39E-01	5.46E-03

Table G-1: Changes fo[illegible] both TAPE[illegible]AT and BRC User's Guide (continued)

ISOTOPE	PARAM[illegible]ER	Version 2.0 value	Corrected value
Ag-110m	AL(N)	9.92E-01	1.01E+00
Cd-109	AL(N)	5.59E-01	5.45E-01
	DCF5(N,10)	2.36E-05	3.35E-05
Sn-126	AL(N)	6.60E-06	6.93E-06
	DCF4(N,1)	2.52E-04	1.46E-04
	DCF4(N,2)	2.32E-04	1.34E-04
	DCF4(N,3)	2.27E-04	1.32E-04
	DCF4(N,5)	2.46E-04	1.43E-04
	DCF4(N,6)	2.34E-04	1.36E-04
	DCF4(N,7)	2.55E-04	1.47E-04
	DCF4(N,8)	2.88E-04	1.70E-04
	DCF4(N,9)	3.17E-04	1.84E-04
	DCF4(N,10)	2.87E-04	1.68E-04
	DCF5(N,1)	1.26E-02	7.23E-03
	DCF5(N,2)	1.17E-02	6.66E-03
	DCF5(N,3)	1.14E-02	6.51E-03
	DCF5(N,5)	1.24E-02	7.06E-03
	DCF5(N,6)	1.18E-02	6.74E-03
	DCF5(N,7)	1.27E-02	7.32E-03
	DCF5(N,8)	1.44E-02	8.38E-03
	DCF5(N,9)	1.59E-02	9.11E-03
	DCF5(N,10)	1.43E-02	8.28E-03
	D/DCF2(N,10)	8.66E-05	8.73E-05
Sb-125	AL(N)	2.56E-01	2.50E-01
I-125	DCF5(N,7)	8.921-06	8.91E-06
I-129	AL(N)	5.92E-08	4.42E-08
	D/DCF2(N,1)	1.16E-07	1.16E-06
I-131	D/DCF1(N,2)	1.13E-07	1.13E-06
Cs-134	AL(N)	3.38E-01	3.36E-01
Cs-135	AL(N)	2.31E-07	3.01E-07
Cs-[illegible]	AL(N)	1.85E+01	1.92E+01
	D/DCF1(N,1)	9.69E-05	9.69E-06
C[illegible]-141	D/DCF1(N,1)	5.29E-08	5.29E-09
Eu-152	AL(N)	5.46E-02	5.10E-02
Eu-154	DCF3	6.91E-06	8.63E-06
	AL(N)	4.33E-02	7.88E-02
Yb-169	FF(N,3)	5.00E-06	2.00E-05
	AL(N)	7.96E+00	7.91E+00
Pb-210	AL(N)	3.40E-02	3.11E-02
Rn-222	AL(N)	6.60E+01	6.62E+01
Ra-228	AL(N)	1.03E-01	1.21E-01
	DCF5(N,1)	1.84E-14	1.82E-14
Ac-227	AL(N)	3.21E-02	3.18E-02
	W/DCF1(N,1)	8.41E-07	8.14E-07
Th-228	DCF5(N,8)	1.26E-06	1.26E-05
Th-230	AL(N)	8.66E-06	9.00E-06
U-233	AL(N)	4.28E-06	4.35E-06
U-234	AL(N)	2.81E-06	2.84E-06
U-235	AL(N)	9.76E-10	9.85E-10
U-236	AL(N)	2.90E-08	2.96E-08
	Y/DCF2(N,3)	1.009-04	1.09E-04
Pu-238	AL(N)	8.02E-03	7.90E-03

Table G-1: Changes for Both TAPE1.DAT and BRC User's Guide (continued)

ISOTOPE	PARAMETER	Version 2.0 value	Corrected value
Pu-239	AL(N)	2.84E-05	2.87E-05
Pu-241	AL(N)	5.25E-02	4.81E-02
	W/DCF1(N,5)	1.18E-09	1.81E-09
Pu-244	AL(N)	9.12E-09	8.39E-09
	DCF4(N,10)	5.80E-09	5.80E-08
Am-241	FF(N,3)	4.10E-07	2.05E-05
	AL(N)	1.51E-03	1.60E-03
Am-243	FF(N,3)	4.10E-07	2.05E-05
	AL(N)	8.72E-05	9.39E-05
Cm-243	AL(N)	2.17E-02	2.43E-02
Cm-244	AL(N)	3.94E-02	3.83E-02
	W/DCF2(N,6)	8.84E-04	8.84E-01
Cm-248	AL(N)	1.47E-06	2.05E-06
Cf-252	W/DCF2(N,6)	2.48E-01	2.45E-01

Table G-2 Recommended Changes for BRC User's Guide

ISOTOPE	PARAMETER	Version 2.0 User's Guide	Corrected value
S-35	FF(N,4)	7.50E-02	7.50E+02
	FF(N,5)	1.00E-02	1.00E+02
Am-241	FF(N,2)	3.90E-04	3.90E-03
Am-243	FF(N,2)	3.90E-04	3.90E-03

Additional Changes to the IMPACTS-BRC Version 2.0 User's Guide: Two of the decay chains indicated as footnotes to the DCF4 and DCF5 tables in the user's guide are erroneous. The values for Ru-103 include the values for Rh-103m and not Rh-103 as indicated. Similarly, the values for Sn-126 include the values for Sb-126m and not the values for Sb-126 as indicated.

Table G-3 Format Inconsistencies in Version 2.0

ISOTOPE	PARAMETER	Version 2.0 value	Corrected value
C-14	FMF(N)	.103	1.03E-01
	RET(N,1)	1.0	1.00E+00
Na-22	RET(N,1)	1.0	1.00E+00
P-32	RET(N,1)	1.0	1.00E+00
P-33	RET(N,1)	1.0	1.00E+00
S-35	RET(N,1)	1.0	1.00E+00
Cl-36	RET(N,1)	1.0	1.00E+00
Ca-45	RET(N,1)	1.0	1.00E+00
Cr-51	RET(N,1)	10.0	1.00E+01
Mn-54	RET(N,1)	10.0	1.00E+01
Fe-55	RET(N,1)	1.0	1.00E+00
Fe-59	RET(N,1)	1.0	1.00E+00
Co-57	RET(N,1)	1.0	1.00E+00
Co-58	RET(N,1)	1.0	1.00E+00
Co-60	RET(N,1)	1.0	1.00E+00
Ni-59	RET(N,1)	1.0	1.00E+00
Ni-63	RET(N,1)	1.0	1.00E+00

Table G-3 Format Inconsistencies in Version 2.0 (continued)

ISOTOPE	PARAMETER	Version 2.0 value	Corrected value
Zn-65	RET(N,1)	1.0	1.00E+00
Rb-86	RET(N,1)	1.0	1.00E+00
Sr-85	RET(N,1)	1.0	1.00E+00
Sr-89	RET(N,1)	1.0	1.00E+00
Sr-90	RET(N,1)	1.0	1.00E+00
Zr-95	RET(N,1)	1.0	1.00E+00
Nb-94	RET(N,1)	1.0	1.00E+00
Nb-95	RET(N,1)	1.0	1.00E+00
Tc-99	RET(N,1)	1.0	1.00E+00
Tc-99m	RET(N,1)	1.0	1.00E+00
Ru-103	RET(N,1)	1.0	1.00E+00
Ru-106	RET(N,1)	1.0	1.00E+00
Ag-108m	RET(N,1)	1.0	1.00E+00
Ag-110m	RET(N,1)	1.0	1.00E+00
Cd-109	RET(N,1)	1.0	1.00E+00
I-125	RET(N,1)	1.0	1.00E+00
I-129	RET(N,1)	1.0	1.00E+00
I-131	RET(N,1)	1.0	1.00E+00
Cs-134	RET(N,1)	1.0	1.00E+00
Cs-136	RET(N,1)	1.0	1.00E+00
Cs-137	RET(N,1)	1.0	1.00E+00
Ce-141	RET(N,1)	10.0	1.00E+01
Ce-144	RET(N,1)	10.0	1.00E+01
Th-228	RET(N,1)	100.0	1.00E+02
Th-229	RET(N,1)	100.0	1.00E+02
Th-230	RET(N,1)	100.0	1.00E+02
Th-232	RET(N,1)	100.0	1.00E+02
Pu-236	RET(N,1)	10.0	1.00E+01
Pu-238	RET(N,1)	10.0	1.00E+01
Pu-239	RET(N,1)	10.0	1.00E+01
Pu-240	RET(N,1)	10.0	1.00E+01
Pu-241	RET(N,1)	10.0	1.00E+01
Pu-242	RET(N,1)	10.0	1.00E+01
Pu-244	RET(N,1)	10.0	1.00E+01
Am-241	RET(N,1)	100.0	1.00E+02
Am-243	RET(N,1)	100.0	1.00E+02

Table G-4 "Round-off" Errors in Version 2.0

ISOTOPE	PARAMETER	Version 2.0 value	Corrected value
H-3	AL(N)	5.64E-02	5.65E-02
Na-22	AL(N)	2.65E-01	2.66E-01
	D/DCF2(N,6)	6.47E-06	6.48E-06
P-32	D/DCF1(N,2)	5.36E-06	5.37E-06
	W/DCF1(N,2)	5.36E-06	5.37E-06
S-35	AL(N)	2.88E+00	2.89E+00
Cl-36	DCF5(N,2)	6.22E-13	6.21E-13
	DCF5(N,5)	3.66E-15	3.65E-15
	DCF5(N,7)	7.92E-13	7.91E-13
	DCF5(N,8)	3.92E-12	3.91E-12
Sc-46	AL(N)	3.01E+00	3.02E+00

Table G-4 "Round-off" Errors in Version 2.0 (continued)

ISOTOPE	PARAMETER	Version 2.0 value	Corrected value
Cr-51	W/DCF2(N,2)	8.69E-08	8.70E-07
Mn-54	W/DCF2(N,2)	4.25E-06	4.26E-06
	DCF2(N,8)	4.62E-06	4.63E-06
Fe-55	W/DCF2(N,2)	6.47E-07	6.48E-07
	DCF2(N,8)	6.47E-07	6.48E-07
Fe-59	D/DCF2(N,1)	1.29E-05	1.30E-05
	W/DCF2(N,3)	1.66E-05	1.67E-05
Co-57	W/DCF2(N,2)	8.32E-07	8.33E-07
	DCF2(N,5)	5.36E-07	5.37E-07
	Y/DCF2(N,2)	2.03E-06	2.04E-06
Co-58	W/DCF2(N,6)	4.25E-06	4.26E-06
Co-60	W/DCF2(N,5)	1.66E-05	1.67E-05
Zn-65	AL(N)	1.03E+00	1.04E+00
	D/DCF1(N,7)	1.66E-05	1.67E-05
	DCF1(N,8)	1.66E-05	1.67E-05
	W/DCF1(N,7)	1.66E-05	1.67E-05
	DCF1(N,8)	1.66E-05	1.67E-05
	Y/DCF1(N,7)	1.66E-05	1.67E-05
	DCF1(N,8)	1.66E-05	1.67E-05
Se-75	AL(N)	2.10E+00	2.11E+00
Sr-85	D/DCF1(N,9)	7.58E-07	7.59E-07
	Y/DCF2(N,8)	1.29E-06	1.30E-06
Sr-90	D/DCF1(N,2)	6.47E-06	6.48E-06
Nb-94	W/DCF1(N,3)	4.62E-05	4.63E-05
Nb-95	AL(N)	7.23E+00	7.22E+00
Mo-99	D/DCF2(N,5)	6.47E-06	6.48E-06
Tc-99	D/DCF2(N,3)	7.58E-07	7.59E-07
Tc-99m	AL(N)	1.00E+03	1.01E+03
	D/DCF2(N,5)	9.06E-09	9.07E-09
Rh-103	AL(N)	6.42E+00	6.43E+00
	DCF4(N,8)	5.10E-05	5.11E-05
	DCF4(N,9)	5.41E-05	5.42E-05
	DCF4(N,10)	5.00E-05	5.01E-05
Ru-106	AL(N)	6.86E-01	6.87E-01
	Y/DCF1(N,5)	5.36E-06	5.37E-06
Cd-109	DCF4(N,9)	1.39E-06	1.40E-06
	DCF5(N,6)	1.44E-05	1.45E-05
Sn-113	DCF4(N,2)	2.19E-05	2.20E-05
Sb-125	D/DCF2(N,3)	4.25E-06	4.26E-06
I-125	AL(N)	4.20E+00	4.21E+00
I-131	AL(N)	3.14E+01	3.15E+01
Cs-134	D/DCF2(N,2)	4.62E-05	4.63E-05
	DCF2(N,10)	4.62E-05	4.63E-05
Cs-137	AL(N)	2.31E-02	2.30E-02
Ba-140	AL(N)	1.97E+01	1.98E+01
Ce-141	Y/DCF2(N,9)	9.43E-08	9.44E-08
	W/DCF2(N,10)	8.32E-06	8.33E-06
	D/DCF2(N,10)	8.32E-06	8.33E-06
Ce-144	AL(N)	8.91E-01	8.90E-01
	DCF5(N,2)	2.11E-04	2.12E-04
Eu-152	W/DCF1(N,10)	6.47E-06	6.48E-06
Eu-154	W/DCF1(N,7)	4.25E-06	4.26E-06

Table G-4 "Round-off" Errors in Version 2.0 (continued)

ISOTOPE	PARAMETER	Version 2.0 value	Corrected value
Pb-210	D/DCF1(N,1)	4.62E-04	4.63E-04
	DCF1(N,2)	4.62E-04	4.63E-04
	DCF1(N,9)	4.62E-04	4.63E-04
	DCF1(N,10)	5.36E-03	5.37E-03
	D/DCF2(N,5)	4.62E-02	4.63E-02
Th-228	AL(N)	3.63E-01	3.62E-01
Th-229	W/DCF2(N,7)	4.25E+00	4.26E+00
Th-232	AL(N)	4.29E-11	4.93E-11
	Y/DCF1(N,1)	4.62E-06	4.63E-06
	DCF1(N,5)	4.62E-06	4.63E-06
	DCF1(N,8)	6.84E-02	6.85E-02
	W/DCF1(N,1)	4.62E-06	4.63E-06
	DCF1(N,5)	4.62E-06	4.63E-06
	DCF1(N,8)	6.84E-02	6.85E-02
Pa-231	AL(N)	2.13E-05	2.12E-05
	Y/DCF1(N,2)	4.62E-06	4.63E-06
	W/DCF1(N,2)	4.62E-06	4.63E-06
U-235	Y/DCF2(N,8)	3.88E-03	3.89E-03
	W/DCF1(N,8)	3.88E-03	3.89E-03
	D/DCF1(N,8)	3.88E-03	3.89E-03
U-236	Y/DCF1(N,2)	4.25E-06	4.26E-06
	W/DCF1(N,2)	1.29E-05	1.30E-05
	D/DCF1(N,2)	1.29E-05	1.30E-05
U-238	AL(N)	1.54E-10	1.55E-10
Np-237	Y/DCF2(N,2)	4.62E-05	4.63E-05
	W/DCF2(N,2)	4.62E-05	4.63E-05
Pu-236	Y/DCF1(N,1)	1.28E-09	1.29E-09
	DCF2(N,10)	1.29E-01	1.30E-01
Pu-239	Y/DCF1(N,9)	2.77E-10	2.78E-10
Pu-240	AL(N)	1.05E-04	1.06E-04
Pu-241	W/DCF1(N,10)	6.84E-05	6.85E-05
Pu-242	AL(N)	1.83E-06	1.84E-06
	W/DCF1(N,2)	4.25E-06	4.26E-06
Cm-242	AL(N)	1.56E+00	1.55E+00
	DCF5(N,10)	4.91E-07	4.90E-07
Cf-252	AL(N)	2.62E-01	2.63E-01

CHANGES TO TAPE2.DAT

The only TAPE2.DAT parameter found to be in error was the value for DISTI, the distance to an offsite receptor for the incineration analysis.

Parameter	Version 2.0	Version 2.1
DISTI	320.0	300.0

APPENDIX H: Results of Quality Assurance Audits

SURVEILLANCE AND QUALITY REVIEW CHECKLIST

Project: Below Regulatory Concern (BRC) **Activities:** General QA & Data Verification **Org.** 6416 **Date(s):** 8/19-9/12/91

Report No: 1 **Project Contact:** Matthew W. Kozak **Surveyor/Reviewer:** Samuel D. Bensonhaver **Page:** 1 of 2

Characteristic	Ref.	Result C	Result NC	Observations and/or Findings	Initials & Date
Project Logbooks	3.1.1				
1) Logbooks clearly labelled as BRC Documentation.		x			
2) Separate areas for Data and code activities.		x		3) Small number of entries in one notebook in blue. However, a typewritten companion report was also filed.	
3) Entries made in black ink, dated, and initialed.		x			
4) Changes made so original left legible.		x			
5) Changes dated and initialed.		x		5) Requirement generally observed. Found one entry in one notebook which did not comply.	
6) No "white out" or "cut and paste".		x			
Quality Assurance Training	3.1.2				
1) QA Information distributed to all project participants.		x		1) Information distributed via company mail approx. 6/18/91.	
2) Training session.		x		2) Session held for participants on 6/24/91.	
Records Management	3.1.3				
1) Commented copies of reviewed material retained.		x			
2) Unincorporated comment rebuttals maintained.		x		2) No unincorporated comments per. fing.	
Security	3.1.5				
1) Data backups available.		x			
2) Backup diskettes kept in locked storage containers		x			
3) Backup copies of the Configuration Management System diskettes and notebook will be maintained in a physically separated building by the Quality Coordinator.		x			
4) PC's locked during nonworking hours (if provisioned) and access by other personnel discouraged.		x		4) External access not allowed.	

SURVEILLANCE AND QUALITY REVIEW CHECKLIST

Project: Below Regulatory Concern (BRC) Activities: General QA & Data Verification Org. 6416 Date(s): 8/19-9/12/91

Report No: 1 Project C[illegible]: Matthew W. Kozak Surveyor/Reviewer: Samuel D. Bensonhaver Page: 2 of 3

Character	Ref.	Result C	Result NC	Observations and/or Findings	Initials & Date
Baselining IMPACTS-BRC Data	3.1.6				
1) CMS established with disks and notebook.		x			
2) Separate code and data directories maintained on PC's.		x		2) Have implemented to the extent possible. It turns out that the original design of the original IMPACTS-BRC package requires that data & code be in the same directory in order to run.	
3) Software coordinator involved in distribution of data versions.		x			
4) Path names to data files recorded in notebooks.		x		3) Started with distribution of original SNL code. "Official" code ordered later from NRC and checked for different sample problem results.	
5) Sample problems run, checked and recorded in logbook each time installed on new machine or HW configuration changed.		x			
Review of Version 2.0 Data	3.2.1				
1) Line by line discrepancy check of tape 1.dat and tape 2.dat.		x			
2) Discrepancies entered into a BRC project data logbook, along with recommended corrective action.		x		2) Comments and general summary of findings entered into logbook along with a reference to a printed report containing the exact values.	
3) Entries initialed and dated.		x			
Verification of first Review	3.2.2				
1) Health physicist involved in choice of correction values.		x			
2) Each corrective action initialed and dated by health physicist.		x			
3) Differences of opinion resolved and documented by Principal Investigator.		x		3) None have surfaced.	

SURVEILLANCE AND QUALITY REVIEW CHECKLIST

Project: Below Regulatory Concern (BRC) Activities: General QA & Data Verification Org. 6416 Date(s): 8/19-9/12/91

Report No: 1 Project Contact: Matthew W. Kozak Surveyor/Reviewer: Samuel D. Bensonhaver Page: 3 of 3

Characteristic	Ref.	Result C	Result NC	Observations and/or Findings	Initials & Date
Generation of Version 2.1 Data	3.2.3				
1) V2.1 Data generated from controlled copy of V2.0 data.		x			
2) V2.1 of the data independently reviewed (dated, and initialed).		x			
3) ASCII copy of V2.1 data archived by Software Coordinator.		x			
Run Existing sample Problems with Version 2.1 Data	3.2.4				
1) Three User's Guide example problems run with controlled copy of V2.0 code and controlled copy of V 2.1 data.		x			
2) Results compared with those generated by V2.0 data and differences noted in the data logbook, dated, and initialed.		x			
Data Verification Letter Report	3.2.5				
1) Principal Investigator review of report and project logbooks to ensure that all appropriate information has been reported accurately.		x		1) No major issues surfaced, therefore PI only reviewed report.	

SURVEILLANCE AND QUALITY REVIEW CHECKLIST

Project: Below Regulatory Concern (BRC) **Activities:** General QA & Code Verification **Org.** 6416 **Date(s):** 8/19-9/30/91

Report No: 2 **Project Contact:** Matthew W. Kozak **Surveyor/Reviewer:** Samuel D. Bensonhaver **Page:** 1 of 4

Characteristic	Ref.	Result C	Result NC	Observations and/or Findings	Initials & Date
Project Logbooks	3.1.1				
1) Logbooks clearly labelled as BRC Documentation.		x			
2) Separate areas for Data and code activities.		x			
3) Entries made in black ink, dated, and initialed.		x		3) Small number of entries in one notebook in blue. However, a typewritten companion report was filed.	
4) Changes made to original left legible.		x			
5) Changes dated and initialed.		x		5) Requirement generally observed. Changes only made on same day as page dated, therefore, changes not specifically dated.	
6) No "white out" or "cut and paste".		x			
Quality Assurance Training	3.1.2				
1) QA Information distributed to all project participants.		x		1) Information distributed via company mail approx. 6/18/91.	
2) Training session.		x		2) Session held for project participants on 6/24/9.	
Records Management	3.1.3				
1) Commented copies of reviewed material retained.		x		1) Grammar only comments received. Therefore, copies were not retained.	
2) Unincorporated comment rebuttals maintained.		x		2) No unincorporated comments pending.	
Security	3.1.5				
1) Code Backups available.		x		1) Only write statements added to test original code (no changes ever made to code logic). Therefore, the Configuration Management System original code backup was considered to be the current backup.	
2) Backup diskettes kept in locked storage containers		x			
3) Backup copies of the Configuration Management System diskettes and notebook maintained in a physically separated building by the Quality Coordinator.		x			
4) PC's locked during nonworking hours (if provisioned) and access by other personnel discouraged.		x		4) External access not allowed.	

SURVEILLANCE AND QUALITY REVIEW CHECKLIST

Project: Below Regulatory Concern (BRC) **Activities:** General QA & Code Verification **Org.** 6416 **Date(s):** 8/19-9/30/91

Report No: 2 **Project Contact:** Matthew W. Kozak **Surveyor/Reviewer:** Samuel D. Bensonhaver **Page:** 2 of 4

Characteristic	Ref.	Result C	Result NC	Observations and/or Findings	Initials & Date
Propose New Sample Problems	3.3.1				
1) FIN A1763 used to determine untested areas of the code.		x			
2) Results of above entered, dated and initialed in logbook.		x		2) Note sheets referenced in logbook and letter report.	
3) Sample problems developed along with method of verification.		x			
4) Sample problems ranked in importance.		x		4) Very little untested code. Therefore, all problems received equal treatment.	
5) Independent assessment by PI of problems and ranking.		x			
6) Problems documented & approved by PI in notebook.		x			
Baseline Code	3.3.2				
1) V2.1 data used exclusively.		x			
2) V2.0 code used for baseline.		x			
3) Modules of V2.0 code tracked by Configuration Manager as necessary.		x		3) Code was never actually broken into modules.	

SURVEILLANCE AND QUALITY REVIEW CHECKLIST

Project: Below Regulatory Concern (BRC) **Activities:** General QA & Code Verification **Org.** 6416 **Date(s):** 8/19-9/301/91

Report No: 2 **Project Contact:** Matthew W. Kozak **Surveyor/Reviewer:** Samuel D. Bensonhaver **Page:** 3 of 4

Characteristic	Ref.	Result C	Result NC	Observations and/or Findings	Initials & Date
Procedures for Verification Testing	3.3.3				
1) Input and output files of every run kept.		x		1) Kept input files and verification files (output of inserted write statements).	
2) Results of test run comparisons stated in logbooks along with version of source code, identification of data files and output files.		x			
3) Noted differences from expected results assessed for cause.		x			
4) Logic errors in code documented in logbook.		x		4-7) All were actually N/A since no errors were found.	
5) Independent assessment by PI of all errors.		x			
6) Corrective actions entered in logbook and initialed by both analyst and Principal Investigator.		x			
7) New baseline version assigned to corrected code for each iteration of code.		x			
Version 2.1 of IMPACTS-BRC	3.3.4				
1) Latest version of code used to create V2.1.		x			
2) Line 2 of code changed to print 2.1 version number.		x			
3) Three original sample problems re-run and results entered into logbook.		x			
4) Entries dated and initialed by analyst.		x			

SURVEILLANCE AND QUALITY REVIEW CHECKLIST

Project: Below Regulatory Concern (BRC) Activities: General QA & Code Verification Org. 6416 Date(s): 8/19-9/30/91

Report No: 2 Project Contact: Matthew W. Kozak Surveyor/Reviewer: Samuel D. Bensonhaver Page: 4 of 4

Characteristic	Ref.	Result C	Result NC	Observations and/or Findings	Initials & Date
Code verification letter report 1) Principal Investigator reviewed draft 3.2 report and project logbooks to ensure all appropriate information accurately reported.	3.3.5	x		1) very little code had to be verified and no errors were found. Therefore, PI reviewed report only	
Baselining Impacts-BRC 1) Project software coordinator archived ASCII copies of:	3.4				
i) V2.1 data,		x			
ii) V2.1 code, and		x			
iii) all sample problem input and output files.		x			

APPENDIX I: Decay Constant Calculations From Documented Half Lives

CALCULATION OF DECAY CONSTANTS (USING QUATTRO)					
Isotope	Half- life			Half-life (yr)	Decay Constant
	DMI Table D-4 page D-10 (yr)	Kocher			
H-3	1.23E+1	1.2280E+01	y	1.228E+01	5.645E-02
C-14	5.73E+0	5.7300E+03	y	5.730E+03	1.210E-04
Na-22	2.62E+0	2.6020E+00	y	2.602E+00	2.664E-01
P-32	3.91E-2	1.4290E+01	d	3.915E-02	1.770E+01
P-33	6.68E-2	2.5400E+01	d	6.959E-02	9.961E+00
S-35	2.41E-1	8.7440E+01	d	2.396E-01	2.893E+00
Cl-36	3.08E+5	3.0100E+05	y	3.010E+05	2.303E-06
Ca-45	4.52E-1	1.6270E+02	d	4.458E-01	1.555E+00
Sc-46	2.30E-1	8.3800E+01	d	2.296E-01	3.019E+00
Cr-51	7.62E-2	2.7704E+01	d	7.590E-02	9.132E+00
Mn-54	8.30E-1	3.1270E+02	d	8.567E-01	8.091E-01
Fe-55	2.60E+0	2.7000E+00	y	2.700E+00	2.567E-01
Fe-59	1.25E-1	4.4630E+01	d	1.223E-01	5.669E+00
Co-57	7.40E-1	2.7090E+02	d	7.422E-01	9.339E-01
Co-58	1.95E-1	7.0800E+01	d	1.940E-01	3.573E+00
Co-60	5.26E+0	5.2710E+00	y	5.271E+00	1.315E-01
Ni-59	8.00E+4	7.5000E+04	y	7.500E+04	9.242E-06
Ni-63	9.20E+1	1.0010E+02	y	1.001E+02	6.925E-03
Zn-65	6.71E-1	2.4440E+02	d	6.696E-01	1.035E+00
Se-75	3.30E-1	1.1978E+02	d	3.282E-01	2.112E+00
Rb-86	5.11E-2	1.8660E+01	d	5.112E-02	1.356E+01
Sr-85	1.75E-1	6.4840E+01	d	1.776E-01	3.902E+00
Sr-89	1.44E-1	5.0550E+01	d	1.385E-01	5.005E+00
Sr-90	2.81E+1	2.8600E+01	y	2.860E+01	2.424E-02
Zr-95	1.79E-1	6.4020E+01	d	1.754E-01	3.952E+00
Nb-94	2.00E+4	2.0300E+04	y	2.030E+04	3.415E-05
Nb-95	9.59E-2	3.5060E+01	d	9.605E-02	7.216E+00
Mo-99	7.61E-3	6.6020E+01	h	7.537E-03	9.197E+01
Tc-99	2.12E+5	2.1300E+05	y	2.130E+05	3.254E-06
Tc-99m	6.91E-4	6.0200E+00	h	6.872E-04	1.009E+03
Ru-103	1.08E-1	3.9350E+01	d	1.078E-01	6.429E+00
Ru-106	1.01E+0	3.6820E+02	d	1.009E+00	6.871E-01
Ag-108m	5.00E+0	1.2700E+02	y	1.270E+02	5.458E-03
Ag-110m	6.99E-1	2.4985E+02	d	6.845E-01	1.013E+00
Cd-109	1.24E+0	4.6400E+02	d	1.271E+00	5.453E-01
Sn-113	3.15E-1	1.1510E+02	d	3.153E-01	2.198E+00
Sn-126	1.00E+5	1.0000E+05	y	1.000E+05	6.931E-06
Sb-124	1.65E-1	6.0200E+01	d	1.649E-01	4.203E+00
Sb-125	2.71E+0	2.7700E+00	y	2.770E+00	2.502E-01
I-125	1.65E-1	6.0140E+01	d	1.648E-01	4.207E+00
I-129	1.17E+7	1.5700E+07	y	1.570E+07	4.415E-08
I-131	2.21E-2	8.0400E+00	d	2.203E-02	3.147E+01
Cs-134	2.05E+0	2.0620E+00	y	2.062E+00	3.362E-01
Cs-135	3.00E+6	2.3000E+06	y	2.300E+06	3.014E-07
Cs-136	3.75E-2	1.3160E+01	d	3.605E-02	1.922E+01
Cs-137	3.00E+1	3.0170E+01	y	3.017E+01	2.297E-02
Ba-140	3.51E-2	1.2789E+01	d	3.504E-02	1.978E+01
La-140	4.59E-3	4.0220E+01	h	4.591E-03	1.510E+02

Isotope	Half- life		Half-life (yr)	Decay Constant
	DMI Table D-4 page D-10 (yr)	Kocher		
Ce-141	8.90E-2	3.250E+01 d	8.904E-02	7.785E+00
Ce-144	7.78E-1	2.843E+02 d	7.789E-01	8.899E-01
Eu-152	1.27E+1	1.360E+01 y	1.360E+01	5.097E-02
Eu-154	1.60E+1	8.800E+00 y	8.800E+00	7.877E-02
Yb-169	8.71E-2	3.197E+01 d	8.759E-02	7.914E+00
Pb-210	2.04E+1	2.226E+01 y	2.226E+01	3.114E-02
Po-210	3.79E-1	1.384E+02 d	3.791E-01	1.828E+00
Rn-222	1.05E-2	3.824E+00 d	1.048E-02	6.617E+01
Ra-226	1.60E+3	1.600E+03 y	1.600E+03	4.332E-04
Ra-228	6.70E+0	5.750E+00 y	5.750E+00	1.205E-01
Ac-227	2.16E+1	2.177E+01 y	2.177E+01	3.184E-02
Th-228	1.19E+0	1.913E+00 y	1.913E+00	3.623E-01
Th-229	7.34E+3	7.340E+03 y	7.340E+03	9.443E-05
Th-230	8.00E+4	7.700E+04 y	7.700E+04	9.002E-06
Th-232	1.41E+10	1.405E+10 y	1.405E+10	4.933E-11
Pa-231	3.25E+4	3.276E+04 y	3.276E+04	2.116E-05
U-232	7.20E+1	7.200E+01 y	7.200E+01	9.627E-03
U-233	1.62E+5	1.592E+05 y	1.592E+05	4.354E-06
U-234	2.47E+5	2.445E+05 y	2.445E+05	2.835E-06
U-235	7.10E+8	7.038E+08 y	7.038E+08	9.849E-10
U-236	2.39E+7	2.342E+07 y	2.342E+07	2.960E-08
U-238	4.51E+9	4.468E+09 y	4.468E+09	1.551E-10
Np-237	2.41E+6	2.140E+06 y	2.140E+06	3.239E-07
Pu-236	2.85E+0	2.851E+00 y	2.851E+00	2.431E-01
Pu-238	8.64E+1	8.775E+01 y	8.775E+01	7.899E-03
Pu-239	2.44E+4	2.413E+04 y	2.413E+04	2.872E-05
Pu-240	6.58E+3	6.537E+03 y	6.537E+03	1.060E-04
Pu-241	1.32E+1	1.440E+01 y	1.440E+01	4.814E-02
Pu-242	3.79E+5	3.758E+05 y	3.758E+05	1.844E-06
Pu-244	7.60E+7	8.260E+07 y	8.260E+07	8.392E-09
Am-241	4.58E+2	4.322E+02 y	4.322E+02	1.604E-03
Am-243	7.95E+3	7.380E+03 y	7.380E+03	9.392E-05
Cm-242	4.45E-1	1.632E+02 d	4.471E-01	1.550E+00
Cm-243	3.20E+1	2.850E+01 y	2.850E+01	2.432E-02
Cm-244	1.76E+1	1.811E+01 y	1.811E+01	3.827E-02
Cm-248	4.75E+5	3.390E+05 y	3.390E+05	2.045E-06
Cf-252	2.65E+0	2.639E+00 y	2.639E+00	2.627E-01

APPENDIX J: Dose Conversion Factor Calculations for Decay Chain Members

This appendix contains the spreadsheets used to calculate external dose conversion factors for several decay chains. The dose conversion factors are calculated by adding the contributions of the parent and first daughter, which in each case is a very short-lived daughter (so the two are always in equilibrium). The resulting sum is used as the dose conversion factor for the parent. The decay chains considered are

Ru-103 ---> Rh-103m
Ru-106 ---> Rh-106
Cd-109 ---> Ag-109m
Sn-113 ---> In-113m
Sn-126 ---> Sb-126m
Cs-137 ---> Ba-137m
Ce-144 ---> Pr-144

CALCULATION OF EXTERNAL DOSE CONVERSION FACTORS FOR DECAY CHAINS

DCF	ORGAN	PARENT	DAUGHTERS	SUM	DCF
		Ru-103	Rh-103m		
4	1	4.350E+01	3.270E-02	4.353E+01	4.353E-05
	2	4.000E+01	1.950E-02	4.002E+01	4.002E-05
	3	3.900E+01	1.980E-02	3.902E+01	3.902E-05
	5	4.230E+01	3.340E-02	4.233E+01	4.233E-05
	6	4.050E+01	1.250E-02	4.051E+01	4.051E-05
	7	4.450E+01	1.130E-02	4.451E+01	4.451E-05
	8	5.100E+01	5.460E-02	5.105E+01	5.105E-05
	9	5.410E+01	6.320E-02	5.416E+01	5.416E-05
	10	5.000E+01	1.150E-01	5.012E+01	5.011E-05
5	1	2.110E+03	3.050E-01	2.110E+03	2.110E-03
	2	1.940E+03	1.880E-01	1.940E+03	1.940E-03
	3	1.890E+03	1.860E-01	1.890E+03	1.890E-03
	5	2.050E+03	3.330E-01	2.050E+03	2.050E-03
	6	1.960E+03	1.340E-01	1.960E+03	1.960E-03
	7	2.160E+03	1.070E-01	2.160E+03	2.160E-03
	8	2.470E+03	5.130E-01	2.471E+03	2.471E-03
	9	2.620E+03	5.890E-01	2.621E+03	2.621E-03
	10	2.420E+03	9.990E-01	2.421E+03	2.421E-03

DCF	ORGAN	PARENT	DAUGHTERS	SUM	DCF
		Ru-106	Rh-106		
4	1	0.000E+00	1.840E+01	1.840E+01	1.840E-05
	2	0.000E+00	1.700E+01	1.700E+01	1.700E-05
	3	0.000E+00	1.660E+01	1.660E+01	1.660E-05
	5	0.000E+00	1.800E+01	1.800E+01	1.800E-05
	6	0.000E+00	1.720E+01	1.720E+01	1.720E-05
	7	0.000E+00	1.880E+01	1.880E+01	1.880E-05
	8	0.000E+00	2.110E+01	2.110E+01	2.110E-05
	9	0.000E+00	2.290E+01	2.290E+01	2.290E-05
	10	0.000E+00	2.100E+01	2.100E+01	2.100E-05
5	1	0.000E+00	9.220E+02	9.220E+02	9.220E-04
	2	0.000E+00	8.500E+02	8.500E+02	8.500E-04
	3	0.000E+00	8.320E+02	8.320E+02	8.320E-04
	5	0.000E+00	9.020E+02	9.020E+02	9.020E-04
	6	0.000E+00	8.610E+02	8.610E+02	8.610E-04
	7	0.000E+00	9.410E+02	9.410E+02	9.410E-04
	8	0.000E+00	1.050E+03	1.050E+03	1.050E-03
	9	0.000E+00	1.150E+03	1.150E+03	1.150E-03
	10	0.000E+00	1.050E+03	1.050E+03	1.050E-03

CALCULATION OF EXTERNAL DOSE CONVERSION FACTORS FOR DECAY CHAINS

DCF	ORGAN	PARENT	DAUGHTERS	SUM	DCF
		Cd-109	Ag-109m		
4	1	3.020E-01	4.720E-01	7.740E-01	7.740E-07
	2	1.880E-01	3.710E-01	5.590E-01	5.590E-07
	3	1.830E-01	3.510E-01	5.340E-01	5.340E-07
	5	4.030E-01	5.030E-01	9.060E-01	9.060E-07
	6	1.360E-01	3.540E-01	4.900E-01	4.900E-07
	7	1.040E-01	2.820E-01	3.860E-01	3.860E-07
	8	5.060E-01	8.150E-01	1.321E+00	1.321E-06
	9	6.110E-01	7.840E-01	1.395E+00	1.395E-06
	10	9.450E-01	8.970E-01	1.842E+00	1.842E-06
5	1	3.570E+00	1.510E+01	1.867E+01	1.867E-05
	2	2.240E+00	1.260E+01	1.484E+01	1.484E-05
	3	2.160E+00	1.190E+01	1.406E+01	1.406E-05
	5	4.890E+00	1.480E+01	1.969E+01	1.969E-05
	6	1.650E+00	1.280E+01	1.445E+01	1.445E-05
	7	1.230E+00	1.020E+01	1.143E+01	1.143E-05
	8	5.990E+00	2.620E+01	3.219E+01	3.219E-05
	9	7.260E+00	2.320E+01	3.046E+01	3.046E-05
	10	1.100E+01	2.250E+01	3.350E+01	3.350E-05

DCF	ORGAN	PARENT	DAUGHTERS	SUM	DCF
		Sn-113	In-113m		
4	1	8.100E-01	2.330E+01	2.411E+01	2.411E-05
	2	6.480E-01	2.130E+01	2.195E+01	2.195E-05
	3	6.260E-01	2.090E+01	2.153E+01	2.153E-05
	5	9.990E-01	2.260E+01	2.360E+01	2.360E-05
	6	6.170E-01	2.160E+01	2.222E+01	2.222E-05
	7	5.900E-01	2.400E+01	2.459E+01	2.459E-05
	8	1.210E+00	2.860E+01	2.981E+01	2.981E-05
	9	1.330E+00	2.930E+01	3.063E+01	3.063E-05
	10	1.520E+00	2.730E+01	2.882E+01	2.882E-05
5	1	2.720E+01	1.100E+03	1.127E+03	1.127E-03
	2	2.330E+01	1.000E+03	1.023E+03	1.023E-03
	3	2.270E+01	9.840E+02	1.007E+03	1.007E-03
	5	3.010E+01	1.060E+03	1.090E+03	1.090E-03
	6	2.290E+01	1.020E+03	1.043E+03	1.043E-03
	7	2.370E+01	1.130E+03	1.154E+03	1.154E-03
	8	3.880E+01	1.340E+03	1.379E+03	1.379E-03
	9	4.010E+01	1.380E+03	1.420E+03	1.420E-03
	10	4.190E+01	1.280E+03	1.322E+03	1.322E-03

CALCULATION OF EXTERNAL DOSE CONVERSION FACTORS FOR DECAY CHAINS

DCF	ORGAN	PARENT	DAUGHTERS	SUM	DCF
		Sn-126	Sb-126m		
4	1	4.630E+00	1.410E+02	1.456E+02	1.456E-04
	2	3.960E+00	1.300E+02	1.340E+02	1.340E-04
	3	3.680E+00	1.280E+02	1.317E+02	1.317E-04
	5	4.480E+00	1.380E+02	1.425E+02	1.425E-04
	6	4.130E+00	1.320E+02	1.361E+02	1.361E-04
	7	3.170E+00	1.440E+02	1.472E+02	1.472E-04
	8	8.150E+00	1.620E+02	1.702E+02	1.701E-04
	9	7.000E+00	1.770E+02	1.840E+02	1.840E-04
	10	6.180E+00	1.620E+02	1.682E+02	1.682E-04
5	1	1.870E+02	7.040E+03	7.227E+03	7.227E-03
	2	1.610E+02	6.500E+03	6.661E+03	6.661E-03
	3	1.500E+02	6.360E+03	6.510E+03	6.510E-03
	5	1.770E+02	6.880E+03	7.057E+03	7.057E-03
	6	1.680E+02	6.570E+03	6.738E+03	6.738E-03
	7	1.300E+02	7.190E+03	7.320E+03	7.320E-03
	8	3.290E+02	8.050E+03	8.379E+03	8.379E-03
	9	2.800E+02	8.830E+03	9.110E+03	9.110E-03
	10	2.440E+02	8.040E+03	8.284E+03	8.284E-03

DCF	ORGAN	PARENT	DAUGHTERS	SUM	DCF
		Cs-137	Ba-137m		
4	1	0.000E+00	5.360E+01	5.360E+01	5.360E-05
	2	0.000E+00	4.950E+01	4.950E+01	4.950E-05
	3	0.000E+00	4.840E+01	4.840E+01	4.840E-05
	5	0.000E+00	5.260E+01	5.260E+01	5.260E-05
	6	0.000E+00	6.000E+01	6.000E+01	6.000E-05
	7	0.000E+00	5.460E+01	5.460E+01	5.460E-05
	8	0.000E+00	6.060E+01	6.060E+01	6.060E-05
	9	0.000E+00	6.720E+01	6.720E+01	6.720E-05
	10	0.000E+00	6.110E+01	6.110E+01	6.110E-05
5	1	0.000E+00	2.680E+03	2.680E+03	2.680E-03
	2	0.000E+00	2.480E+03	2.480E+03	2.480E-03
	3	0.000E+00	2.430E+03	2.430E+03	2.430E-03
	5	0.000E+00	2.630E+03	2.630E+03	2.630E-03
	6	0.000E+00	2.510E+03	2.510E+03	2.510E-03
	7	0.000E+00	2.740E+03	2.740E+03	2.740E-03
	8	0.000E+00	3.040E+03	3.040E+03	3.040E-03
	9	0.000E+00	3.370E+03	3.370E+03	3.370E-03
	10	0.000E+00	3.060E+03	3.060E+03	3.060E-03

CALCULATION OF EXTERNAL DOSE CONVERSION FACTORS FOR DECAY CHAINS

DCF	ORGAN	PARENT	DAUGHTERS	SUM	DCF
		Ce-144	Pr-144		
4	1	1.680E+00	2.650E+00	4.330E+00	4.330E-06
	2	1.480E+00	2.460E+00	3.940E+00	3.940E-06
	3	1.410E+00	2.440E+00	3.850E+00	3.850E-06
	5	1.650E+00	2.660E+00	4.310E+00	4.310E-06
	6	1.510E+00	2.510E+00	4.020E+00	4.020E-06
	7	1.390E+00	2.690E+00	4.080E+00	4.080E-06
	8	2.720E+00	2.840E+00	5.560E+00	5.560E-06
	9	2.430E+00	3.220E+00	5.650E+00	5.650E-06
	10	2.160E+00	2.980E+00	5.140E+00	5.140E-06
5	1	7.160E+01	1.590E+02	2.306E+02	2.306E-04
	2	6.350E+01	1.480E+02	2.115E+02	2.115E-04
	3	6.110E+01	1.470E+02	2.081E+02	2.081E-04
	5	6.880E+01	1.600E+02	2.288E+02	2.288E-04
	6	6.480E+01	1.510E+02	2.158E+02	2.158E-04
	7	6.080E+01	1.620E+02	2.228E+02	2.228E-04
	8	1.160E+02	1.700E+02	2.860E+02	2.860E-04
	9	1.020E+02	1.930E+02	2.950E+02	2.950E-04
	10	9.090E+01	1.790E+02	2.699E+02	2.699E-04

APPENDIX K: Verification Test Problems' Input Data Files

VERIFICATION PROBLEM 1 INPUT FILE: TAPE5.DAT

```
  1  3  1  1  2 20 50  1
TEST1,IQ=1  8.00E+02  1.00E+00  8.00E+02
    3     2     0    50     4    -1    -1    10   100     7     1    50    40    10     0
PU-236 Y 1.000E-04  CF-252 Y 2.000E-04  MO-99  D 3.000E-04  BA-140 D 4.000E-04
```

VERIFICATION PROBLEM 2 INPUT FILE: TAPE5.DAT

```
  1  3  4  1  2 20 50  1
TEST2,IQ=4  8.00E+02  1.00E+00  8.00E+02
    3     2     0    50     1    -1    -1    10   100     7     1    50    40    10     0
PU-236 Y 1.000E-04  CF-252 Y 2.000E-04  MO-99  D 3.000E-04  BA-140 D 4.000E-04
```

VERIFICATION PROBLEM 3 INPUT FILE: TAPE5.DAT

```
  1  3  5  1  2 20  0  1
TEST3,IQ=5 18.00E+02  1.00E+00  8.00E+02
    3     2     0    50     2    -1    -1     1   100     7     1    50    40    10     0
RA-226 W 1.000E-04
```

APPENDIX L: Verification Test Problems' Output Data Files

VERIFICATION PROBLEM 1 OUTPUT FILE: TAPE 6.OUT

```
IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:14:14.01

ONSITE INC, S. LANDF

LIFE= 20  OVFL=  1  NSTR=  1
RXGN=  1  DATA=  3
IPOP=  2  INST= 50

OPTIONAL XOQ PARAMS
 4.023E+03 3.440E+03 3.000E+00 0.000E+00
 1.207E+04 2.051E+04 3.000E+00 0.000E+00
 2.414E+04 7.364E+04 3.000E+00 3.300E-01
 4.023E+04 1.216E+05 3.000E+00 3.300E-01
 5.632E+04 5.566E+05 3.000E+00 0.000E+00
 7.241E+04 1.013E+06 2.000E+00 3.300E-01
 6.100E+01 0.000E+00 3.000E+02 1.000E+02 3.300E-01 3.300E-01

OPTIONAL ENVIRONMENTAL PARAMETERS
PRC = 1.80E-01  TXC = 1.00E+00  QFC = 1.10E+02 2.00E+05 4.50E+06
FSC = 2.64E-10  DTTM= 1.70E+00  TTM = 1.85E+00 2.50E+01 5.00E+01
FSA = 8.06E-11  DTPC= 0.00E+00  TPC = 0.00E+00 0.00E+00 0.00E+00
WVEL= 6.67E+00  AXOQ= 1.40E-10  EFAC= 7.95E-06

WASTE: TEST1,IQ=1  WEIGHT: 8.00E+02 MT  DENSITY: 1.00E+00 MT/M3

ID= 3  IA= 2  IK1= 0  IK2= 50  PROCESS= 4
IXS=  10 100   7   1
ICS=  50  40  10   0

TRANSPORTATION IMPACTS          TR-MAX = 1.58E+00 MREM/YR
                                TR-OCC = 3.16E+01 PERSON-MREM/YR
                                TR-POP = 7.73E+01 PERSON-MREM/YR
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INTRUDER IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
INT-CO	5.76E-01	2.00E-02	2.00E-02	1.99E-02	2.07E-02	2.07E-02	2.50E-02	8.26E-02	2.00E-02	8.92E-02
INT-AG	2.64E-01	9.45E-02	9.47E-02	9.45E-02	9.48E-02	9.47E-02	9.62E-02	1.16E-01	9.45E-02	1.15E-01

EXPOSED WASTE IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IN-AIR	6.28E-01	9.21E-05	5.87E-04	0.00E+00	1.02E-03	9.11E-04	6.29E-03	7.76E-02	8.14E-05	7.87E-02
ER-AIR	7.62E-03	1.84E-05	5.81E-05	0.00E+00	4.53E-05	2.59E-02	1.18E-02	1.46E-01	9.29E-06	8.82E-03
IN-WAT	1.68E-07	6.75E-08	2.42E-06	0.00E+00	7.57E-07	3.80E-07	2.84E-06	3.56E-05	3.48E-08	1.71E-06
ER-WAT	9.12E-09	1.87E-08	3.28E-07	0.00E+00	2.79E-08	1.24E-05	5.63E-06	7.00E-05	4.45E-09	3.81E-06

INCINERATION AND OPERATIONAL IMPACTS: UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IC-POP	9.65E+03	4.15E+00	5.40E+01	0.00E+00	2.87E+00	9.93E+02	5.91E+02	7.35E+03	1.42E+00	1.53E+03
IC-IND	3.68E-03	1.58E-06	2.06E-05	0.00E+00	1.10E-06	3.78E-04	2.25E-04	2.80E-03	5.41E-07	5.83E-04
IC-WOR	8.15E+01	1.40E+00	1.41E+00	1.38E+00	1.40E+00	8.62E+00	5.48E+00	5.22E+01	1.40E+00	1.36E+01
IC-MWR	5.06E-01	8.51E-03	8.56E-03	8.39E-03	8.47E-03	5.34E-02	3.37E-02	3.24E-01	8.46E-03	8.40E-02
OP-POP	2.76E+01	1.19E-02	1.54E-01	0.00E+00	8.20E-03	2.84E+00	1.69E+00	2.10E+01	4.05E-03	4.37E+00
OP-IND	1.98E-01	8.54E-05	1.11E-03	0.00E+00	5.90E-05	2.04E-02	1.21E-02	1.51E-01	2.92E-05	3.14E-02
OP-WOR	4.88E+00	2.15E+00	2.15E+00	2.15E+00	2.15E+00	2.40E+00	2.29E+00	3.88E+00	2.15E+00	2.56E+00
OP-MWR	4.88E+00	2.15E+00	2.15E+00	2.15E+00	2.15E+00	2.40E+00	2.29E+00	3.88E+00	2.15E+00	2.56E+00

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	2.23E-03	5.36E-03	7.01E-02	0.00E+00	1.09E-02	2.19E-01	1.76E-01	2.15E+00	1.80E-03	1.12E-01
LA-OVF	1.11E-09	3.34E-09	9.55E-08	0.00E+00	9.37E-10	3.32E-07	2.76E-07	3.42E-06	1.57E-10	1.72E-07
LA-AIR	2.83E-05	1.11E-08	1.27E-07	0.00E+00	4.73E-09	2.28E-06	1.57E-06	1.95E-05	2.87E-09	4.35E-06

1

GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	7.45E-07	9.80E-07	4.36E-05	0.00E+00	4.05E-10	8.43E-06	3.35E-06	4.20E-05	4.33E-10	6.06E-06
40YR	1.15E-08	1.52E-08	6.76E-07	0.00E+00	6.27E-12	1.31E-07	5.19E-08	6.50E-07	6.72E-12	9.40E-08
60YR	1.34E-10	1.76E-10	7.86E-09	0.00E+00	7.29E-14	1.52E-09	6.03E-10	7.56E-09	7.81E-14	1.09E-09
80YR	1.39E-12	1.82E-12	8.12E-11	0.00E+00	7.53E-16	1.57E-11	6.23E-12	7.81E-11	8.06E-16	1.13E-11
100YR	1.34E-14	1.77E-14	7.86E-13	0.00E+00	7.29E-18	1.52E-13	6.04E-14	7.56E-13	7.81E-18	1.09E-13
120YR	1.25E-16	1.64E-16	7.31E-15	0.00E+00	6.78E-20	1.41E-15	5.61E-16	7.03E-15	7.26E-20	1.02E-15
160YR	1.12E-20	1.48E-20	6.58E-19	0.00E+00	6.10E-24	1.27E-19	5.05E-20	6.33E-19	6.54E-24	9.15E-20
200YR	7.50E-25	9.86E-25	4.39E-23	0.00E+00	4.07E-28	8.49E-24	3.37E-24	4.22E-23	4.36E-28	6.10E-24
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Total Run Time = 0.2117E-01 Minute(s)

****

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VERIFICATION PROBLEM 1 OUTPUT FILE: TAPE10.OUT

IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:14:14.01

ONSITE INC, S. LANDF

TEST1,IQ=1

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC	MAX INDIVIDUAL
MO-99	5.850E-01
BA-140	9.894E-01
PU-236	2.638E-05
CF-252	4.911E-05

TOTAL TRANSPORTATION IMPACTS = 1.579E+00

INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIES ****

NUC	MAXIMUM OFF-SITE INDIVIDUAL
MO-99	1.308E-06
BA-140	3.544E-06
PU-236	1.141E-03
CF-252	2.938E-03

TOTAL NON-NORMALIZED INCINERATOR IMPACT = 4.083E-03

WORKER INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIES ****

NUC	RESIDUE HANDLERS	MAINTENANCE
MO-99	2.181E-02	2.181E-02
BA-140	3.690E-02	3.690E-02
PU-236	1.541E-01	1.541E-01
CF-252	3.752E-01	3.752E-01
TOTAL NON-NORMALIZED WORKER IMPACTS	5.880E-01	5.880E-01

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	CONSTRUCTION	AGRICULTURE
MO-99	2.369E-12	2.226E-09
BA-140	0.000E+00	0.000E+00
PU-236	8.918E-02	1.157E-01
CF-252	6.943E-05	2.273E-05
RADON		0.000E+00
TOTAL NON-NORMALIZED INTRUDER IMPACTS	8.924E-02	1.157E-01

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
MO-99	1.562E-11	1.517E-09	5.601E-14	6.653E-12
BA-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PU-236	7.857E-02	8.139E-04	1.874E-06	2.122E-08
CF-252	8.401E-05	8.008E-03	3.236E-08	3.786E-06

TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS

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            7.865E-02   8.822E-03   1.706E-06   3.808E-06


 OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)

 ****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

 NUC          TREATMENT    OVERFLOW  EVAPORATOR

 MO-99        4.082E-03   0.000E+00   0.000E+00
 BA-140       1.138E-05   0.000E+00   0.000E+00
 PU-236       1.553E-04   8.214E-10   5.965E-07
 CF-252       1.073E-01   1.710E-07   3.756E-06

 TOTAL NON-NORMALIZED OVERFLOW IMPACTS
              1.116E-01   1.718E-07   4.352E-06


 GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME
 ****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

 FIRST ROW IS INTRUDER WELL
 SECOND ROW IS POPULATION WELL
 THIRD ROW IS SURFACE WATER

    20YR    40YR    60YR    80YR   100YR   120YR   160YR   200YR   400YR   600YR   800YR    1K YR   2K YR   5K YR  10K
YR  20K YR

  MO-99
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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  BA-140
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0.0E+00
  PU-236
 6.1E-06 9.4E-08 1.1E-09 1.1E-11 1.1E-13 1.0E-15 9.1E-20 6.1E-24 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
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0.0E+00
  CF-252
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00

  TOTAL NON-NORMALIZED GROUNDWATER IMPACTS
 6.1E-06 9.4E-08 1.1E-09 1.1E-11 1.1E-13 1.0E-15 9.1E-20 6.1E-24 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
-----------------------------------------------------------------
 Total Run Time =    0.2117E-01 Minute(s)

*****************************************************************************************************************************
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VERIFICATION PROBLEM 1 OUTPUT FILE: TAPE11.OUT

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IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:14:14.01

ONSITE INC, S. LANDF

LIFE= 20  OVFL=  1  NSTR=  1
REGN=  1  DATA=  3
IPOP=  2  INST= 50

OPTIONAL XOQ PARAMS
 4.023E+03 3.440E+03 3.000E+00 0.000E+00
 1.207E+04 2.051E+04 3.000E+00 0.000E+00
 2.416E+04 7.364E+04 3.000E+00 3.300E-01
 4.023E+04 1.216E+05 3.000E+00 3.300E-01
 5.632E+04 5.566E+05 3.000E+00 0.000E+00
 7.241E+04 1.013E+06 2.000E+00 3.300E-01
 6.100E+01 0.000E+00 3.000E+02 1.000E+02 3.300E-01 3.300E-01

OPTIONAL ENVIRONMENTAL PARAMETERS
PRC = 1.80E-01  TXC = 1.00E+00  QPC = 1.10E+02 2.00E+05 4.50E+06
FSC = 2.64E-10  DTTM= 1.70E+00  TTM = 1.85E+00 2.50E+01 5.00E+01
FSA = 8.06E-11  DTPC= 0.00E+00  TPC = 0.00E+00 0.00E+00 0.00E+00
WVEL= 6.67E+00  AXOQ= 1.40E-10  EFAC= 7.95E-06

WASTE: TEST1,IQ=1  WEIGHT: 8.00E+02 MT  DENSITY: 1.00E+00 MT/M3

ID= 3  IA= 2  IK1= 0  IK2= 50  PROCESS= 4
IXS=  10 100   7   1
ICO=  50  40  10   0

TRANSPORTATION IMPACTS           TR-MAX = 1.58E+00 MREM/YR
                                 TR-OCC = 3.16E+01 PERSON-MREM/YR
                                 TR-POP = 7.73E+01 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

  SCN    ICRP
INT-CO 8.82E-02
INT-AG 1.16E-01

EXPOSED WASTE IMPACTS (MREM/YR):

  SCN    ICRP
IN-AIR 7.87E-02
ER-AIR 8.82E-03
IN-WAT 1.71E-06
ER-WAT 3.81E-06

INCINERATION AND OPERATIONAL IMPACTS:
 UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
        IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

  SCN    ICRP
IC-POP 1.53E+03
IC-IND 5.83[illegible]
IC-WOR 1.36E+01
IC-MWR [illegible].40E-[illegible]2
OP-POP 4.37E+00
OP-IND [illegible].14E-02
OP-WOR [illegible].56E+00
OP-MWR 2.56E+00

LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

  SCN    ICRP
LA-OPS 1.12E-01
LA-OVF 1.72E-07
LA-AIR 4.35E-06
1
GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL
  TIME  ICRP
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```
 20YR 6.06E-06
 40YR 9.40E-08
 60YR 1.09E-09
 80YR 1.13E-11
100YR 1.09E-13
120YR 1.02E-15
160YR 9.15E-20
200YR 6.10E-24
400YR 0.00E+00
600YR 0.00E+00
800YR 0.00E+00
 1K YR 0.00E+00
 2K YR 0.00E+00
 5K YR 0.00E+00
10K YR 0.00E+00
20K YR 0.00E+00

POPULATION-WELL
  TIME  ICRP
  20YR 0.00E+00
  40YR 0.00E+00
  60YR 0.00E+00
  80YR 0.00E+00
 100YR 0.00E+00
 120YR 0.00E+00
 160YR 0.00E+00
 200YR 0.00E+00
 400YR 0.00E+00
 600YR 0.00E+00
 800YR 0.00E+00
  1K YR 0.00E+00
  2K YR 0.00E+00
  5K YR 0.00E+00
 10K YR 0.00E+00
 20K YR 0.00E+00

POPULATION-SURFACE WATER
  TIME  ICRP
  20YR 0.00E+00
  40YR 0.00E+00
  60YR 0.00E+00
  80YR 0.00E+00
 100YR 0.00E+00
 120YR 0.00E+00
 160YR 0.00E+00
 200YR 0.00E+00
 400YR 0.00E+00
 600YR 0.00E+00
 800YR 0.00E+00
  1K YR 0.00E+00
  2K YR 0.00E+00
  5K YR 0.00E+00
 10K YR 0.00E+00
 20K YR 0.00E+00
-------------------------------------------------------
Total Run Time =   0.2117E-01 Minute(s)

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VERIFICATION PROBLEM 2 OUTPUT FILE: TAPE 6.OUT

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IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:16:08.59


HAZARDOUS WASTE I

LIFE= 20  OVFL=  1  NSTR=  1
REGN=  1  DATA=  3
IPOP=  2  INST= 50
```

OPTIONAL KOQ PARAMS

```
 6.023E+03 3.440E+03 3.000E+00 0.000E+00
 1.207E+04 2.051E+04 3.000E+00 0.000E+00
 1.414E+04 7.254E+04 3.000E+00 3.300E-01
 4.023E+04 1.216E+05 3.000E+00 3.300E-01
 5.632E+04 5.586E+05 3.000E+00 0.000E+00
 7.241E+04 1.013E+06 2.000E+00 3.300E-01
 6.100E+01 0.000E+00 1.000E+02 1.000E+02 3.300E-01 3.300E-01
```

OPTIONAL ENVIRONMENTAL PARAMETERS

```
PRC = 1.80E-01  TXC = 1.00E+00  QFC = 1.10E+02 2.00E+05 4.50E+06
PSC = 2.64E-10  DTTM= 1.70E+00  TTM = 1.85E+00 2.50E+01 5.00E+0.
PSA = 8.06E-11  DTPC= 0.00E+00  TPC = 0.00E+00 0.00E+00 0.00E+00
WVEL= 8.82E+00  AXOQ= 1.40E-10  EFAC= 7.95E-08
```

WASTE: TEST2,IQ=4 WEIGHT: 8.00E+02 MT DENSITY: 1.00E+00 MT/M3

```
ID= 3  IA= 2  IK1= 0  IK2= 50  PROCESS= 1
IXS=  10 100   7   1
ICS=  50  40  10   0
```

TRANSPORTATION IMPACTS TR-MAX = 3.23E+00 MREM/YR
TR-OCC = 8.45E+01 PERSON-MREM/YR
TR-POP = 4.42E+02 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
INT-CO	1.22E-02	4.24E-04	4.24E-04	4.22E-04	4.38E-04	4.38E-04	5.30E-04	1.75E-03	4.24E-04	1.89E-03
INT-AG	5.59E-03	2.00E-03	2.00E-03	2.00E-03	2.01E-03	2.00E-03	2.06E-03	2.45E-03	2.00E-03	2.45E-03

EXPOSED WASTE IMPACTS (MREM/YR):

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IN-AIR	1.33E-02	1.05E-06	1.24E-05	0.00E+00	2.16E-05	1.93E-05	1.33E-04	1.64E-03	1.72E-06	1.66E-03
ER-AIR	1.36E-02	3.28E-05	1.04E-04	0.00E+00	8.11E-05	4.63E-02	2.11E-02	2.62E-01	1.66E-05	1.58E-02
IN-WAT	3.55E-09	1.43E-09	5.13E-08	0.00E+00	1.60E-08	8.03E-09	6.01E-08	7.53E-07	7.37E-10	3.61E-06
ER-WAT	1.63E-08	3.35E-08	5.87E-07	0.00E+00	5.00E-08	2.21E-05	1.01E-05	1.25E-04	7.96E-09	6.81E-06

INCINERATION AND OPERATIONAL IMPACTS: UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
IC-POP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IC-IND	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IC-WOR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
IC-MWR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OP-POP	1.44E+00	6.22E-04	8.08E-03	0.00E+00	4.30E-04	1.46E-01	8.84E-02	1.10E+00	2.12E-04	2.29E-01
OP-IND	1.04E-02	4.47E-06	5.81E-05	0.00E+00	3.09E-06	1.07E-03	6.38E-04	7.92E-03	1.53E-06	1.65E-03
OP-WOR	5.51E+00	4.05E+00	4.05E+00	4.05E+00	4.05E+00	4.19E+00	4.13E+00	4.98E+00	4.05E+00	4.28E+00
OP-MWR	1.54E-01	1.29E-01	1.29E-01	1.29E-01	1.29E-01	1.31E-01	1.31E-01	1.45E-01	1.29E-01	1.33E-01

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	3.99E-04	9.58E-04	1.25E-02	0.00E+00	1.94E-03	3.91E-02	3.14E-02	3.85E-01	3.22E-04	2.00E-02
LA-OVF	1.98E-10	5.98E-10	1.71E-08	0.00E+00	1.68E-10	5.94E-08	4.93E-08	6.12E-07	2.81E-11	3.07E-08
LA-AIR	5.06E-06	1.98E-08	2.26E-08	0.00E+00	0.46E-10	4.08E-07	2.80E-07	3.46E-06	5.14E-10	7.79E-07

1

GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	2.69E-08	3.54E-08	1.58E-06	0.00E+00	1.46E-11	3.04E-07	1.21E-07	1.52E-06	1.56E-11	2.19E-07
40YR	4.17E-10	5.48E-10	2.44E-08	0.00E+00	2.26E-13	4.72E-09	1.87E-09	2.35E-08	2.43E-13	3.39E-09
60YR	4.65E-12	6.37E-12	2.84E-10	0.00E+00	2.63E-15	5.48E-11	2.18E-11	2.73E-10	2.82E-15	3.94E-11
80YR	5.01E-14	6.58E-14	2.93E-12	0.00E+00	2.72E-17	5.67E-13	2.25E-13	2.82E-12	2.91E-17	4.08E-13
100YR	4.85E-16	6.38E-16	2.84E-14	0.00E+00	2.63E-19	5.49E-15	2.18E-15	2.73E-14	2.82E-19	3.95E-15
120YR	4.51E-18	5.93E-18	2.64E-16	0.00E+00	2.45E-21	5.11E-17	2.03E-17	2.54E-16	2.62E-21	3.67E-17
160YR	4.06E-22	5.34E-22	2.38E-20	0.00E+00	2.21E-25	4.60E-21	1.83E-21	2.29E-20	2.36E-25	3.31E-21
200YR	2.71E-26	3.57E-26	1.59E-24	0.00E+00	1.47E-29	3.07E-25	1.22E-25	1.53E-24	1.58E-29	2.21E-25
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Total Run Time = 0.2017E-01 Minute(s)

VERIFICATION PROBLEM 2 OUTPUT FILE: TAPE10.OUT

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IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:18:08.59

HAZARDOUS WASTE I

TEST2,IQ=4

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC     MAX INDIVIDUAL

MO-99        1.195E+00
BA-140       2.022E+00
PU-238       5.387E-05
CF-252       1.004E-02

TOTAL TRANSPORTATION IMPACTS =   3.227E+00
```

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	CONSTRUCTION	AGRICULTURE
MO-99	5.014E-14	4.711E-11
BA-140	0.000E+00	0.000E+00
PU-236	1.887E-03	2.449E-03
CF-252	1.469E-06	4.810E-07
RADON		0.000E+00
TOTAL NON-NORMALIZED INTRUDER IMPACTS	1.889E-03	2.449E-03

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	INTRUDER-AIR	EROSION-AIR	INTRUDER-WATER	EROSION-WATER
MO-99	3.307E-13	2.713E-09	1.185E-15	1.190E-11
BA-140	0.000E+00	0.000E+00	0.000E+00	0.000E+00
PU-236	1.663E-03	1.458E-03	3.542E-08	3.795E-08
CF-252	1.778E-06	1.432E-02	6.649E-10	6.773E-06
TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS	1.665E-03	1.578E-02	3.611E-08	6.811E-06

OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)

**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

NUC	TREATMENT	OVERFLOW	EVAPORATOR
MO-99	7.319E-04	0.000E+00	0.000E+00
BA-140	2.038E-06	0.000E+00	0.000E+[illegible]
PU-236	2.578E-05	1.469E-10	1.067E-07
CF-252	1.920E-02	3.058E-08	6.718E-07
TOTAL NON-NORMALIZED OVERFLOW IMPACTS	1.996E-02	3.073E-08	7.786E-07

GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME
**** IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES ****

FIRST ROW IS INTRUDER WELL
SECOND ROW IS POPULATION WELL
THIRD ROW IS SURFACE WATER

	20YR	40YR	60YR	80YR	100YR	120YR	160YR	200YR	400YR	600YR	800YR	1K YR	2K YR	5K YR	10K YR	20K YR
MO-99																
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
BA-140																
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
PU-236																
	2.2E-07	1.4E-09	3.9E-11	4.1E-13	3.9E-15	3.7E-17	3.3E-21	2.2E-25	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	

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0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
  CF-252
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00

  TOTAL NON-NORMALIZED GROUNDWATER IMPACTS
 2.2E-07 3.4E-09 3.9E-11 4.1E-13 3.9E-15 3.7E-17 3.3E-21 2.2E-25 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
0.0E+00
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 Total Run Time =   0.2017E-01 Minute(s)

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VERIFICATION PROBLEM 2 OUTPUT FILE: TAPE11.OUT

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IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:16:08.59


HAZARDOUS WASTE I

LIFE= 20  OVFL=  1  NSTR=  1
REGN=  1  DATA=  3
IPOP=  2  INST= 50

OPTIONAL XOQ PARAMS
 4.023E+03 3.440E+03 3.000E+00 0.000E+00
 1.207E+04 2.051E+04 3.000E+00 0.000E+00
 2.414E+04 7.364E+04 3.000E+00 3.300E-01
 4.023E+04 1.216E+05 3.000E+00 3.300E-01
 5.632E+04 5.566E+05 3.000E+00 0.000E+00
 7.241E+04 1.013E+06 2.000E+00 3.300E-01
 6.100E+01 0.000E+00 3.000E+02 1.000E+02 3.300E-01 3.300E-01

OPTIONAL ENVIRONMENTAL PARAMETERS
PRC = 1.90E-01  TXC = 1.00E+00  QFC = 1.10E+02 2.00E+05 4.50E+06
FSC = 2.64E-10  DTTM= 1.70E+00  ITM = 1.85E+00 2.50E+01 5.00E+01
FSA = 8.06E-11  DTPC= 0.00E+00  TPC = 0.00E+00 0.00E+00 0.00E+00
WVEL= 6.67E+00  AXOQ= 1.40E-10  EFAC= 7.95E-06

WASTE: TEST2,IQ=4  WEIGHT: 8.00E+02 MT  DENSITY: 1.00E+00 MT/M3

ID= 3  IA= 2  IK1= 0  IK2= 50  PROCESS= 1
IXS=  10 100   7   1
ICS=  50  40  10   0

TRANSPORTATION IMPACTS          TR-MAX = 3.23E+00 MREM/YR
                                TR-OCC = 6.45E+01 PERSON-MREM/YR
                                TR-POP = 4.42E+02 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

  SCN   ICRP
INT-CO 1.89E-03
INT-AG 2.45E-03

EXPOSED WASTE IMPACTS (MREM/YR):

  SCN   ICRP
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 IN-AIR 1.66E-03
 ER-AIR 1.58E-02
 IN-WAT 3.61E-08
 ER-WAT 8.21E-06

 INCINERATION AND OPERATIONAL IMPACTS:
  UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
         IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

   SCN   ICRP
 IC-POP 0.00E+00
 IC-IND 0.00E+00
 IC-WOR 0.00E+00
 IC-MWR 0.00E+00
 OP-POP 2.28E-01
 OP-IND 1.55E-03
 OP-WOR 6.38E+00
 OP-MWR 1.33E-01

 LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

   SCN   ICRP
 LA-OPS 2.00E-02
 LA-OVF 3.07E-08
 LA-AIR 7.79E-07
1
 GROUND WATER IMPACTS (MREM/YR):

 INTRUDER-WELL
   TIME  ICRP
   20YR 2.19E-07
   40YR 3.39E-09
   60YR 3.94E-11
   80YR 4.08E-13
  100YR 3.95E-15
  120YR 3.67E-17
  160YR 3.31E-21
  200YR 2.21E-25
  400YR 0.00E+00
  600YR 0.00E+00
  800YR 0.00E+00
  1K YR 0.00E+00
  2K YR 0.00E+00
  5K YR 0.00E+00
 10K YR 0.00E+00
 20K YR 0.00E+00

 POPULATION-WELL
   TIME  ICRP
   20YR 0.00E+00
   40YR 0.00E+00
   60YR 0.00E+00
   80YR 0.00E+00
  100YR 0.00E+00
  120YR 0.00E+00
  160YR 0.00E+00
  200YR 0.00E+00
  400YR 0.00E+00
  600YR 0.00E+00
  800YR 0.00E+00
  1K YR 0.00E+00
  2K YR 0.00E+00
  5K YR 0.00E+00
 10K YR 0.00E+00
 20K YR 0.00E+00

 POPULATION-SURFACE WATER
   TIME  ICRP
   20YR 0.00E+00
   40YR 0.00E+00
   60YR 0.00E+00
   80YR 0.00E+00
  100YR 0.00E+00
```

```
 120YR 0.00E+00
 160YR 0.00E+00
 200YR 0.00E+00
 400YR 0.00E+00
 600YR 0.00E+00
 800YR 0.00E+00
 1K YR 0.00E+00
 2K YR 0.00E+00
 5K YR 0.00E+00
 10K YR 0.00E+00
 20K YR 0.00E+00
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Total Run Time =   0.2017E-01 Minute(s)

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VERIFICATION PROBLEM 3 OUTPUT FILE TAPE 6.OUT

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IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:14:14.01


ONSITE INC, S. LANDF

LIFE= 20  OVFL=  1  NSTR=  1
REGN=  1  DATA=  3
IPOP=  2  INST= 50

OPTIONAL FOQ PARAMS
 4.023E+03 5.440E+03 3.000E+00 0.000E+00
 1.207E+04 2.051E+04 3.000E+00 0.000E+00
 2.414E+04 7.364E+04 3.000E+00 3.300E-01
 4.0[illegible]       1.216E+05 3.000E+00 3.300E-01
 5.63[illegible]      5.566E+05 3.000E+00 0.000E+00
 7.24[illegible]      1.013E+06 2.000E+00 3.300E-01
 8.100      0.000E+00 3.000E+02 1.000E+02 3.300E-01 3.300E-01

OPTIONAL ENVIRONMENTAL PARAMETERS
PRC = 1.80E-01  TKC = 1.00E+00  QFC = 1.10E+02 2.00E+05 4.50E+06
FSC = 2.64E-10  DTTM= 1.70E+00  TTM = 1.85E+00 2.50E+01 5.00E+01
FSA = 8.06E-11  DTPC= 0.00E+00  TPC = 0.00E+00 0.00E+00 0.00E+00
WVEL= 6.67E+00  AXOQ= 1.40E-10  EFAC= 7.9[illegible]-06

WASTE: TEST1,IQ=1  WEIGHT: 8.00E+02 MT  DENSITY: 1.00E+00 MT/M3

ID= 3  IA= 2  IK1= 5  IK2= 50  PROCESS= 4
IXS=  10 100   7   1
ICS=  50  40  10   0

TRANSPORTATION IMPACTS          TR-MAX = 1.58E+00 MREM/YR
                                TR-OCC = 3.16E+01 PERSON-MREM/YR
                                TR-POP = 7.73E+01 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

  SCN   LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER   RED MAR    BONE   THYROID    ICRP
INT-CO 5.76E-01 2.00E-02 2.00E-02 1.99E-02 2.07E-02 2.07E-02 2.50E-02 8.26E-[illegible] 2.00E-02 8.92E-02
INT-AG 2.64E-01 9.45E-02 9.47E-02 9.45E-02 9.48E-02 9.47E-02 9.62E-02 1.16E-01 9.45E-02 1.36E-01

EXPOSED WASTE IMPACTS (MREM/YR):

  SCN   LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER   RED MAR    BONE   THYROID    ICRP
IN-AIR 5.28E-01 9.21E-05 5.87E-04 0.00E+00 1.02E-03 9.11E-04 6.29E-03 7.76E-02 8.14E-05 7.87E-02
ER-AIR 7.62E-03 1.84E-05 5.61E-05 0.00E+00 4.53E-05 2.55E-02 1.16E-02 1.46E-01 9.29E-06 8.62E-03
IN-WAT 1.68E-07 6.75E-08 2.42E-06 0.00E+00 7.57E-07 3.80E-07 2.84E-06 3.56E-05 3.48E-08 1.71E-06
ER-WAT 8.12E-09 1.87E-08 3.28E-07 0.00E+00 2.79E-08 1.24E-05 3.63E-06 7.00E-05 4.45E-09 3.81E-06

INCINERATION AND OPERATIONAL IMPACTS:   UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
                                               IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

  SCN   LUNGS    S.WALL   LLI WALL T. BODY  KIDNEYS   LIVER   RED MAR    BONE   THYROID    ICRP
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IC-POP	9.65E+03	4.15E+00	5.40E+01	0.00E+00	2.67E+00	9.93E+02	5.91E+02	7.35E+03	1.42E+00	1.53E+03
IC-IND	3.68E-03	1.58E-08	2.06E-05	0.00E+00	1.10E-08	3.78E-04	2.25E-04	2.80E-03	5.41E-07	5.83E-04
IC-WGA	8.15E+01	1.40E+00	1.41E+00	1.38E+00	1.40E+00	8.62E+00	5.46E+00	5.22E+01	1.40E+00	1.38E+01
IC-MWR	5.06E-01	8.51E-03	8.56E-03	8.39E-03	8.47E-03	5.34E-02	3.37E-02	3.24E-01	[illegible]	8.40E-02
OP-POP	2.76E+01	1.19E-02	1.54E-01	0.00E+00	8.20E-03	2.84E+00	1.69E+00	2.10E+01	4.05E-03	4.37E+00
OP-IND	1.98E-01	8.54E-05	1.11E-03	0.00E+00	5.90E-05	2.04E-02	1.21E-02	1.51E-01	2.92E-05	3.14E-02
OP-WOR	4.88E+00	2.15E+00	2.15E+00	2.15E+00	2.15E+00	2.40E+00	2.29E+00	3.88E+00	2.15E+00	2.56E+00
OP MWR	4.88E+00	2.15E+00	2.15E+00	2.15E+00	2.15E+00	2.40E+00	2.29E+00	3.88E+00	2.15E+00	2.56E+00

LEACHATE ACCUMULATION IMPACTS UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

SCN	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
LA-OPS	[illegible]	5.36E-03	7.01E-02	0.00E+00	1.00E-02	2.19E-01	1.76E-01	2.15E+00	1.80E-03	1.12E-01
LA-OVF	1.11E-09	3.34E-09	9.55E-08	0.00E+00	9.37E-10	[illegible]	2.76E-07	3.42E-06	1.57E-10	1.72E-07
LA-AIR	2.83E-05	1.11E-08	1.27E-07	0.00E+00	4.73E-09	2.28E-06	1.57E-06	1.95E-05	2.87E-09	4.35E-06

1

GROUND WATER IMPACTS (MREM/YR):

INTRUDER-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	7.45E-07	9.80E-07	4.36E-05	0.00E+00	[illegible]	[illegible]	3.35E-06	4.20E-05	4.33E-10	6.06E-06
40YR	1.15E-08	1.52E-08	6.76E-07	0.00E+00	6.27E-12	1.31E-07	5.19E-08	6.50E-07	6.72E-12	9.40E-08
60YR	1.34E-10	1.76E-10	7.86E-09	0.00E+00	7.29E-14	1.52E-09	6.03E-10	7.56E-09	7.81E-14	1.09E-09
80YR	1.39E-12	1.82E-12	8.12E-11	0.00E+00	7.53E-16	1.57E-11	6.23E-12	7.81E-11	8.06E-16	1.13E-11
100YR	1.34E-14	1.77E-14	7.86E-13	0.00E+00	7.29E-18	1.52E-13	6.04E-14	7.56E-13	7.81E-18	1.09E-13
120YR	1.25E-16	1.64E-16	7.31E-15	0.00E+00	6.78E-20	1.41E-15	5.61E-16	7.03E-15	7.26E-20	1.02E-15
160YR	1.12E-20	1.48E-20	6.58E-19	0.00E+00	6.10E-24	1.27E-19	5.05E-20	6.33E-19	6.54E-24	9.15E-20
200YR	7.50E-25	9.86E-25	4.39E-23	0.00E+00	4.07E-28	[illegible]	3.37E-24	4.22E-23	4.36E-28	6.10E-24
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-WELL

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

POPULATION-SURFACE WATER

TIME	LUNGS	S.WALL	LLI WALL	T. BODY	KIDNEYS	LIVER	RED MAR	BONE	THYROID	ICRP
20YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
40YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
60YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
80YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
100YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
120YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
160YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
200YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
400YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
600YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
800YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10K YR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

```
 20K YR 0.00E+00 0.00E+00 0.00E+r^ 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00 0.00E+00
------------------------------------------------------------------
Total Run Time =   0.2117E-01 Minute(s)

*********************************************************************************************** *****
****************************************************************************************
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VERIFICATION PROBLEM 3 OUTPUT FILE: TAPE10.OUT

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IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:17:08.49

HAZARDOUS WASTE II

TEST3,IQ=5

TRANSPORTATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

NUC    MAX INDIVIDUAL

RA-226        6.482E+01

TOTAL TRANSPORTATION IMPACTS =   6.482E+01

INCINERATION ICRP IMPACTS BY NUCLIDE (MREM/YR)

****  IMPACTS NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIE/  ****

NUC       MAXIMUM OFF-SITE INDIVIDUAL

RA-226      8.067E-04

TOTAL NON-NORMALIZED INCINERATOR IMPACT =   8.067E-04

WORKER INCINERATION ICRP IMPACTS I  NUCLIDL (MREM/YR)

****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF PROCESSING FACILITIES  ****

NUC  RESIDUE HANDLERS  MAINTENANCE

RA-226       4.209E-01   4.209E-01

TOTAL NON-NORMALIZED WORKER IMPACTS
             4.209E-01   4.209" 01

INTRUDER ICRP IMPACTS BY NUCLIDE (MREM/YR)

****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

NUC      CONSTRUCTION  AGRICULTURE

RA-226       4.7 1E-01   2.034E+00
RADON                    2.240E-03

TOTAL NON-NORMALIZED INTRUDER IMPACTS
             4.381E-01   2.036E+00

EXPOSED WASTE ICRP IMPACTS BY NUCLIDE (MREM/YR)

****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

NUC     INTRUDER-AIR EROSION-AIR INTRUDER-WATER EROSION-WATER

RA-226       2.828E-02   8.3 4E+01   8.751E-05   7.860E-01
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TOTAL NON-NORMALIZED EXPOSED WASTE IMPACTS
            2.929E-02   8.344E+01   8.751E-05   7.860E-01


OVERFLOW ICRP IMPACTS BY NUCLIDE (MREM/YR)

****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

NUC          TREATMENT    OVERFLOW  EVAPORATOR

RA-226       1.130E+00   1.130E+00   2.710E+00

TOTAL NON-NORMALIZED OVERFLOW IMPACTS
            1.130E+00   1.130E+00   2.710E+00


GROUNDWATER ICRP IMPACTS BY NUCLIDE (MREM/YR) AT EACH TIME
****  IMPACTS ARE NOT NORMALIZED BY NUMBER OF DISPOSAL FACILITIES  ****

FIRST ROW IS INTRUDER WELL
SECOND ROW IS POPULATION WELL
THIRD ROW IS SURFACE WATER

   20YR    40YR    60YR    80YR   100YR   120YR   160YR   200YR   400YR   600YR   800YR   1K YR   2K YR   5K YR  10K
YR  20K YR

RA-226
 0.0E+00 0.0E+00 2.4E-01 2.3E-01 2.3E-01 4.6E-01 6.7E-01 6.5E-01 1.3E+00 1.6E+00 1.4E+00 1.2E+00 6.3E-01 8.1E-02 2.7E-03
2.8E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 7.2E-02 3.1E-01 3.2E-01 4.1E-02 1.3E-03
1.4E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.6E-02 2.1E-03 6.8E-05
7.2E-08

TOTAL NON-NORMALIZED GROUNDWATER IMPACTS
 0.0E+00 0.0E+00 2.4E-01 2.3E-01 2.3E-01 4.6E-01 6.7E-01 6.5E-01 1.3E+00 1.6E+00 1.4E+00 1.2E+00 6.3E-01 8.1E-02 2.7E-03
2.8E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 7.2E-02 3.1E-01 3.2E-01 4.1E-02 1.3E-03
1.4E-06
 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 1.6E-02 2.1E-03 6.8E-05
7.2E-08
----------------------------------------------------
Total Run Time =    0.1817E-01 Minute(s)

********************************************************************************************************************
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VERIFICATION PROBLEM 3 OUTPUT FILE: TAPE11.OUT

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IMPACTS-BRC - VERSION 2.1: Run on 10/04/91 at 10:17:08.29


HAZARDOUS WASTE II

LIFE= 20  OVFL=  1  NSTR=  1
REGN=  1  DATA=  3
IPOP=  2  INST=  0

OPTIONAL TOQ PARAMS
 4.023E+03 3.440E+03 3.000E+00 0.000E+00
 1.207E+04 2.051E+04 3.000E+00 0.000E+00
 2.414E+04 7.364E+04 3.000E+00 3.300E-01
 4.023E+04 1.216E+05 3.000E+00 3.300E-01
 5.632E+04 5.566E+05 3.000E+00 0.000E+00
 7.241E+04 1.013E+06 2.000E+00 3.300E-01
 6.100E+01 0.000E+00 3.000E+02 1.000E+02 3.300E-01 3.300E-01

OPTIONAL ENVIRONMENTAL PARAMETERS
PRC = 1.80E-01  TAC = 1.00E+00  QFC = 1.10E+02 2.00E+05 4.50E+03
FSC = 2.64E-10  DTTM= 1.70E+00  TTM = 1.85E+00 2.50E+01 5.00E+01
FSA = 8.06E-11  DTPC= 0.00E+00  TPC = 0.00E+00 0.00E+00 0.00E+00
```

```
WVZ1= 6.67E+00  AXOQ= 1.40E-10  EFAC= 7.95E-06

WASTE: TEST3,IQ=5  WEIGHT: 1.80E+03 MT  DENSITY: 1.00E+00 MT/M3

ID= 3  IA= 2  IK1= 0  IK2= 50  PROCESS= 2
IKS=   1 100   7   1
ICS=  50  40  10   0

TRANSPORTATION IMPACTS          TR-MAX = 6.48E+01 MREM/YR
                                TR-OCC = 2.06E+02 PERSON-MREM/YR
                                TR-POP = 1.41E+03 PERSON-MREM/YR

INTRUDER IMPACTS (MREM/YR):

  SCN   ICRP
INT-CO 4.38E-01
INT-AG 2.04E+00

EXPOSED WASTE IMPACTS (MREM/YR):

  SCN   ICRP
IN-AIR 2.93E-02
ER-AIR 6.34E+01
IN-WAT 8.75E-05
ER-WAT 7.86E-01

INCINERATION AND OPERATIONAL IMPACTS:
 UNITS: IC-IND,IC-MWR,OP-IND,OP-MWR - (MREM/YR)
        IC-POP,IC-WOR,OP-POP,OP-WOR - (PERSON-MREM/YR)

  SCN   ICRP
IC-POP 4.02E+02
IC-IND 1.15E-04
IC-WOR 3.36E+00
IC-MWR 6.01E-02
OP-POP 2.26E-02
OP-IND 1.62E-04
OP-WOR 1.29E+02
OP-MWR 4.11E+00

LEACHATE ACCUMULATION IMPACTS  UNITS : LA-OPS, LA-OVF - (MREM/YR); LA-AIR - (PERSON-MREM/YR)

  SCN   ICRP
LA-OPS 1.13E+00
LA-OVF 1.13E+00
LA-AIR 2.71E+00
1
 GROUND WATER IMPACTS (MREM/YR):

 INTRUDER-WELL
   TIME  ICRP
   20YR 0.00E+00
   40YR 0.00E+00
   60YR 2.39E-01
   80YR 2.34E-01
  100YR 2.31E-01
  120YR 4.56E-01
  160YR 5.66E-01
  200YR 6.48E-01
  400YR 1.32E+00
  600YR 1.64E+00
  800YR 1.43E+00
   1K YR 1.25E+00
   2K YR 6.31E-01
   5K YR 8.11E-02
  10K YR 2.65E-03
  20K YR 2.85E-06

 POPULATION-WELL
   TIME  ICRP
   20YR 0.00E+00
   40YR 0.00E+00
   60YR 0.00E+00
```

```
  80YR 0.00E+00
 100YR 0.00E+00
 120YR 0.00E+00
 160YR 0.00E+00
 200YR 0.00E+00
 400YR 0.00E+00
 600YR 0.00E+00
 800YR 7.19E-02
 1K YR 3.13E-01
 2K YR 3.10E-01
 5K YR 4.07E-02
10K YR 1.33E-03
20K YR 1.43E-06

POPULATION-SURFACE WATER
  TIME  ICRP
  20YR 0.00E+00
  40YR 0.00E+00
  60YR 0.00E+00
  80YR 0.00E+00
 100YR 0.00E+00
 120YR 0.00E+00
 160YR 0.00E+00
 200YR 0.00E+00
 400YR 0.00E+00
 600YR 0.00E+00
 800YR 0.00E+00
 1K YR 0.00E+00
 2K YR 1.61E-02
 5K YR 2.06E-03
10K YR 8.76E-05
20K YR 7.25E-08
----------------------------------------------------
Total Run Time =   0.1917E-01 Minute(s)
```

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Codes and Data Verification

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5. AUTHOR(S)
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9. SPONSORING ORGANIZATION — NAME AND ADDRESS (If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

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U.S. Nuclear Regulatory Commission
Washington, DC 20555

10. SUPPLEMENTARY NOTES

11. ABSTRACT (200 words or less)

In the Federal Register, Volume 51, Number 168, NRC has intended the use of IMPACTS-BRC to evaluate petitions for evaluating radioactive waste streams as below regulatory concern. IMPACTS-BRC is a generic radiological assessment code that allows calculation of potential impacts to maximum individuals, waste disposal workers, and the general population resulting from exemption of very low-level radioactive wastes from regulatory control. The code allows calculations to be made of human exposure to the waste by many pathways and exposure scenarios.

This document describes the code history and the quality assurance work that has been carried out on IMPACTS-BRC. The report includes a summary of all the literature reviews pertaining to IMPACTS-BRC up to Version 2.0. The new code and data verification work necessary to produce IMPACTS-BRC, Version 2.1 is presented. General comments about the models and treatment of uncertainty in IMPACTS-BRC are also given.

12. KEY WORDS/DESCRIPTORS (List words or phrases that will assist researchers in locating the report.)
Below Regulatory Concern (BRC)
Low-Level Radioactive Waste Disposal
IMPACTS-BRC

13. AVAILABILITY STATEMENT
Unlimited

14. SECURITY CLASSIFICATION
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