COMPARISON OF RESULTS FROM IMPACTS-BRC AND IMPACTS CODES FOR TYPICAL BRC LOW-LEVEL WASTE CASES

D.W. Chan, J.P. Davis, B.R. Parrish, and B.R. Wofford
General Physics Corporation
Columbia, Maryland 21044

ABSTRACT

The objectives of this study are: (1) to analyze the changes in IMPACTS-BRC compared to the original code IMPACTS; and (2) to compare calculated doses from IMPACTS and IMPACTS-BRC using AIF/NESP-035 (base case) waste stream data. Supporting documentation for IMPACTS can be found in Ref. 1. The new NRC code IMPACTS-BRC and the modifications made to the original code IMPACTS are described in Ref. 2.

The IMPACTS-BRC code is intended primarily to evaluate below regulatory concern (BRC) low-level radioactive waste rulemaking/exemption petitions and is specifically identified by NRC staff as the vehicle of choice for evaluating petitions for BRC approval. The intent of modifications to the original code is to ensure that more conservative doses are calculated for BRC waste streams. Previous work using IMPACTS and its companion code INVERSE indicated that a large proportion of compactible trash from BWR's and PWR's plants disposed in EPA style sanitary landfills would result in doses less than 1 mrem/year to the general public and could be de-regulated (3). Therefore, IMPACTS-BRC and IMPACTS calculations will be compared using BWR and PWR waste stream characteristics in this paper.

OVERVIEW OF IMPACTS-BRC CHANGES

Modifications made to the original IMPACTS code in the new NRC code IMPACTS-BRC include the following:

1. Modifications of the ground water pathway model to maximize contaminated water doses from the following scenarios:
   a. Intruder Well
   b. Population Well
   c. Surface Water
2. Deletion of onsite and open dump disposal methods and associated parametric values.
3. An increase in the transportation distances for all disposal methods.
4. Addition of a new set of environmental parameters to calculate maximum individual impacts.
5. The addition of a new output file, Tape10.OUT, which provides a summary of doses by waste stream radionuclides.

Changes made to the ground water model in the IMPACTS-BRC program include the following:

- Deletion of the portion of the model which accounted for longitudinal dispersion of ground water from the disposal site.
- Parametric values used to calculate longitudinal dispersion (i.e. Peclet numbers) have been assigned a new value of zero.
- Contact time fractions for each disposal region have been assigned the same value of 1.0.
- Water travel times for each disposal method have been reduced.
- Retardation coefficients for each element have been reduced.

The remaining changes made in the IMPACTS-BRC code, including the replacement of onsite and open dump burials with onsite incineration and burial in sanitary landfill or hazardous waste site, are intended to limit or restrict disposal method selection in the calculation. New parameter values for onsite incineration and burial in a sanitary landfill or a hazardous waste site have been substituted for those used for onsite and open dump disposal methods.

EVALUATION OF GROUND WATER PATHWAY CHANGES

The most significant modifications to the original code are those made to the ground water model. They include the deletion of longitudinal dispersion calculations and the changes to retardation coefficients, contact time fractions, and ground water travel times.

The original code, IMPACTS, calculated retardation coefficients for each region based on the valence of the element or the exchange capacity of the soils. The IMPACTS-BRC code uses retardation coefficients which have either been reduced to the lowest published value or changed to

unity. For example, the lowest retardation coefficient values for Fe, Co, Ni and Cs in IMPACTS are 630, 420, 420 and 85, respectively for the southwest region. Instead,
IMPACTS-BRC uses more conservative value of 1.0 for these elements. The default regional parameter value which selects the retardation coefficients for all elements have been changed to unity for all three regions in TAPE2.DAT. This means that the retardation coefficients for all three regions will be the same for all elements. The overall effect of the change in the retardation coefficients is that radionuclides are released at faster rates, independent of regional soil characteristics. Thus calculated concentrations and resulting doses increase, and the resulting doses from ground water pathways occur earlier.

The contact time fraction, which expresses the fraction of time that ground water is in contact with disposed waste, has been changed to unity for all three regions in IMPACTS-BRC. This value of unity represents 100% saturation of the disposal site with ground water. The contact time fraction have increased by a factor of 70 times for the northeast and 27,000 times for the southwest. Overall, the changes result in larger volume of contaminated ground water for each region.

The IMPACTS-BRC code also uses shorter travel times for contaminated ground water to reach boundaries of the disposal site and water supplies for both intruders and general public. The IMPACTS-BRC values for travel times have generally been reduced by 25 percent (or lower) of the IMPACTS value, and especially in the southwest region, the value has been reduced to zero for population surface water scenario. Consequently, these changes result in faster arrival of contaminated water in the intruder well, population well and population surface water scenarios; and therefore, higher doses.

Finally, IMPACTS-BRC uses a ground water model which assumes only saturated uni-directional flow in the direction of the receptor, instead of unsaturated-saturated uni-directional flow with lateral dispersion in the original IMPACTS code. With the deletion of the lateral dispersion calculation, contaminated ground water will arrive earlier at the dose receptor (i.e. intruder well, population well and population surface water).

METHODOLOGY

In this study, IMPACTS and IMPACTS-BRC calculations were performed for the following cases:

- BWR and PWR compacted trash disposed in a sanitary landfill located in the southeast.
- BWR compacted trash disposed in sanitary landfills located in the northeast, and the southwest.

Data for BWR and PWR compacted waste streams including radionuclide fractions and limiting concentrations were obtained from NESP-035 (3). The waste stream data and waste disposal parameters for the base cases are summarized in Tables I and II. With the exception *of altering* the regional parameters for the BWR compacted trash calculations, the data in Tables I and II remained constant for all calculations.

Generic environmental and disposal method parameters found in the NUREG/CR-3585 were used in the calculations for both codes. Table III summarizes difference between the regional default values for IMPACTS and the modified regional default values for IMPACTS-BRC. All other parametric values for sanitary landfill and the disposal site environment (i.e. Tape2.DAT) are the same for both codes and can be found in Refs. 1 and 2.

SUMMARY OF RESULTS

Comparison of BWR And PWR Compacted Trash

The results of the IMPACTS and IMPACTS-BRC calculations led to the following observations for BWR and PWR compacted trash disposal base case in a southeastern sanitary landfill:

1. IMPACTS-BRC and IMPACTS calculated the same doses except for:

   - Ground Water Pathway

   IMPACTS-BRC doses occur earlier and are several orders of magnitude higher than IMPACTS doses for all three water borne scenarios. As shown in Table IV, IMPACTS-BRC doses occur at 20 years, 100 years and 200 years for the intruder well, population well and population surface water scenarios, respectively. The IMPACTS doses occur at 40 years, 400 years and 800 years.

   - Leachate Treatment

   The Leachate Treatment scenario doses are much higher for IMPACTS-BRC than for IMPACTS by a factor of 154 (See Table IV). Leachate treatment dose is controlled by the contact time fraction. For the southeast, IMPACTS uses 6.47E-03 and IMPACTS-BRC 1.0 (i.e. 1/6.47 E-03 = 154) (See Table III).

   - Transportation Population

   Transportation Population doses (expressed in person-mrem/yr) are higher for IMPACTS-BRC than IMPACTS by a factor 5 (See Table IV). This is due to the transportation distance for IMPACTS-BRC is 100 miles versus 20 miles for IMPACTS (See Table III).

2. The calculated individual doses are less than 1 mrem/year for either code.
3. The calculated doses using both codes are proportional to the concentrations and the total annual activity

TABLE I

Waste Stream Specific Concentrations for IMPACTS-BRC and IMPACTS Calculations (TAPE5.DAT)

PWR COMPACTED TRASH
(110 MT/Y, 136 M3/Y, 0.8 MT/M3)

RADIONUCLIDE	PERCENT	INVERSE LEVEL (Ci/m3)	IMPACTS CONCENTRATION (Ci/m3)
H-3	1.70%	1.78 E-04	3.03 E-06
Fe-55	15.6%	3.24 E+00	5.05 E-01
Co-60	46.0%	9.64 E-06	4.43 E-06
Ni-63	17.2%	4.09 E-02	7.03 E-03
Cs-137	17.7%	1.70 E-05	3.01 E-06
Pu-241	1.40%	2.31 E-04	3.23 E-06

BWR COMPACTED TRASH
(348 MT/Y, 435 M3/Y, 0.8 MT/M3)

RADIONUCLIDE	PERCENT	INVERSE LEVEL (Ci/m3)	IMPACTS CONCENTRATION (Ci/m3)
H-3	0.9 %	1.13 E-05	1.02 E-07
Fe-55	14.4%	9.30 E-01	1.34 E-01
Co-60	37.3%	2.45 E-06	9.14 E-07
Ni-63	1.0 %	7.33 E-04	7.33 E-06
Cs-137	46.4%	1.39 E-05	6.45 E-06
Pu-241	0.9 %	1.55 E-05	1.39 E-07

TABLE II

Waste Stream and Disposal Parameters for IMPACTS-BRC and IMPACTS (TAPE5.DAT)

PARAMETER	VALUE	COMMENTS
Region	1,2,3	1 = Northeast 2 = Southeast Region 3 = Southwest Region
Disposal Treatment Index	0	Generic Environmental Data
Facility Index	2	Sanitary Landfill
Number of Waste Streams	1	
Facility Environment Index	1	Rural
Life Span of Facility	10 years	
Institutional Control Period	20 years	
Calculated Over flow Impacts	1	Yes
Dispersivity of Waste Stream	2	Moderate
Accessibility of Waste to Wind, Water	1	Ordinary waste
Packaging Index	0	Unpackaged
Percent of Metal Packaging Required	0	None recycled
Processing Index	1	Disposal only
Number of Shipping Vehicles	1	
Percent of Vehicles That Are LLW	100	
Number of Processing Facility	0	
Number of Disposal Facilities	1	
Percent of Waste Combustible	100	
Percent By Weight of Metal Waste	0	
Percent By Weight of Glass	0	
Percent By Weight of Other Waste	0	

TABLE III

Input Parameters For IMPACTS Versus Modified Input Parameters For IMPACTS-BRC For Sanitary Landfill Disposal By Region (TAPE2.DAT)

PARAMETER	SOUTHEAST IMPACTS	SOUTHEAST IMPACTS-BRC	NORTHEAST IMPACTS	NORTHEAST IMPACTS-BRC	SOUTHWEST IMPACTS	SOUTHWEST IMPACTS-BRC
Retardation Coefficient	2	1	3	1	1	1
Contact Time Factor	6.47 E-03	1.0	2.66 E-03	1.0	3.6E-05	1.0
Travel Time Between Sectors	27.2y	6.8y	170y	34y	3.4y	3.4y
Travel Time To Intruder Well	23.6y	4.4y	95y	18y	280y	11.7y
Travel Time To Pop. Well	400y	100y	2,500y	500y	580y	300y
Travel Time To Pop. Surf.	800y	200y	5,000y	1,000y	880y	0*
Peclet Number For Disp. Site	680	0	340	0	340	0
Peclet Number Intruder Well	340	0	170	0	170	0
Peclet Number Pop. Well	10,000	0	20,000	0	30,000	0
Peclet Number Pop. Surface	20,000	0	20,000	0	60,000	0
Transport Distance	20mi	100mi	20mi	100mi	20mi	100mi

Note: All other parametric values for IMPACTS and IMPACTS-BRC are equal.
*: Changed to 1.0 in order to execute IMPACTS-BRC.

disposed per year. Comparison Of BWR Compacted Trash By Region

Comparing the IMPACTS-BRC and IMPACTS results for BWR Compacted Trash buried in sanitary landfills located in the southeast, northeast and southwest, the following relationships were found:1.The observations for BWR and PWR compacted trash discussed previously apply for each region (see Tables IV and V).

2. There is an overall increase in the relative importance of ground water dependent pathways for IMPACTS-BRC calculations for all regions. IMPACTS-BRC leachate treatment doses are second highest doses (i.e. 1.4 E-01 mrem/y SE and 5.8 E-02 mrem/y NE) compared to fourth highest for IMPACTS doses (i.e. 9.2E-04 mrem/y SE and 1.5 E-04 mrem/y NE).

   - IMPACTS-BRC intruder well doses are fifth highest versus sixth highest for IMPACTS doses.
   - In general, IMPACTS-BRC calculates intruder well doses beginning at year 20 for all three regions. IMPACTS calculates intruder well doses at 40 years for the southeast and 1000 years for the northeast and southwest regions, respectively.
   - IMPACTS-BRC calculates more significant doses (relatively small) earlier than IMPACTS for the population well and population surface water scenarios.

3. IMPACTS-BRC leachate treatment doses are higher than the IMPACTS doses by a factor equal to the reciprocal of the contact time fraction.

4. With the exception of the transportation population scenario, all doses calculated for the southeast region are greater than those for the northeast and southwest regions using either code (see Table V).

REFERENCES

1. "De Minimis Waste Impacts Methodology", O.I. Oztunali (Dames & Moore) and G.W. Roles (USNRC) NUREG/CR-3585 Vol.1; 1984.

2. "De Minimis Waste Impacts Methodology", J.M. Forstrom, and D.J. Goode USNRC, NUREG/CR 3585 Vol. 2 1986.

3. "Evaluation of the Potential for De-Regulated Disposal of Very Low Level Wastes from Nuclear Power Plants". D.W. Chan, J.P. Davis, R. Danna, J.A. Palmer, J.V. Palmer, B.R. Parrish, M. Donovan (General Physics Corporation) and O.I. Oztunali (Ebasco Service, Inc.) AIF/NESP-035, 1986.

4. "IMPACTS-BRC Changes", Memorandum, General Physics Corporation, March 1987.

TABLE IV

Summary of IMPACTS Versus IMPACTS-BRC Doses for Base Cases (Results in mrem/y Except as Indicated)

SCENARIO/PATHWAY	ICRP DOSE PWR TRASH SE IMPACTS	ICRP DOSE PWR TRASH SE IMPACTS-BRC	ICRP DOSE BWR TRASH SE IMPACTS	ICRP DOSE BWR TRASH SE IMPACTS-BRC
Transportation	5.13 E-01	2.57 E+00	7.42 E-01	3.71 E+00
Leachate Treatment	1.11 E-03	1.72 E-01	9.23 E-04	1.43 E-01
Intruder Well				
20 yrs	0	4.41 E-02	0	1.56 E-02
40 yrs	4.18 E-08	4.38 E-02	4.45 E-09	4.50 E-04
60 yrs	9.70 E-08	5.62 E-02	1.03 E-08	3.32 E-04
100 yrs	2.77 E-08	4.62 E-02	2.95 E-09	2.16 E-04
1,000 yrs	7.26 E-25	5.27 E-05	9.76 E-31	1.74 E-07
Population Well				
100 yrs	0	2.11 E-04	0	9.93 E-07
400 yrs	5.87 E-21	2.20 E-04	6.25 E-22	7.28 E-07
1,000 yrs	4.07 E-31	2.40 E-06	4.34 E-32	7.91 E-09
Population Surface Water				
200 yrs	0	5.20 E-06	0	2.12 E-08
800 yrs	1.01 E-30	5.61 E-07	1.08 E-31	1.81 E-09
1,000 yrs	1.32 E-32	1.26 E-07	1.40 E-33	4.15 E-10

TABLE V

Comparison of IMPACTS-BRC and IMPACTS Results for BWR Compacted Trash in Three Regions

PATHWAY	SOUTHEAST IMPACTS	SOUTHEAST IMPACTS-BRC	NORTHEAST IMPACTS	NORTHEAST IMPACTS-BRC	SOUTHWEST IMPACTS	SOUTHWEST IMPACTS-BRC
Leachate Treatment	9.23 E-04	1.43 E-01	1.56 E-04	5.86 E-02	2.85 E-08	7.92 E-04
Transport-ation	7.42 E-01	3.71 E+00	2.77 E+00	1.39 E+01	4.05 E-02	2.02 E-01
Intruder Well						
20y	0	1.56 E-02	0	2.53 E-03	0	1.03 E-04
40y	4.45 E-09	4.50 E-04	0	3.89 E-05	0	4.73 E-06
60y	1.03 E-08	3.32 E-04	0	3.74 E-05	0	2.53 E-06
100y	2.95 E-09	2.16 E-04	0	3.16 E-05	0	1.43 E-06
1000y	9.76 E-31	1.74 E-07	1.15 E-31	8.45 E-08	3.57 E-35	1.14 E-09
Population Well						
100y	0	9.93 E-07	0	0	0	0
400y	6.25 E-22	7.28 E-07	0	0	0	4.05 E-09
600y	1.92 E-22	1.61 E-07	0	1.98 E-08	7.34 E-28	8.94 E-10
1000y	4.34 E-32	7.91 E-09	0	3.25 E-09	1.37 E-36	4.40 E-11
2000y	0	4.25 E-12	0	1.75 E-12	0	2.36 E-14
Population Surface Water						
200y	0	2.12 E-08	0	0	0	0
400y	0	3.48 E-08	0	0	0	0
800y	1.08 E-31	1.87 E-09	0	0	0	0
1000y	1.40 E-33	4.15 E-10	0	1.71 E-11	0	0
2000y	0	2.23 E-13	0	9.16 E-14	0	0