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Unrestricted Disposal of Minimal Activity Levels of Radioactive Wastes: Exposure and Risk Calculations

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UNRESTRICTED DISPOSAL OF MINIMAL ACTIVITY LEVELS OF RADIOACTIVE WASTES: EXPOSURE AND RISK CALCULATIONS

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ACKNOWLEDGEMENTS

1. INTRODUCTION

The U.S. Nuclear Regulatory Commission is currently considering revision of rules 10 CFR 20 (USNRC, 1982) and 10 CFR 61 (USNRC, 1981), which cover various methodologies for disposal of solid wastes, including wastes containing minimal activity quantities of radionuclides. Wastes containing minimal activity levels are expected to be disposed of without special attention to post-burial radionuclide releases. Quantitative definition of minimal activity levels may be included in a revision to the aforementioned rules.

In order to establish the maximum radionuclide concentrations and/or amounts that low-level wastes may contain and still be considered minimal activity, it is necessary to consider the consequences of waste disposal for example situations. An example situation is defined as the combination of a well-characterized waste stream, a specific disposal site and disposal mode, a sample set of site parameters which is used to simulate transport from the disposal site to at-risk population(s), and a data base of exposure and health risk parameters which is used to evaluate consequences to the population(s) of interest.

This document describes the evaluation of human exposures and health risks for 48 example cases. These cases consist of the combinations of four waste streams, four types of disposal areas, and three different geographic locations. Each waste stream, described in Chapter 3, is specified as to the concentration of each of 23 radionuclides contained in it. Each waste stream is a generalized industrial waste product. The streams considered in this study and described in Chapter 3 are (1) dewatered pressurized water reactor (PWR) ion exchange resins; (2) PWR compressible trash; (3) boiling water reactor (BWR) compressible trash; and (4) institutional liquid scintillation waste. The four types of disposal areas, described in Chapter 4, are (1) burial at a (low-level) radionuclide waste disposal facility; (2) burial at a reactor site; (3) burial at a municipal waste disposal facility; and (4) dispersal into the general environment. The geographic locations considered in this study are Barnwell, South Carolina; West Valley, New York; and Beatty, Nevada. These locations

were chosen because site data were available. The sites are described in Chapter 4 and in Appendices A, B, and C.

The PRESTO methodology was chosen for evaluating radionuclide transport and health effects. This methodology, described in Chapter 2, was developed to assess radionuclide transport, ensuing exposure, and health impact to a static local population for a 1000-year period following disposal. Pathways and processes of transit from the trench to exposed populations included groundwater transport, overland flow, erosion, surface water dilution, resuspension, atmospheric transport, deposition, inhalation, and ingestion of contaminated beef, milk, crops, and water. The PRESTO-EPA model (Little et al., 1981) was written for the U.S. Environmental Protection Agency to evaluate the consequences associated with burial of low-level wastes. The PRESTO-II model, implemented by the same authors (Fields et al., in preparation), is based on the PRESTO-EPA model but provides more realistic simulations of infiltration through the trench cap, calculation of the trench water balance, of vertical transport, and of transport through the aquifer-to-stream pathway. A version of the PRESTO-II model is used for this study.

2. DISCUSSION OF METHODOLOGY

A version of the PRESTO-II (Fields et al., in preparation) methodology was chosen for the de minimis simulations. This code was based on the PRESTO-EPA model. PRESTO-EPA (Prediction of Radiation Exposures from Shallow Trench Operations) is a computer code developed under U.S. Environmental Protection Agency funding to evaluate possible health effects from radionuclide releases from shallow, radioactive-waste disposal trenches and from associated areas contaminated by operational spillage. This model is designed to simulate transport of radionuclides from the disposal site and to predict radionuclide exposures and cancer risks for the 1000-year period following the end of burial operations. PRESTO is a versatile methodology for calculating risks to local and intermediate-range populations resulting from waterborne and airborne transport (Little et al., 1981 and Fields, Little, and Emerson, 1981). The DARTAB code (Begovich et al., 1981) is used by PRESTO as a subroutine to combine simulated radionuclide exposure values with dose and health risk factors to produce tabulations of dose and health risk.

The computer code used in these simulations is modular and organized according to transport pathways. Figure 1 denotes the major pathways of hydrologic transport considered in this model. Near-surface transport mechanisms considered are trench cap failure, cap erosion, farming or reclamation practices, human intrusion, chemical exchange within an active soil layer, contamination from trench overflow, and dilution by surface streams. Subsurface processes include infiltration and drainage into the trench, the ensuing dissolution of radionuclides, and chemical exchange between trench water and buried solids. Mechanisms leading to contaminated water outflow include trench overflow and downward vertical percolation. If the latter outflow reaches an aquifer, the model considers radiological exposure resulting from drinking contaminated water and from irrigation and subsequent ingestion.

Wind-driven human exposure pathways are schematized in Fig. 2. Atmospheric transport of contaminant deposited in normal operations or carried to the surface by trench overflow is handled either by an

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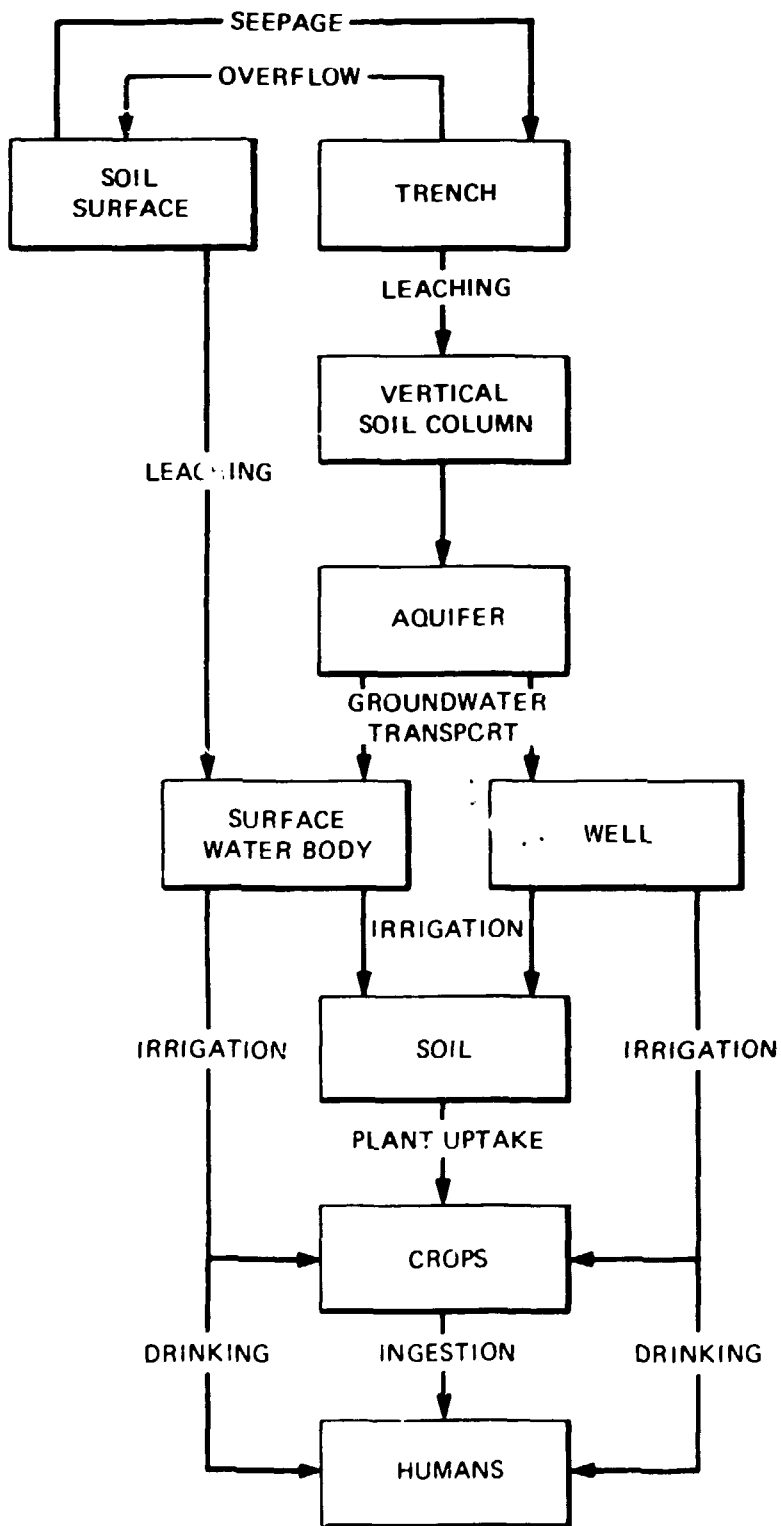
Figure 1. Shown here are the major pathways of hydrologic routing considered in the PRESTO model. Sources of radionuclides are the trench contents and the surrounding soil surface, assumed to be contaminated during trench filling and covering operation- and by trench water over-flow.
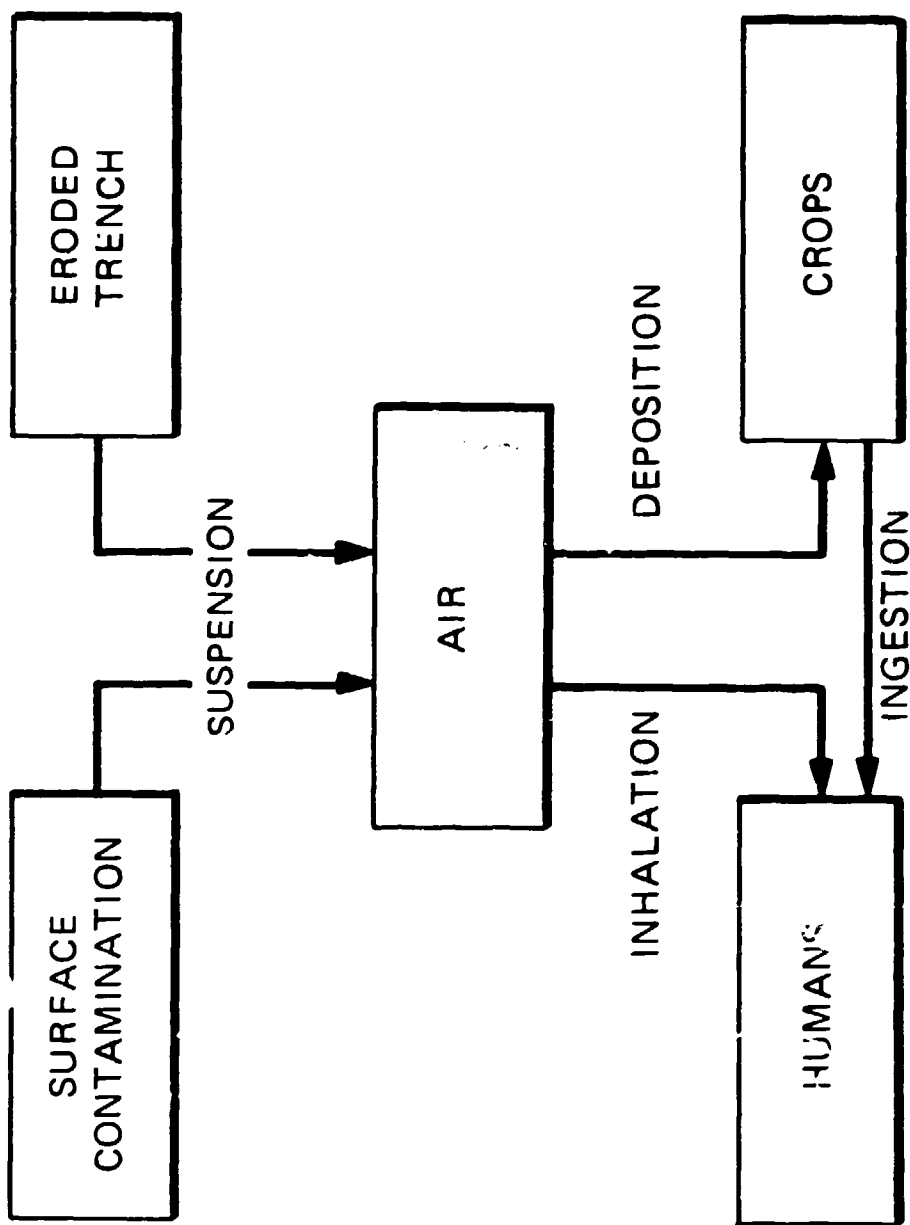
Figure 2. Soil surface contaminant may be suspended by winds or mechanical disturbances and transported downwind. Human exposure may result either by inhaling the suspended solids or by consuming food on which the radionuclides have been deposited.

internal Gaussian plume approach based on the DWNWND model (Fields and Miller, 1980) that considers exposed individuals to be located at the population centroid, or by an externally computed and user input exposure term. This exposure term should be calculated using the actual population distribution.

The transport-related computations are simplified by several assumptions. First, daughter nuclide ingrowth resulting from radioactive decay is not calculated because, for the most part, the inventory of commercial low-level waste burial grounds includes few radionuclides that yield long chains. We assume that for those radionuclides that do have significant daughter ingrowth, secular equilibrium has been attained by the time of site closure. Daughters, if any, must be assumed to be present initially. Chemical reactions are not considered explicitly. Instead, they are parameterized using element-specific chemical solubilities or chemical distribution coefficients k_d. Different values of exchange coefficient may be specified for different physical regions (surface soil, trench, subtrench soil, and aquifer material). Waste material in the trench is considered uncontained and homogeneous. Perhaps the most useful simplification consists of expressing as many mechanisms as possible in "unit response" form, so that a single submodel run yields results applicable in each of the 1000 model iterations.

Simulation results must be regarded as estimates. We have proposed to evaluate the uncertainties associated with predictions of the PRESTO model, as functions of the precision with which input variables are known. Determination of the sensitivity of model results to variations in model input values would indicate which parameters need to be known most accurately.

3. CHARACTERIZATION OF WASTE STREAMS

Radionuclide concentrations for four example waste streams used in the de minimis study simulations were specified by the NRC. The radionuclide composition was based on previous NRC work in support of rule 10 CFR 61 as described in an earlier report (USNRC, 1981). These waste streams were characterized as (1) resins from PWR's with condensate polishing systems (PIXRESIN); (2) PWR compactible trash (PCOTRASH); (3) BWR compactible trash (BCOTRASH); and (4) institutional liquid scintillation waste (ILQSCNVL). Table 1 summarizes the radionuclide concentrations in these waste streams for 23 radionuclides. Also provided by the NRC were expected yearly production volumes and activities for a 1000-MWe plant for the first three waste streams. A yearly volume and activity of ILQSCNVL was also provided, and this volume corresponded to approximately 10 g of waste production for the entire United States, collected and disposed of at a single disposal site. These yearly values are for PIXRESIN, 9.06 m^3 and 0.304 Ci; for PCOTRASH, 215 m^3 and 4.9 Ci; for BCOTRASH, 221 m^3 and 5.2 Ci; and for ILQSCNVL, 1.67 x 10^4 m^3 and 53.8 Ci. The radionuclide volumes were used to estimate the areas used for radionuclide disposal, as described in Chapter 4.

These four waste streams were assumed to be disposed of at the example sites (see Chapter 4). Thus the simulated consequences are associated with each year of waste disposal. No radionuclide decay or daughter ingrowth was assumed between the time of waste generation and the time of disposal. In addition to the specified disposal inventory, we have assumed that an additional surface contamination results from operational spillage during normal operations. In the absence of actual measurements of the amount of such spillage, we have arbitrarily assumed this amount to be 1 x 10^{-6} of the initial trench inventory.

Table 1. Radionuclide concentrations (µCi/cc) in example waste streams.

Nuclide	PIXRESIN	PCOTRASH	BCOTRASH	ISQSCNVL
H-3	2.66E-3	3.04E-4	6.75E-5	1.67E-3
C-14	9.74E-5	1.12E-5	4.17E-6	8.37E-5
FE-55	2.34E-3	5.97E-3	6.01E-3	0.0
NI-59	2.79E-6	7.11E-6	6.21E-6	0.0
CO-60	4.53E-3	1.15E-2	1.01E-2	0.0
NI-63	8.61E-4	2.19E-3	1.36E-4	0.0
NB-94	8.84E-8	2.25E-7	1.96E-7	0.0
SR-90	1.94E-4	2.22E-5	1.27E-5	1.45E-3
TC-99	8.23E-7	9.42E-8	2.68E-7	0.0
I-129	2.44E-6	2.78E-7	7.14E-7	0.0
CS-134	8.23E-7	9.42E-8	2.68E-7	0.0
CS-137	2.19E-2	2.51E-3	7.14E-3	0.0
U-235	4.71E-8	7.89E-9	1.22E-9	0.0
U-238	3.71E-7	6.22E-8	9.60E-9	0.0
NP-237	9.06E-12	1.52E-12	2.35E-13	0.0
PU-238	2.60E-5	5.97E-6	2.30E-6	0.0
PU-239	1.82E-5	5.53E-6	1.16E-6	0.0
PU-241	7.94E-4	2.41E-4	5.63E-5	0.0
PU-242	3.99E-8	1.21E-8	2.53E-9	0.0
AM-241	1.87E-5	3.96E-6	9.67E-7	0.0
AM-243	1.26E-6	2.67E-7	6.52E-8	0.0
CM-243	9.92E-9	2.74E-9	1.93E-9	0.0
CM-244	1.38E-5	2.61E-6	1.49E-6	0.0

4. CHARACTERIZATION OF DISPOSAL SITES AND CLIMATES

Sites chosen for simulations were located near Barnwell, South
Carolina; Beatty, Nevada; and West Valley, New York. The sites were
characterized as to location, meteorology, demography, soil
characteristics, and geography.

Site data for surface and subsurface environmental variables were
taken from U.S. Geological Survey data, site operator literature, and
other literature are discussed in Appendices A, B, and C. Table 2
summarizes the classes of disposal sites considered in this study and
will be described in detail in the following paragraphs.

The first class of disposal site to be discussed will be the low-
level waste disposal site. The site descriptions included in
Appendices A, B, and C describe the input data sets used for the low-
level waste disposal site characterization. One site was located in each
of the three geographical regions considered in this study. Low-level
waste disposal site input parameters were based on values described in
the PRESTO-II document (Fields et al., in preparation). As an aid to
interpretation of the values provided in Appendices A, B, and C, Table 3
lists and defines model input parameters. For the low-level waste
disposal site, the top of the water table was assumed to be located 2 m
below the bottom of the trench. The trench area (projected onto a
horizontal plane) was calculated by dividing the yearly waste volume for
the waste stream being considered by 2 m (an approach consistent with an
assumed waste layer thickness of 2 m). The cross slope extent of the
spillage about the trench was assumed to be the square root of the trench
area. Distances to streams were chosen to agree with actual measured
values for the low-level waste disposal areas at these sites. For low-
level disposal simulations as well as for simulations for other modes of
disposal considered in this study, water use was assumed to be 50% taken
from a well drilled into an aquifer and 50% from surface waters. In
cases where calculated water use exceeded the volume of contaminated
water available at the well, additional required water was assumed to be
taken from surface water supplies. Surface water supplies in this study
were assumed to be contaminated by atmospheric deposition and runoff from
contaminated areas. These areas were assumed to be contaminated by

Table 2. Classification of sites considered in de minimis study

Site classification	Assumptions for initial simulations
Burial at low-level waste disposal site (L)	Site-specific climatological, geological, and demographic data are used. Low-level waste disposal sites considered are Barnwell, South Carolina, Beatty, Nevada, and West Valley, New York. The ground surface is assumed contaminated by operational spillage present in an amount, per radionuclide, of 10^{-6} of the buried amount. Water use for ingestion and farm use is 0.5 from well and 0.5 from stream. Ratio of trench cap to undisturbed site infiltration is 0.5.
Burial at reactor site (R)	Site similar to type (L) site, except that reactor is assumed near stream, and water table is 2.5 m below land surface. Stream is assumed located 50 m downslope of disposal area. For initial runs, well position is same as for type (L).
Burial at municipal site (M)	Similar to type (L), except that well distance = 500 m for all sites. Dilution of radionuclide wastes by nonnuclear wastes accounted for by assuming large trench area. Ratio of trench cap to undisturbed site infiltration is assumed to be 1.0.
Disposal in general environment (G)	A stream dump of the waste stream is assumed. Site climate and demographics are identical to type (L), but water use is assumed totally from stream.

Table 3. PRESTO-II environmental and nuclide input data format

Card number	Format	Variables Name	Variables Meaning
1	20A4	TITLE	
2	20A4	LOCATE	Burial site information

Code Control Data 1

3	15I5		
	I5	MAXYR	Length of simulation (y)
	I5	NONCLD	Number of radionuclides
	I5	LEAOPT	Leaching option
	I5	NYR1	First year of cap failure function
	I5	NYR2	Last year of cap failure function
	I5	IOPVWV	Vertical water velocity option
	I5	IOPSAT	Saturation option
	I5	IPRT1	Yearly print out beginning (y)
	I5	IPRT2	Yearly print out ending (y)
	I5	IDELT	Print annual summary each IDELT years
	I5	IRRES1	Mechanical suspension beginning year
	I5	IRRES2	Mechanical suspension ending year
	I5	LIND	Population indicator
	I5	IAVG1	First year of averaging window
	I5	JAVG2	Last year of averaging window

Code Control Data 2

4	3I5		
	I5	IVAP	Trench cap infiltration switch
	I5	IBSMT	Basement calculation beginning year
	I5	IAQSTR	Aquifer to stream switch

Cap Integrity and Water Use Data

5	8F10.0		
	F10.0	PCT1	Fraction of cap failure at year NYR1
	F10.0	PCT2	Fraction of cap failure at year NYR2
	F10.0	WATL	Fractional well water use for land (1.0 if all land water comes from well, 0.0 if none)
	F10.0	WATA	Fractional well water use for animals (1.0 if all water comes from well, 0.0 if none)
	F10.0	WATH	Fractional well water use by humans (1.0 if all human water used from well, 0.0 if none)
	F10.0	SATL	Fractional surface water use for land (1.0 if all land water comes from surface, 0.0 if none)

Table 3. (continued)

Card number	Format	Variables	
		Name	Meaning
	F10.0	SATA	Fractional surface water use for animals (1.0 if all animal water comes from surface, 0.0 if none)
	F10.0	SATH	Fractional surface water used by humans (1.0 if all human water used comes from surface, 0.0 if none)

Evapotranspiration Data

6	4F10.0		
	f10.0	PPN	Average precipitation (m/y)
	f10.0	P	Average barometric pressure (mbar)
	f10.0	XIRR	Irrigation (m/y)
	f10.0	PHID	Site latitude (degrees)
7-8	12F10.0	S(I)	Ratio of observed to maximum sunshine twelve monthly values (Jan.-Dec.)
9-10	12F10.0	T(I)	Average ambient temperature (°C) twelve monthly values (Jan.-Dec.)
11-12	12F10.0	TD(I)	Average dewpoint temperature (°C) twelve monthly values (Jan.-Dec.)

Trench Data

13	8F10.0		
	F10.0	TAREA	Trench area (m^2)
	F10.0	TDEPTH	Trench depth (m)
	F10.0	OVER	Cap thickness (m)
	F10.0	PORT	Trench porosity
	F10.0	DENCON	Density of waste materials (g/cm^3)
	F10.0	RELFAC	Annual activity release fraction
	F10.0	FN	Ratio of trench cap to watershed infiltration
	F10.0	SINFL	Nontrench annual infiltration rate (m/y)
14	F10.0	PERMC	Trench permeability (m/y)

Aquifer Data

15	8F10.0		
	F10.0	DTRAQ	Trench to aquifer depth (m)
	F10.0	DWELL	Trench to well distance (m)
	F10.0	GWV	Groundwater velocity (m/y)
	F10.0	AQTHK	Aquifer thickness (m)
	F10.0	AQDISP	Aquifer dispersion angle (radians)
	F10.0	PORA	Aquifer porosity
	F10.0	PORV	Subtrench porosity
	F10.0	PERMV	Subtrench permeability (m/y)

Table 3. (continued)

Card number	Format	Variables	
		Name	Meaning

Atmospheric Data 1

16	7F10.0		
	F10.0	H	Atmospheric source height (m)
	F10.0	VG	Gravitational fall velocity (m/s)
	F10.0	U	Mean wind speed (m/s)
	F10.0	VD	Deposition velocity (m/s)
	F10.0	XG	Source-to-receptor distance (m)
	F10.0	HLID	Atmospheric lid height (m)
	F10.0	ROUGH	Hosker roughness factor (m)

Atmospheric Data 2

17	7F10.0		
	F10.0	FTWIND	Fraction of time wind blows toward population
	F10.0	CHIQ	User-specified x/Q for impacted population
	F10.0	RE1	Beginning coefficient in resuspension equation
	F10.0	RE2	Decay factor in resuspension equation
	F10.0	RE3	Final coefficient in resuspension equation. Values of RE1, RE2, and RE3 must include both the algebraic sign and the magnitude.
	F10.0	RR	Resuspension rate (sec^{-1})
	F10.0	FTMECH	Fraction of year mechanical disturbance occurs

Atmospheric Data 3

18	2I5		
	I5	IT	Type of stability class formulation
	I5	IS	Stability class

Universal Soil Loss Equation Factors

19	6F10.0		
	F10.0	RAINF	Rainfall factor
	F10.0	ERODF	Erodibility factor
	F10.0	STPLNG	Slope steepness-length factor
	F10.0	COVER	Cover factor
	F10.0	CONTRL	Erosion control factor
	F10.0	SEDELR	Sediment delivery factor

Surface Soil Data 1

20	5F10.0		
	F10.0	PORS	Soil porosity (unitless)
	F10.0	BDENS	Soil bulk density (gm/cm^3)
	F10.0	STFLOW	Stream flow rate (m^3/y)

Table 3. (continued)

Card number	Format	Variables	
		Name	Meaning
	F10.0	EXTENT	Cross slope extent cf spillage (m)
	F10.0	ADEPTH	Depth of soil active region for soluble contamination (m)

Surface Soil Data 2

Card number	Format	Variables	
21	2F10.0		
	F10.0	PD	Average downslope distance to stream (m)
	F10.0	RUNOFF	Fraction of precipitation that runs off

Air-Foodchain Data 1

Card number	Format	Variables	
22	6F10.0		
	F10.0	Y1	Productivity for grass (kg/m^2 y)
	F10.0	Y2	Productivity for vegetation (kg/m^2 y)
	F10.0	PP	Surface density for soil (kg/m^2)
	F10.0	XAMBWE	Weathering decay constant (h^{-1})
	F10.0	TE1	Period pasture grass exposed during growing season (h)
	F10.0	TE2	Period crops/veg. exposed during growing season (h)

Air-Foodchain Data 2

Card number	Format	Variables	
23	8F10.0		
	F10.0	TH1	Period between harvest of pasture and ingestion by animal (h)
	F10.0	TH2	Period between storage of feed and ingestion by animal (h)
	F10.0	TH3	Period between harvest of leafy vegetation and ingestion by man (h)
	F10.0	TH4	Period between harvest of produce and ingestion by man (h)
	F10.0	TH5	Period between harvest of leafy vegetable and ingestion by man for general population exposure (h)
	F10.0	TH6	Period between harvest of produce and ingestion by man for general population exposure (h)
	F10.0	FP	Fraction of year that animals graze on pasture
	F10.0	FS	Fraction of daily feed that is fresh grass, while animals are on pasture

Table 3. (continued)

Card number	Format	Variables	
		Name	Meaning

Air-Foodchain Data 3

24	7F10.0		
	F10.0	QFC	Amount of feed consumed daily by cattle (kg)
	F10.0	QFG	Amount of feed consumed daily by goats (kg)
	F10.0	TF1	Transport time feed-mill-receptor for maximum individual exposure (h)
	F10.0	TF2	Transport time feed-mill-receptor for general population exposure (h)
	F10.0	TS	Time from slaughter of meat to consumption (h)
	F10.0	ABSH	Absolute humidity of the atmosphere (g/m^3)
	F10.0	P14	Fractional equilibrium ratio for C-14

Water-Foodchain Data

25	5F10.0		
	F10.0	FI	Fraction of year crops are irrigated
	F10.0	WIRATE	Irrigation rate ($1/m^2$-hr)
	F10.0	QCW	Amount of water consumed by cows (1/d)
	F10.0	QGW	Amount of water consumed by goats (1/d)
	F10.0	QBW	Amount of water consumed by beef cattle (1/d)

Human Intake Data

26	8F10.0		
	F10.0	ULEAFY	Leafy vegetation (kg/y)
	F10.0	UPROD	Produce (kg/y)
	F10.0	UCMILK	Cow milk (1/y)
	F10.0	UGMILK	Goat milk (1/y)
	F10.0	UMEAT	Meat (kg/y)
	F10.0	UWAT	Drinking water (1/y)
	F10.0	UAIR	Inhalation rate (m^3/y)
	F10.0	POP	Population

Radionuclide Inventory Data

27	A8,2X, 6F10.0		
	A8,2X	NUCLID(I)	Radionuclide name
	F10.0	TRAM(I)	Amount of NUCLID(I) in trench at t=0 (Ci)

Table 3. (continued)

Card number	Format	Variables	
		Name	Meaning
	F10.0	SOAM(I)	Amount of spillage on surface at t=0 (Ci)
	F10.0	STAM(I)	Amount of radionuclide in stream at t=0 (Ci)
	F10.0	ATAM(I)	Amount of radionuclide in air above trench at t=0 (Ci)
	F10.0	DECAY(I)	Decay constant (y^{-1})
	F10.0	SOL(I)	Solubility (g/ml)

Chemical Exchange (k_d) Data

28	A8,2X, 4F10.0		
	A8,2X	NUCLID(I)	Radionuclide name
	F10.0	XKD(1,I)	Surface k_d (ml/g)
	F10.0	XKD(2,I)	Trench k_d (ml/g)
	F10.0	XKD(3,I)	Subtrench vertical zone k_d (ml/g)
	F10.0	XKD(4,I)	Aquifer k_d (ml/g)

Radionuclide-Specific Foodchain Data

29	A8,2X, 9F10.0		
	A8,2X	NUCLID(I)	Radionuclide name
	F10.0	RA(I)	Retention fraction for air
	F10.0	RW(I)	Retention fraction for irrigation
	F10.0	BV(I)	Soil-to-plant uptake factor for vegetative parts
	F10.0	BR(I)	Soil-to-plant uptake factor for reproductive parts (grain)
	F10.0	FMC(I)	Forage-to-milk transfer factor for cows
	F10.0	FMG(I)	Forage-to-milk transfer factor for goats
	F10.0	FF(I)	Forage-to-beef transfer factor
30,33+	- same as card 27 for subsequent radionuclides -		
31,34+	- same as card 28 for subsequent radionuclides -		
32,35+	- same as card 29 for subsequent radionuclides -		

Hourly Precipitation Data

--	2(I2,1X), 24F3.0		
	I2	MO	Month of rainfall event
	I2	IDA	Day of rainfall event
	24F3.0	HP	Hourly precipitation values for MO and IDA (tenths of mm) (one data card for each day having measurable precipitation) (last card must have "99" in first two columns)

operational spillage (see Chapter 3) and by trench water overflow (described in Chapter 2).

Simulations of consequences from burial at a reactor site were consistent with location of a reactor in the same geographical region as the low-level waste disposal site, but with location near a surface water body (assumed to be a river). The distance to the stream was assumed to be only 50 m (downslope) and the water table was assumed to be only 0.5 m beneath the bottom of the trench.

Simulations of consequences from burial at a municipal site were consistent with location of the municipal site in the same geographical region as the low-level waste disposal site, but with the horizontal distance from the primary water supply (well) to the point below the disposal area set to 500 m for all runs. For the municipal site, significant dilution of the radionuclide wastes by nonradioactive wastes was assumed. The radionuclide waste thickness was assumed to be only 0.05 m, so the trench area was the yearly waste stream volume divided by 0.05 m.

Simulations of disposal of radionuclide waste streams in the general environment were based on dumping the waste stream into surface waters.

Populations at risk from buried wastes are assumed to breathe air at a distance corresponding to the location of the nearest existing population center. Thus the distance from the radionu. ide burial area was chosen to be 8,000 m for the Barnwell site, 6,500 m for the West Valley site, and 16,800 m for the Beatty site

Water for the Barnwell population was assumed taken from a well located 914 m from the site boundary. We consider this to be a very conservative, although not a worst case, assumption.

The Barnwell site is characterized by a high annual rainfall rate and highly permeable soils. As a result, the pathway of maximum risk is expected to be water-mediated radionuclide migration downward to the aquifier and subsequent horizontal transport to wells or surface seepage points. This pathway becomes important for the Beatty site due to our assumption that the site is irrigated; this pathway is not likely so important for the West Valley site because of the possibility of surface contamination from trench leachate overflow.

UNRESTRICTED DISPOSAL OF MINIMAL ACTIVITY LEVELS OF RADIOACTIVE WASTES: EXPOSURE AND RISK CALCULATIONS

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ABSTRACT

The U.S. Nuclear Regulatory Commission is currently considering revision of rule 10 CFR part 20, which covers disposal of solid wastes containing minimal radioactivity. In support of these revised rules, we have evaluated the consequences of disposing of four waste streams at four types of disposal areas located in three different geographic regions. Consequences are expressed in terms of human exposures and associated health effects. Each geographic region has its own climate and geology. Example waste streams, waste disposal methods, and geographic regions chosen for this study are clearly specified. Monetary consequences of minimal activity waste disposal are briefly discussed.

The PRESTO methodology was used to evaluate radionuclide transport and health effects. This methodology was developed to assess radiological impacts to a static local population for a 1000-year period following disposal. Pathways and processes of transit from the trench to exposed populations included the following considerations: groundwater transport, overland flow, erosion, surface water dilution, resuspension, atmospheric transport, deposition, inhalation, and ingestion of contaminated beef, milk, crops, and water.

5. RESULTS AND DISCUSSION

Table 4 summarizes the dose and health effects associated with
disposal of the PIXRESIN waste stream at the sites and using the disposal
methodologies described previously. The activity-specific values shown
in this table are based on the waste stream activities specified in
Chapter 3. The analogous tabulations for the PCOTRASH, BCOTRASH, and
ILQSCNVL waste streams are presented as Tables 5, 6, and 7. These
simulation results must be generally regarded as estimates based on the
assumptions about waste stream composition, disposal methodology, and
site geography.

The simulation results presented in Tables 4-7 indicate that
relative human radiological impacts for these waste streams scale
according to the relative gross radioactivity of the streams. For
example, the ILQSCNVL wastes specified by the NRC have the highest gross
radioactivity (higher than the highest activity value by a factor of ten)
and their impact is predicted to be correspondingly high. This
conclusion might be modified if account were taken of the (unknown)
chemical composition of the waste streams - certain chemical
constituents, even when present in minor amounts, might radically alter
the effective chemical exchange parameter for some elements.

It may be misleading, due to some of the arbitrary assumptions
describing release scenarios, to generalize about the relative
consequences of burying wastes in different geographic regions.
Nevertheless, one can hardly fail to note the lower consequences
predicted for the West Valley region, relative to the Barnwell and Beatty
regions. The wastes are, in the absence of water buildup and trench
overflow, better isolated from aquifers in the West Valley region.
Consequences for the Beatty region are predicted to be of the same order
of magnitude as for the Barnwell region, but this conclusion results
largely from the assumption that these sites may eventually be used for
farm land. This assumption necessitates the specification of irrigation
for the Beatty site. If the Beatty site were not irrigated, predicted
consequences for this site would be considerably lessened.

Table 4. Summary of population doses and health effects associated with
disposal of PIXRESIN waste stream. The activity-specific values
are based on the waste stream activities specified in Chapter 3.

	Low level	Reactor	Municipal	General
PIXRESIN population dose (person rem/y)				
Barnwell	6.92E-05	6.93E-05	6.96E-05	1.03E+02
West Valley	5.58E-10	5.58E-10	5.59E-10	4.72E+00
Beatty	4.28E-05	4.36E-05	9.66E-05	1.30E+00
PIXRESIN health effects (deaths/y)				
Barnwell	6.10E-09	6.13E-09	6.21E-09	2.62E-02
West Valley	1.46E-13	1.46E-13	1.46E-13	1.25E-03
Beatty	4.78E-09	5.02E-09	1.11E-08	3.68E-02
PIXRESIN population dose per curie (person rem/Ci/y)				
Barnwell	2.29E-04	2.29E-04	2.30E-04	3.40E+02
West Valley	1.84E-09	1.84E-09	1.84E-09	1.56E+01
Beatty	1.41E-04	1.44E-04	3.19E-04	4.29E+02
PIXRESIN health effects per curie (deaths/Ci/y)				
Barnwell	2.01E-08	2.02E-08	2.05E-08	8.66E-02
West Valley	4.83E-13	4.83E-13	4.83E-13	4.12E-03
Beatty	1.58E-08	1.66E-08	3.67E-08	1.21E-01

Table 5. Summary of population doses and health effects associated with disposal of PCOTRASH waste stream. The activity-specific values are based on the waste stream activities specified in Chapter 3.

	Low level	Reactor	Municipal	General
PCOTRASH population dose (person rem/y)				
Barnwell	1.88E-04	1.88E-04	1.89E-04	4.71E+02
West Valley	3.04E-09	3.04E-09	3.04E-09	2.09E+01
Beatty	1.16E-04	1.18E-04	2.64E-04	5.41E+02
PCOTRASH health effects (deaths/y)				
Barnwell	1.66E-08	1.67E-08	1.69E-08	1.13E-01
West Valley	7.79E-13	7.79E-13	7.79E-13	5.27E-03
Beatty	1.29E-08	1.36E-08	3.05E-08	1.50E-01
PCOTRASH population dose per curie (person rem/Ci/y)				
Barnwell	3.83E-05	3.83E-05	3.85E-05	9.61E+01
West Valley	6.20E-10	6.20E-10	6.20E-10	4.26E+00
Beatty	2.36E-05	2.40E-05	5.38E-05	1.10E+02
PCOTRASH health effects per curie (deaths/Ci/y)				
Barnwell	3.38E-09	3.40E-09	3.45E-09	2.31E-02
West Valley	1.59E-13	1.59E-13	1.59E-13	1.08E-03
Beatty	2.64E-09	2.77E-09	6.23E-09	3.06E-02

Table 6. Summary of population doses and health effects associated with
disposal of BCOTRASH waste stream. The activity-specific values
are based on the waste stream activities specified in Chapter 3.

	Low level	Reactor	Municipal	General
BCOTRASH population dose (person rem/y)				
Barnwell	4.03E-04	4.03E-04	4.03E-04	7.94E+02
West Valley	4.82E-09	4.82E-09	4.82E-09	3.79E+01
Beatty	2.25E-04	2.25E-04	5.04E-04	1.13E+03
BCOTRASH health effects (deaths/y)				
Barnwell	1.64E-08	1.64E-08	1.65E-08	2.26E-01
West Valley	1.38E-12	1.38E-12	1.38E-12	1.09E-02
Beatty	1.04E-08	1.06E-08	2.48E-08	3.28E-01
BCOTRASH population dose per curie (person rem/Ci/y)				
Barnwell	7.74E-05	7.74E-05	7.75E-05	1.53E+02
West Valley	9.27E-10	9.27E-10	9.27E-10	7.28E+00
Beatty	4.32E-05	4.33E-05	9.68E-05	2.16E+02
BCOTRASH health effects per curie (deaths/Ci/y)				
Barnwell	3.15E-09	3.15E-09	3.17E-09	4.34E-02
West Valley	2.65E-13	2.65E-13	2.65E-13	2.09E-03
Beatty	2.00E-09	2.03E-09	4.77E-09	6.30E-02

Table 7. Summary of population doses and health effects associated with disposal of ISQSCNVL waste stream. The activity-specific values are based on the waste stream activities specified in Chapter 3.

	Low level	Reactor	Municipal	General
ILQSCNVL population dose (person rem/y)				
Barnwell	2.40E-02	2.42E-02	2.47E-02	1.19E+04
West Valley	2.67E-07	2.67E-07	2.59E-07	6.86E+02
Eeatty	2.00E-02	2.10E-02	4.95E-02	8.75E+03
ILQSCNVL health effects (deaths/y)				
Barnwell	7.10E-06	7.14E-06	7.28E-06	4.47E+00
West Valley	6.26E-11	6.26E-11	6.07E-11	1.61E-01
Eeatty	5.92E-06	6.21E-06	1.45E-05	2.05E+00
ILQSCNVL population dose per curie (person rem/Ci/y)				
Barnwell	4.46E-04	4.49E-04	4.57E-04	3.53E+02
West Valley	4.95E-09	4.95E-09	4.80E-09	1.27E+01
Beatty	3.72E-04	3.90E-04	9.19E-04	1.62E+02
ILQSCNVL health effects per curie (deaths/Ci/y)				
Barnwell	1.32E-07	1.33E-07	1.35E-07	8.29E-02
West Valley	1.16E-12	1.16E-12	1.13E-12	2.99E-03
Beatty	1.10E-07	1.15E-07	2.70E-07	3.80E-02

The influence of the disposal methodology is also reflected in the results shown in Tables 4-7. In order of increasing adverse consequences, these methodologies may be ranked as follows: burial at a low-level waste disposal site; burial at a reactor site; burial at a municipal site; and dispersal in the general environment. Indeed, choosing the last methodology of disposal (general environmental dispersal) is expected to result in consequences higher by about four to ten orders of magnitude than choosing one of the other disposal methodologies.

The proposed NRC radiation protection standard 10 CFR part 20 (USNRC, 1982) defines de minimis wastes as being those which will result in members of the public receiving individual doses of no more than 0.1 mrem/year from ionizing radiation. Simulated individual doses for the representative waste streams considered in this study summarized in Table 8 were less than this amount for all disposal scenarios, except for dispersion into the general (aquatic) environment. However, for no case of dispersal into the general environment did the predicted dose fall below the proposed limit for dc minimis wastes.

The predicted relative differences between consequences of disposal using one of the first three methodologies are insignificant within a single geographical region. This somewhat surprising result arises because for most simulations, greater than 98% of the radiological impact was due to isotopes C-14 and I-129. Both of these radionuclides have very low chemical exchange coefficients in soils with low concentrations of organic material (Baes et al., 1982), and both are predicted to migrate at close to hydrologic velocities.[*] Therefore little difference is seen between different burial disposal methodologies for the same waste stream and same geography. When comparing the impact of different disposal methodologies, one must, however, regard the municipal site as a less secure area than either the low-level waste disposal site or the reactor site. The municipal site is probably more likely in the short

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[*] It has been shown that for many soils, the exchange coefficient of iodine may be large (Kocher, 1982).

Table 8. Summary of average individual doses to the public for the example
waste streams. These values may be compared to the proposed limit
for the de minimis wastes (see text).

	Low level	Reactor	Municipal	General
PIXRESIN average individual dose (rem/y)				
Barnwell	9.48E-09	9.86E-09	9.90E-09	1.46E-02
West Valley	5.58E-14	5.58E-14	5.59E-14	4.72E-04
Beatty	2.14E-08	2.18E-08	4.83E-08	6.50E-02
PCOTRASH average individual dose (rem/y)				
Barnwell	2.67E-08	2.67E-08	2.68E-08	6.70E-02
West Valley	3.04E-13	3.04E-13	3.04E-13	2.09E-03
Beatty	5.77E-08	5.88-086	1.32E-07	2.17E-01
BCOTRASH average individual dose (rem/y)				
Barnwell	5.73E-08	5.73E-08	5.73E-08	1.13E-01
West Valley	4.82E-13	4.82E-13	4.82E-13	3.79E-03
Beatty	1.12E-07	1.13E-07	2.52E-07	5.63E-01
ILQSCNVL average individual dose (rem/y)				
Barnwell	3.42E-06	3.44E-06	3.51E-06	2.71E+00
West Valley	2.67E-11	2.67E-11	2.59E-11	6.86E-02
Beatty	1.00E-05	1.05E-05	2.48E-05	4.38E+00

term to suffer neglect and to be visited by "recyclers" or "scavengers" than the other two classes of burial disposal sites. Results of disturbance of municipal sites by intruders or dispersal of wastes buried there during future construction operations were not considered in these simulations. The possible consequences of such future exposure modes should be carefully considered before burial at municipal sites is allowed. A disturbed municipal site may correspond closely to dispersal into the general environment, which is a disposal mode with higher radiological impact. Local storage of water has the attendant advantage of avoiding hazards associated with accidental release of the wastes during transport.

One must also consider the effects of combining de minimis wastes. A waste stream composed of several waste streams, each defined to be de minimis according to gross radioactivity rather than according to concentration, might no longer be considered de minimis waste. Futhermore, the term "de minimis" might best be defined, for each disposal situation being considered, on the basis of fractional health risk increase for exposed populations. This approach would require comparing expected radiological consequences to anticipated consequences from other activities (background risk levels). Waste disposal might be considered acceptable if the radionuclide-associated risk could be shown to have a high probability of being only a small fraction of the background risk.

For example, the sum of all radiological impacts from exposure of the local population of 7033 persons to contaminants contained in the specific quantity of ILQSCNVL wastes in a low-level waste disposal area near Barnwell is 7.1×10^{-6} deaths/year (Table 7). By comparison, the current annual death rate due to cancer for the United States population is 183.5 per 100,000 persons (Lane, 1981), so the expected annual death rate from cancer for a representative population of 7033 would be 13 persons. The waste disposal-associated death rate is less than the background cancer death rate by a factor of 5.5×10^{-7}.

To consider the results of an alternative disposal methodology -- if the same waste stream were disposed of at this site by release into the general environment, the waste disposal-associated death rate, using the

values given in Table 7, would be less than the background cancer death rate by a factor of 0.35.

Relative monetary savings associated with disposal of low-activity-level wastes in local land fills instead of sending such wastes to licensed burial sites can be considerable. An unpublished Edison Electric Institute survey resulted in estimates by ten utilities that, after initial setup costs, from 0.67 to 14 $k\$/m^3$ might be saved. The mean estimated annual saving was 4.7 (standard deviation 3.8) $k\$/m^3$. The mean estimated net annual savings by these ten utilities was, excluding setup costs, 120 (standard deviation 170) $k\$$. The activity levels of the wastes that these utilities considered for alternative disposal varied among utilities. These monetary savings arise from lowered packing and transportation costs associated with local disposal, together with lower site costs than those associated with special radioactive waste disposal facilities.

In a recent paper (Dunn and Vance, 1983), the cost for disposing of dry active wastes was estimated to be 962 $\$/m^3$. Of the total disposal cost, 24% was estimated to be for transportation for a representative distance of 1600 km. Another 63% of the cost is associated with site costs and special containers. Local disposal of de minimis wastes would yield a saving of about 87%, or 836 $\$/m^3$. This value is toward the lower end of the range of utility savings estimated above, but wastes considered in the paper by Dunn and Vance were considered 50% compactible with a volume reduction factor of 1.7. De minimis wastes buried locally might not be compacted, and this would result in an additional savings.

We may conclude that burial of de minimis wastes at a local low-level waste disposal facility rather than a 1600-km distant facility would result in monetary savings to the waste generator of 230 $\$/m^3$. If the local facility were a municipal disposal facility, an additional monetary savings to the waste generator of 0.3-4 $k\$/m^3$ would result.

In conclusion, a de minimis designation for low-level waste may result in significant monetary savings in cases where minimal additional adverse radiological impacts would result. Our results suggest that there would be little difference in the health impacts associated in burying these wastes in a low-level disposal area, or in burying them at a reactor site. Municipal sites, if long-term security can be

guaranteed, might also be acceptable. Local disposal would have several advantages. General environmental dispersal would likely not be acceptable.

REFERENCES

Baes, C. F., III, R. D. Sharp, A. L. Sjoreen, and R. V. Shor. 1982. *A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture.* ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Begovich, C. L., K. F. Eckerman, E. C. Schlatter, S. Y. Ohr, and R. O. Chester. 1981. *DARTAB: A Program to Combine Airborne Radionuclide Environmental Exposure Data With Dosimetric and Health Effects Data to Generate Tabulations of Predicted Health Impacts.* ORNL-5692, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Dunn, M. J. and J. N. Vance. 1983. "Evaluation of a Shredder/Compactor for DAW Treatment," *Trans. Am. Nucl. Soc.* 44:433.

Fields, D. E., R. O. Chester, C. A. Little, G. Hiromoto, and C. J. Emerson (in preparation). *PRESTO-II: A Low-Level Radioactive Waste Environmental Transport and Risk Assessment Code.* ORNL-5970, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Fields, D. E., C. A. Little, and C. J. Emerson. 1981. "A Computerized Methodology for Evaluating the Long-Range Radiological Impact of Shallow-Land Burial," in T. Oakes, Ed., *Selected Papers from the 1981 UCCND Environmental Protection Meeting, Barkeley Lodge, Cadiz, Kentucky, April 21-22, 1981.* CONF-810452, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Fields, D. E. and C. V. Miller. 1980. *User's Manual for DWNWND — An Interactive Gaussian Plume Atmospheric Transport Model with Eight Dispersion Parameter Options.* ORNL/TM-6874, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Kocher, D. C. 1982. "On the Long-Term Behaviour of Iodine-129 in the Terrestrial Environment," *Environmental Migration of Long-Lived Radionuclides.* International Atomic Energy Agency, pp. 669-679.

Lane, R. U., Editor. 1981. *The World Almanac and Book of Facts 1982.* Newspaper Enterprises Association, Inc.

Little, C. A., D. E. Fields, L. M. McDowell-Boyer, and C. J. Emerson. 1981. "The PRESTO Low-Level Waste and Risk Assessment Code," in R. G. Post, Ed., *The State of Waste Isolation in the U.S. and Elsewhere, Advocacy Programs and Public Communications.* Proceedings of the ANS Topical Meeting on Waste Management, Tucson, Arizona.

Little, C. A., D. E. Fields, C. J. Emerson, and G. Hiromoto. 1981. *Environmental Assessment Model for Shallow-Land Disposal of Low-Level Radionuclide Wastes: Interim Report.* ORNL/TM-7943, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

U.S. Nuclear Regulatory Commission (USNRC). 1982. (10 CFR Part 20) Standard for Protection Against Radiation – Proposed Rulemaking. Draft report. U.S. Nuclear Regulatory Commission, Washington, D.C.

U.S. Nuclear Regulatory Commission (USNRC). 1981. "Licensing Requirements for Land Disposal of Radioactive Waste," Draft Environmental Impact Statement on 10 CFR Part 61. NUREG-0782, Vol. 2, U.S. Nuclear Regulatory Commission, Washington, D.C.

A.1 GENERAL DESCRIPTION OF THE SITE*

A.1.1 Location and climate

The Barnwell low-level radioactive waste disposal facility is located 8 km west of the town of Barnwell, South Carolina, in Barnwell County. The 95-acre site is leased from the state of South Carolina by Chem-Nuclear Systems, Inc. (CNSI), which operates the facility. The site is adjacent to the Allied General Nuclear Services Barnwell Fuel Facility on the west and is only 0.3 km from the eastern boundary of the Savannah River Plant.

The Barnwell site is in a largely rural setting, with much of the land in the region used for farming or growing timber. Primary farm products are soybeans, corn, cotton, and dairying. The population of the county in 1970 was slightly above 17,000.

The climate near Barnwell is relatively mild. The monthly mean temperatures range from 8°C to 27°C for January and July, respectively. Precipitation occurs mostly in the summer with a mean annual total of 1.13 m. For the 20-year period before 1972, the mean precipitation ranged from 0.73 m (1954) to 1.87 m (1964). Snowfall occurs only rarely in Barnwell County, as do damaging winds or ice storms. The relatively long growing season ranges from 230-270 days.

The atmosphere around the site would be considered relatively stable. The mean wind speed at the Savannah River Plant is only 0.4 m per second and inversion or neutral conditions occur more than 75% of the time.

A.1.2 Geology and soils

The Barnwell site is located on the Atlantic Coast Plain physiographic province near the eastern edge of the Aiken Plateau portion of that province. The topography of the site is gently rolling with grade elevation averaging 74-80 m above mean sea level. The area is underlain by about 300 m of flat-lying, loose to poorly consolidated

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* Unless otherwise stated, information in this appendix was found in Chem-Nuclear Systems, Inc. (1980).

sediments of upper cretaceous, tertiary, and quaternary ages. Surface-
quaternary soils include loose to medium dense fine sand and silty sand
to depths of 0.6-2.1 m below grade. Below the surface soils is found
4.3-9.1 m of the embedded sandy clay and clayey fine sand of the Miocene
Hawthorn formation. The Hawthorn is underlain by 11.6-18 m of the
Barnwell formation (late Eocene) and 14.6-35 m of the McB.an formation
(early Eocene). The Ellenton and Tuscaloosa formations include sand and
gravel with some clay and cretaceous sediments underlying tertiary sands
and clays.

Topsoil of the region is generally fuquay loamy sand of the family
loamy siliceous thermic. According to Olson, Emerson, and Nungessser
(1980), Barnwell County encompasses the following soil orders and
suborders: Order Ultisols, suborders Paleudults and Hapludults (gently
sloping), suborders Ochraquults, Paleudults, Hapludults, and Quartzip-
samments (gently sloping) and order Entisols, suborder Quartzipsamments
(gently sloping). Suborders Paleudults and Hapludults comprise about
70% of the county soils.

Portions of the soil layer just below the topsoil to a depth of
about 2.1 m are very firm, tan and purple, and slightly micaceous. This
soil layer is generally slightly clayey fine to coarse sand.

A.1.3 Hydrology

The Barnwell site is located between the Savannah River on the west
and the Salkehatchie River on the east. The Salkehatchie is the nearest
river at some 4.1 km, but the surface drainage of the site is to Lower
Three Runs Creek, a tributary of the Savannah River. There are no
flowing streams on the site and Mary's Creek is a tributary of Lower
Three Runs Creek. Flow rates in Lower Three Runs Creek varied from
0.14-14 m^3/s during the eleven-year period from July 1958-August 1969 at
Patterson's Hill Bridge.

Surface water from precipitation is collected for evaporation by
Chem-Nuclear. In the event of a heavy rainfall, water above a
predetermined level in the collection pond is pumped to another pond for
further evaporation. This system was devised to prevent recharge of the
ground water near the trenches and thereby reduce the likelihood of

contamination of surface water. More details on surface water flows are to be found on pages 93-95 of CNSI (1980).

The Hawthorn formation contains the highest water table on the site and extends within 9.1 m of the surface. The Barnwell formation underlies the Hawthorn with a thickness of about 12 m. The Barnwell is slightly more permeable than the Hawthorn and has been used for a few small wells in the area.

The McBean and Congaree formations underlie the Barnwell formation to some 90 m below the surface. The Congaree is fairly permeable and the municipal wells for the town of Barnwell, the nearest municipal user, yield about 1400 liters per minute. Beneath the McBean/Congaree formations are the Ellenton and Tuscaloosa formations. Although geologically differentiable, groundwater is free to move between them and they are considered a single aquifer. The Tuscaloosa is the principal aquifer for the site area and extends to more than 300 m below the surface.

The water table depth at the site gradually decreases as it nears the Savannah River. Fluctuations in the water table depth are a function of the locally varying permeabilities and the inclination of the piezometric surface. It is, therefore, not unusual to find significant differences in fluctuation patterns within relative small areas. The water table at the site generally occurs at depths of 9.1 to 18 m with a mean of about 12.2 m. Normal fluctuations between the high in late spring or summer and the low in fall or winter is about 2 m.

The groundwater moves under the site to the west and south toward Mary's Creek, 914 m away. The velocity is estimated to be 5×10^{-3} m/d as shown by CNSI (1980). More detail about groundwater movement and composition at the site can be found in CNSI (1980) pages 10-14, 89-91, and 95-98.

A.2 INPUT VARIABLES FOR THE LOW-LEVEL WASTE
DISPOSAL SITE SIMULATIONS

A.2.1 Options or control variables

Most of the input variables on the first four cards are for code
control or option selection (see Table A.1).

A.2.2 Site-description variables that are well-known

Some of the input data describing the site are very well known and
not likely to change drastically. The previous statement assumes that
none of the following variables will be arbitrarily varied for the
purposes of a sensitivity analysis to determine the effect of a given
parameter on code predictions.

Noncontrol variables which are considered well known include the
following (refer to Table A.1): TDEPTH (trench depth), OVER
(overburden), DWELL (distance to nearest well), all variables on cards
15 and 17, BDENS (soil bulk density), STFLOW (stream flow), PD (site
boundary to nearest stream), SAREA (area of contaminated surface soil),
and the radiological decay rate. References or notes on calculation are
given for each of these in Table A.1.

A.2.3 Radionuclide-independent variables that are poorly known

A number of the input variables listed in Table A.1 are poorly
known; that is to say, there may be a large amount of variation
associated with the value listed in Table A.1. This is in spite of the
fact that the values listed have been taken from referencable sources.
This section will briefly describe the variation or source of variation
expected in each of these variables as listed in Table A.1.

WATL. Fraction of total irrigation water taken from well. The
referenced value is a state average of groundwater use as a fraction of
total water use for 1970. Value may vary over time and across state.
The national range of value is from 0.01 (West Virginia) to 0.83
(Kansas). Most common United States range is 0.10-0.25.

Table A.1. Input data for Barnwell, SC; refer to Table 3
for formats and definitions of variables.

Card number	Variable	Value	Reference or note
1	TITLE		User option
2	LOCATE	Barnwell SC	User option
3	MAXYR	1000	User option
	NONCLD	40	Must be 40 or less
	LEAOPT	2	User option
	NYR1	100	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	NYR2	200	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	IOPVIv	1	User option
	IOPSAT	1	User option
	IPRT1	0	User option
	IPRT2	1000	User option
	IDELT	100	User option
	IRRES1	0	User option
	IRRES2	0	User option
	LIND	1	User option
	IAVG1	1	User option
	IAVG2	1000	User option
4	IVAP	0	User option
	IBSMT	0	User option
	IAQSTR	0	User option
5	PCT1	0.01	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	PCT2	0.1	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	WATL	1.0	User option
	WATA	1.0	User option
	WATH	1.0	User option
	SATL	0.0	User option
	SATA	0.0	User option
	SATH	0.0	User option
6	PPN	1.130	Ruffner (1978)
	P	1002.3	Ruffner (1978)
	XIRR	0.0	Ruffner (1978)
	PHID	33.2	Ruffner (1978)
7	S	0.56	Ruffner (1978)
		0.60	Ruffner (1978)
		0.64	Ruffner (1978)
		0.70	Ruffner (1978)
		0.68	Ruffner (1978)
		0.65	Ruffner (1978)
		0.65	Ruffner (1978)

Table A.1. Input data for Barnwell, SC; refer to Table 3
for formats and definitions of variables (cont.).

Card number	Variable	Value	Reference or note
8	'	0.56	Ruffner (1978)
		0.60	Ruffner (1978)
		0.64	Ruffner (1978)
		0.70	Ruffner (1978)
9	T	8.0	Ruffner (1978)
		9.3	Ruffner (1978)
		12.9	Ruffner (1978)
		18.0	Ruffner (1978)
		22.3	Ruffner (1978)
		25.9	Ruffner (1978)
		27.1	Ruffner (1978)
		26.7	Ruffner (1978)
10		23.7	Ruffner (1978)
		18.2	Ruffner (1978)
		12.4	Ruffner (1978)
		8.4	Ruffner (1978)
11	TD	3.1	Ruffner (1978)
		3.3	Ruffner (1978)
		5.8	Ruffner (1978)
		10.3	Ruffner (1978)
		15.5	Ruffner (1978)
		19.2	Ruffner (1978)
		21.2	Ruffner (1978)
		21.2	Ruffner (1978)
12		18.5	Ruffner (1978)
		12.5	Ruffner (1978)
		6.7	Ruffner (1978)
		2.6	Ruffner (1978)

Table A.1. Input data for Barnwell, SC; refer to Table 3
for formats and definitions of variables (cont.).

Card number	Variable	Value	Reference or note
13	TAREA	9150	CNSI (1980) p. 48
	TDEPTH	6.7	CNSI (1980) p. 48
	OVER	1.5	CNSI (1980) p. 47
	PORT	0.4	Sediment porosity; CNSI(1980) p. 90
	DENCON	2.0	Assumed
	RELFAC	0	User option
	FN	1.0	
	XINFL	0.09	Calculated
14	PERMC	43.3	
15	DTRAQ	2.4	Lowest water table depth less TDEPTH, CNSI, p. 88
	DWELL	914	Site boundary to nearest spring; CNSI, p. 91
	GWV	83	Personal Communication, C. Y. Hung to T. Broadway, March 18, 1983
	AQTHK	25	Inferred from discussion CNSI(1980) pp. 80–90
	AQDISP	0.3	Assumed
	PORA	0.4	CNSI (1980) p. 90
	PORV	0.4	CNSI (1980) p. 90
	PERMV	43.3	CNSI (1980)
16	H	1.0	Assumed
	VG	0.01	Calculated from particle sizes
	U	0.4	Savannah River Lab. meteor.; National Climatic Center
	VD	0.01	Generic value
	XG	8000	Distance to town of Barnwell, SC
	HLID	300	C. F. Baes III (personal communication)
	ROUGH	0.01	Generic value
17	FTWIND	0.49	Savannah River meteorology
	CHIQ	7.7E-9	Computed using AIRDOS-EPA, Moore et al. (1979)
	RE1	1.0E-6	Assumed lower than Nevada, Anspaugh et al. (1975)
	RE2	-0.15	Same as Anspaugh et al. (1975)
	RE3	1.0E-11	Assumed lower than Nevada, Anspaugh et al. (1975)
	RR	0	User option
	FTMECH	0	User option
18	IT	1	User option
	IS	2	Savannah River meteorology
19	RAINF	250	McElroy et al. (1976) pg 44, Fig. 3.2

Table A.1. Input data for Barnwell, SC; refer to Table 3
for formats and definitions of variables (cont.).

Card number	Variable	Value	Reference or note
	ERODF	0.23	McElroy et al. (1976) p. 46; see Table 3.5
	STPLNG	0.27	McElroy et al. (1976) Fig. 3.8
	COVER	0.30	McElroy et al. (1976)
	CONTRL	0.30	McElroy et al. (1976) Table 3.3
	SEDELR	1.0	Assumed; see McElroy et al. (1976); p. 60-68
20	PORS	0.4	Set equal to sediment porosity; CNSI p. 90
	BDENS	1.6	CNSI (1980) p. 87
	STFLOW	5300	CNSI (1980) p. 9.2
	EXTENT	305	User option; this value = trench length, CNSI p. 48
	ADEPTH	0.01	Assumed
21	PD	914	Site boundary to nearest stream, CNSI p.91
	RUNOFF	0.29	Calculated from Geraghty et al. (1973)
22	Y1	0.19	Shor, Baes, and Sharp (1982); Appendix C
	Y2	0.53	Shor, Baes, and Sharp (1982); Appendix B
	PP	240	Assumes 15 cm plow depth
	XAMBWE	0.0021	AIRDOS-EPA (1979)
	TA	4380.	
	TE1	720	Generic; AIRDOS-EPA (1979) Table E-15

Table A.1. Input data for Barnwell, SC; refer to Table 3
for formats and definitions of variables (cont.).

Card number	Variable	Value	Reference or note
23	TE2	1440	Generic; AIRDOS-EPA (1979)
	TH1	0	Generic; AIRDOS-EPA (1979) Table E-15
	TH2	2160	Generic; AIRDOS-EPA (1979) Table E-15
	TH3	24	Generic; AIRDOS-EPA (1979) Table E-15
	TH4	1440	Generic; AIRDOS-EPA (1979) Table E-15
	TH5	336	Generic; AIRDOS-EPA (1979) Table E-15
	TH6	336	Generic; AIRDOS-EPA (1979) Table E-15
24	FP	0.77	Shor, Baes, and Sharp (1982)
	FS	0.94	Shor, Baes, and Sharp (1982)
	QFC	50	Generic; AIRDOS-EPA (1979) Table E-15
	QFG	6	Generic; AIRDOS-EPA (1979) Table E-15
	TF1	48	Generic; AIRDOS-EPA (1979) Table E-15
	TF2	96	Generic, AIRDOS-EPA (1979) Table E-15
	TS	480	Generic; AIRDOS-EPA (1979) Table E-15
25	A'SH	9.9	State average; Etnier (1980)
	P14	1.0	Assumed
	TW	6408	
	FI	0.73	Growing season length/8760
	WIRATE	.015	Calculated from Olson, Emerson and Nungesser (1980)
	QCW	60	Generic; AIRDOS-EPA (1979)
	QGW	8	Generic; AIRDOS-EPA (1979)
	QBW	50	Generic; AIRDOS-EPA (1979)

Table A.1. Input data for Barnwell, SC; refer to Table 3
for formats and definitions of variables (cont.).

Card number	Variable	Value	Reference or note
26	ULEAFY	190	Generic, AIRDOS-EPA (1979)
	UPROD	190	Generic, AIRDOS-EPA (1979)
	UCMILK	110	Generic, AIRDOS-EPA (1979)
	UGMILK	0	Generic, AIRDOS-EPA (1979)
	UMEAT	95	Generic, AIRDOS-EPA (1979)
	UWAT	370	Generic, AIRDOS-EPA (1979)
	UAIR	8000	Generic, AIRDOS-EPA (1979)
	POP	7033	1980 Census; Durfee (personal comm.)
27+		see Table A.2	

SINFL. Nontrench annual rate of infiltration (m/y). County-wide value calculated by referenced worke~s. Site-specific differences in permeability, compaction, etc., may greatly reduce infiltration rate and increase runoff.

PORA, PORT, PORS. Porosity of aquifer, trench, and surface region. In Table A.1, these values are equal to the reference surface porosity. This is likely incorrect for PORA, the porosity used within the trench. If the total trench were tightly compacted, the value could be much lower. A more likely situation is that trench contents are variably porous due to heterogeneous materials and voids. Value used for PORS is probably within 20% for surface soil users.

PERMV. Permeability of trench bottom. Referenced value is probably reasonable for surface region, but the permeability inside trench is probably extremely heterogeneous.

DENCON. Density of the trench contents. This number listed is strictly an assumption. For waste materials such as cardboard, clothing, gloves and soil, assuming few voids, the number may be reasonable. However, given sizeable voids or large masses of highly dense materials, the value listed is probably too small and could range as high as ten.

RELFAC. User-option annual release fraction for activity leaching from trench. It has been estimated for at least three sites: Savannah River Plant (10^{-8}), Oak Ridge National Laboratory (10^{-6}), and West Valley (2.5×10^{-4}) (Dole and Fields, 1981).

GWV. Groundwater velocity. Referenced value from C. Y. Hung, personal communication to Jon Broadway, March 18, 1983.

AQTHK. Thickness of the aquifer. Used for dilution calculations. For Barnwell, depends on the aquifer and the location at which thickness is measured. The value in Table A.1 is based on the Barnwell formation.

AQDISP. Angle of pollutant dispersion in the aquifers plume. The value in Table A.1 is an assumption. Obviously a function of rate of flow, porosity, and permeability.

Card 19. Factors for use in the Universal Soil Loss Equation. Values listed in Table A.1 were calculated as prescribed by McElroy et al. (1976). However, the methods of McElroy et al. are generalized for large sections of the country. More detailed methods might yield

more precise value. Except for RAINF, all factors vary only from 0-1. RAINF ranges from 20 to 350 nationwide. The range in the area of central Georgia-South Carolina appears to be about 200-270. The sediment delivery ratio (SEDELR) was conservatively set 1.0.

ADEPTH. The active depth of the surface soil. Used to calculate soil and water radionuclide concentrations as a result of overflow. Value in table is assumed. No reference for depth of subsurface runoff, etc., to substantiate ADEPTH. It could reasonably be set to plow depth, nominally 15 cm. It is unlikely that ADEPTH would approach 1 m.

RUNOFF. Fraction of annual precipitation that runs off. Referenced value is probably too large. Jack Robertson of USGS (personal communication) estimates a range of 4-7%.

A.2.4 Radionuclide-specific parameters that are poorly known

KD. Distribution coefficient, k_d. Code allows a separate k_d value for each radionuclide and for each of four regions at the site: the soil surface, the trench, the subtrench region, and the aquifer. Values used are median values of a range of k_d measurements compiled by Baes and Sharp (1982) for agricultural soils of pH 4.5 to 9.0. Even for that limited sample of media, the range of reported k_d values is extreme. For example, the minimum k_d range of any element considered was over an order of magnitude for Cd (1.26-26.8). The maximum reported range of k_d compiled by Baes and Sharp (1982) was for Mn (0.2 to 10^4). The k_d of most of the elements range over three or more orders of magnitude. One might expect that variation of k_d in agricultural soils of pH 4.5-9.0 to be comparable to the variation of k_d in other media such as addressed by the code.

SOAM. The initial amount of spillage onto the surface. Assumed 1×10^{-6} of radionuclide activity (see Chapter 3). One would presume that SOAM (1) varies between radionuclides and (2) is a small number at a well-operated disposal facility.

BR, BV. Plant uptake factors for grain or fruits (reproductive) and grass (vegetative). The BV, BR values embody a certain amount of uncertainty. However, relative to the magnitude of uncertainty in many of the other parameters, these data are fairly well known.

FMC, FMG. Forage-to-milk transfer factors for cows and goats.
Most of the listed values are taken from AIRDOS-EPA (Moore et al.,
1979). In a few cases, values were calculated from Ng et al. (1968).
Variation likely to be small compared to other parameters; also
difficult to improve upon due to expense of determination.

FF. Forage-to-beef transfer factors. Most of the listed values
are from AIRDOS-EPA (Moore et al., 1979), but some were calculated from
data in Ng et al. (1968). Variation probably small compared to other
parameters.

A.3   ADDITIONAL SUPPORTING INFORMATION FOR INPUT DATA SET

Table A.2 lists the mean annual wind direction frequencies and
true-averaged wind speeds for the Savannah River Plant, South Carolina.
These, or similar data, should be used to calculate CHIQ for input.

Table A.3 lists population determined by the 1980 census for a
polar grid surrounding the Barnwell site.

Table A.4 lists the hourly precipitation for one year for the
weather station at Augusta, Georgia.

Table A.2. Mean annual wind direction frequencies and true-average wind speeds (SRL/Barnwell)

Wind toward	Frequency	Wind speed for each stability class (m/s)						
		A	B	C	D	E	F	G
N	0.085	3.88	3.54	3.42	3.75	4.22	4.01	4.32
NNW	0.067	3.97	3.32	3.61	3.88	4.46	4.43	3.68
NW	0.043	3.25	3.36	3.25	3.39	4.30	3.91	4.04
WNW	0.044	3.87	3.77	3.30	3.63	3.88	4.08	3.49
W	0.056	4.27	4.02	4.73	3.67	4.00	4.70	4.55
WSW	0.057	4.94	4.46	4.56	3.47	4.21	4.07	3.81
SW	0.063	4.47	4.23	4.33	3.54	3.77	4.28	4.02
SSW	0.034	3.02	3.66	4.31	2.72	3.98	4.37	4.11
S	0.026	3.61	3.31	3.67	2.59	3.01	3.88	4.52
SSE	0.036	3.87	3.11	2.74	2.92	3.46	4.04	4.85
SE	0.060	2.98	3.30	3.78	3.17	3.58	3.92	4.12
ESE	0.089	3.83	4.02	3.17	4.24	4.24	4.24	4.00
E	0.085	3.87	3.44	3.82	3.93	4.50	4.27	3.59
ENE	0.081	3.62	4.07	3.65	3.59	3.70	4.01	2.81
NE	0.080	3.70	3.69	4.09	3.75	3.83	3.56	3.65
NNE	0.091	3.68	3.54	3.21	3.34	4.12	4.01	3.60

Table A.3. Population distribution by distance and direction for Barnwell, SC

DIR	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
N	91	523	1177	1090	1398	1639	3214	11449	12275	5896
NNE	114	931	2611	1637	2292	9143	9809	7526	21873	147549
NE	254	1086	2158	2213	2922	9742	5508	3267	4975	6388
ENE	666	2536	2085	4668	4276	9816	25974	11991	5568	5193
E	290	1953	1689	2019	2586	2210	2885	4241	9743	7217
ESE	360	609	1266	921	1500	1752	2357	5303	12579	9710
SE	105	346	3090	9792	2392	5700	1765	2942	2272	4934
SSE	124	259	542	727	918	2924	1577	1479	19048	5526
S	72	153	468	555	1121	2599	1733	1840	3458	5410
SSW	52	185	475	727	2757	2602	1683	2997	17106	10269
SW	41	182	428	1258	1297	2484	3864	1842	2369	4159
WSW	47	142	351	1140	3519	2973	1408	1986	5655	4380
W	47	147	369	1006	2528	2792	1610	2349	5113	2916
WNW	37	59	627	3562	7106	107579	49485	12906	9371	2892
NW	66	112	1605	3846	14793	52072	9811	3164	2244	2905
NNW	73	631	2090	4109	25104	4395	9869	7271	4911	5404
TOTAL	2439	9854	20971	33272	86509	202364	114144	84147	127764	234488

Distance from site trench (km)

Table A.X. Hourly precipitation data for Augusta, GA (site 90495)

Rainfall during indicated hours of day (hundredths of inches)

YR MO DA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOT
78 01 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 01 06	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	5
78 01 08	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
78 01 09	0	0	0	0	0	0	0	0	0	0	0	0	0	6	9	10	17	8	0	0	0	0	0	0	54
78 01 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	10	10	21	8	12	13	0	80
78 01 13	7	4	1	0	5	2	5	14	8	1	4	10	3	14	15	2	0	0	0	0	0	0	0	0	95
78 01 17	0	0	0	1	0	0	0	0	1	19	11	4	0	0	0	0	0	0	0	0	0	0	0	0	36
78 01 19	0	0	0	0	0	0	0	2	35	35	36	12	2	2	2	2	1	2	3	3	7	7	9	2	195
78 01 20	1	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
78 01 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	5	4	4	7	22
78 01 25	6	9	12	17	17	14	46	19	2	2	6	2	5	5	5	28	28	1	9	32	6	0	2		278
78 02 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	6	4		14
78 02 02	5	4	2	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
78 01 03	0	2	2	2	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
78 02 13	0	0	0	0	0	0	0	0	3	9	12	0	0	0	0	0	0	0	0	0	0	0	0	0	24
78 02 16	0	0	0	0	0	0	0	0	0	6	2	2	5	4	2	3	1	0	0	0	6	0	0	0	15
78 02 18	0	0	2	12	5	14	0	0	0	2	4	1	1	2	1	1	1	0	0	0	0	0	0	0	46
78 02 28	0	0	0	0	0	0	0	3	1	2	2	1	1	0	1	2	3	3	1	1	1	0	0	0	22
78 03 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 03 03	0	7	17	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37
78 03 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	3	3	1	1	13
78 03 08	1	0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
78 03 09	0	0	0	0	0	0	0	0	0	0	0	0	1	1	12	18	31	20	11	3	2	2	0	6	101
78 03 10	0	1	1	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
78 03 12	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6
78 03 14	0	0	0	0	0	0	0	0	0	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 03 25	0	0	14	1	4	20	1	0	3	1	0	0	0	0	1	2	4	45	49	23	6	0	0	0	174
78 03 26	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
78 04 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 04 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	8	0	1	1	24
78 04 12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
78 04 13	1	0	0	0	30	56	46	22	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	157

Table A.4. Hourly precipitation data for Augusta, GA (cont.)

Rainfall during indicated hours of day (hundredths of inches)

YR MO DA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOT
78 04 18	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	5
78 04 19	0	0	0	0	4	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13
78 04 25	0	0	0	0	0	0	3	5	6	3	29	11	1	0	0	0	12	2	8	1	0	0	0	0	80
78 04 26	0	0	0	0	0	0	0	0	0	1	2	2	15	1	1	0	0	0	0	0	0	0	0	0	22
78 04 30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	10	0	0	55
78 05 01	0	0	0	0	0	0	0	0	0	1	24	21	1	0	0	0	0	0	0	0	0	0	0	0	47
78 05 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	8	3	16	8	6	0	45
78 05 04	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5
78 05 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	7	6	1	1	0	0	0	17
78 05 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	3	0	0	0	8
78 05 09	0	0	0	0	0	0	0	15	47	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63
78 05 18	0	0	0	0	0	0	0	0	0	0	0	0	20	3	0	0	0	0	0	0	0	0	0	0	23
78 05 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	8
78 06 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 06 03	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	0	0	0	0	0	0	64	2	0	73
78 06 05	0	0	0	0	0	0	0	4	0	0	0	0	0	8	3	0	0	0	0	0	0	0	0	0	15
78 06 07	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	15
78 06 08	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	5	34	0	0	0	3	1	0	63
78 06 26	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
78 06 30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
78 07 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
78 07 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	7
78 07 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0	15
78 07 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	2	0	0	12
78 07 15	0	0	0	0	0	0	0	0	0	0	0	0	0	28	5	50	26	1	0	0	0	0	0	0	110
78 07 16	1	0	0	0	1	3	3	1	2	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	16
78 07 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	4
78 07 27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5
78 08 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 08 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
78 08 03	0	0	0	0	0	5	0	0	0	0	0	0	0	0	3	4	0	0	0	0	0	0	0	0	12

Table A.4. Hourly precipation data for Augusta, GA (cont.)

							Rainfall during indicated hours of day (hundredths of inches)																		
YR MO DA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOT
78 C3 04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	1	0	1	0	0	0	0	0	0	27
78 08 05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	16
78 08 06	0	0	0	0	0	0	0	0	1	2	0	0	0	6	0	0	0	0	0	0	0	0	0	0	9
78 08 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2	0	0	0	0	0	0	7
78 08 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	4
78 08 14	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	4
78 08 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	2	0	0	0	0	0	0	52
78 08 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	6
78 08 26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	4
78 08 29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	47	0	0	0	0	0	0	87
78 08 31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	120	10	0	13	1	0	86	32	0	0	262
78 09 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
78 09 03	0	10	13	20	77	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	123
78 09 23	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	:
78 09 29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	:	1
78 09 30	0	0	0	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
78 10 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 10 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	12	1	0	4	0	0	0	2	111
78 10 14	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
78 11 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 11 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	1	2	3	2	3	27
78 11 08	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
78 11 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
78 11 27	0	0	0	0	0	0	0	4	15	13	6	1	0	0	0	3	6	0	0	1	1	3	1	1	55
78 11 29	0	0	1	0	0	0	0	0	1	2	13	22	24	17	9	2	16	12	11	11	3	5	3	1	153
78 11 30	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	3	0	1	0	1	0	11
78 12 01	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
78 12 04	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
78 12 05	0	0	1	2	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
78 12 09	0	0	0	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0	0	10
78 12 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
78 12 21	0	0	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 12 24	0	0	0	0	0	0	18	25	21	7	6	5	8	2	0	1	0	0	0	0	0	0	0	0	93

Unlisted days had zero rainfall

REFERENCES

Anspaugh, L. R., J. J. Shinn, P. L. Phelps, and N. C. Kennedy. 1975. "Resuspension and redistribution of plutonium in soils." Health Phys. 29:571-582.

Baes, C. F., III, and R. D. Sharp. 1982. "A method for determination of leaching rates of elements in agricultural soils." J. Env. Quality. (In press).

Baes, C. F., III, R. D. Sharp, A. L. Sjoreen, and R. W. Shor. 1982. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture. ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Chem-Nuclear Systems, Inc. 1980. Environmental Assessment for Barnwell Low-Level Radioactive Waste Disposal Facility. Chem-Nuclear Systems, Inc., Columbia, South Carolina.

Dole, L. R., and D. F. Fields. 1981. "Summary of Release Mechanisms Workshop." In C. A. Little and L. E. Stratton (compilers). Modeling and Low-Level Waste Management: An Interagency Workshop, pp. 343-350, ORO-821, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee.

McElroy, A. D., S. Y. Chiu, J. W. Nebgen, A. Aleti, and F. W. Bennett. 1976. Loading Function for Assessment of Water Pollution from Nonpoint Sources. USEPA report EPA-600/2-76-151, Midwest Research Institute, Kansas City, Missouri.

Moore, R. E., C. F. Baes III, L. M. McDowell-Boyer, A. P. Watson, F. O. Hoffman, J. C. Pleasant, and C. W. Miller. 1979. AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides. ORNL-5532, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Ng, Y. C., C. A. Burton, S. E. Thompson, R. K. Tandy, H. K. Kretner, and M. W. Pratt. 1968. "Prediction of the Maximum Dosage to Man from the Fallout of Nuclear Devices." In Handbook for Estimating the Maximum Internal Dose from Radionuclides Released to the Biosphere. UCRL 50163, Pt. IV, Lawrence Radiation Laboratory, Livermore, California.

Olson, R. J., C. J. Emerson, and M. K. Nungesser. 1980. Geoecology: A County-Level Environmental Data Base for the Conterminous United States. ORNL/TM-7351, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Ruffner, J. A. 1978. Climates of the States, 1 and 2. Gale Research Co., Book Tower, Detroit, Michigan.

Shor, R. W., C. F. Baes III, and R. D. Sharp. 1982. _Agricultural Production in the United States By County: A Compilation of Information From The 1974 Census of Agriculture For Use In Terrestrial Food-Chain Transport And Assessment Models_. ORNL-5768, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

U. S. Nuclear Regulatory Commission. 1977. Regulatory Guide 1.109: _Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I_. U.S. Nuclear Regulatory Commission, Washington, D.C.

APPENDIX A

Input Data and Supporting Information for Example
Problem - Barnwell, South Carolina

APPENDIX B

Input Data and Supporting Information for Example
Problem - Beatty, Nevada

B.1 GENERAL DESCRIPTION OF THE SITE[*]

B.1.1 Location and climate

The Beatty low-level waste site is located 16 km south-southeast of
Beatty, Nevada, and 29 km northwest of Lathrop Wells, Nevada. The site
is in the Amargosa Desert and lies in the Basin and Range physiographic
province which is characterized by broad, open, relatively flat-floored
valleys separated by rugged mountain ranges. At the site, the valley
tends northwesterly.

The area surrounding the disposal site gently slopes towards the
south or southeast. The regional slope is about 6-8 m/km.
Precipitation in the area is very small, averaging about 17 cm per year.
Most of the annual precipitation comes in relatively high-intensity
short summer thunderstorms. The rainfall profile is very erratic with
little or no sustained rainfalls in the region. The relatively high
temperatures and low rainfall suggests that virtually all precipitation
is susceptible to a rapid return to atmosphere as water vapor.

The area nearby the site is virtually uninhabited. The villages of
Beatty and Lathrop Wells are the nearest populations. Las Vegas located
140 km southeast of the site is the nearest metropolitan area.

B.1.2 Geology and soils

Unconsolidated deposits of gravel, sand, silt, and clay form the
valley floor in the Amargosa Desert. The thickness of this material has
been tested by drilling only at a few places, but the maximum thickness
is at least 175 m. A definite statement regarding the thickness of the
valley fill cannot be made, but based on drilling at the Nevada Test
Site the relief on the bedrock surface may be rugged, and consequently
abrupt changes in the depth to bedrock could be expected. Other types
of bedrock beneath the fill of the Amargosa Desert probably include
sandstone, siltstone, conglomerate, dolomite, limestone, shale,
phyllite, schist, and marble. The rocks have been classified as the

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[*] Unless otherwise noted, information in this appendix was found in
Clebsch (1968).

Nopah Formation, Stirling Quartzite, and Bonanza King Formation. Thin
dikes of brown or reddish brown rhyolite porphyry and dacite or
rhyodacite porphyry also may occur beneath the valley fill, but probably
to a lesser degree.

The most significant feature of the bedrock units is that although
they are dense, hard, and inherently impermeable, they do contain
limestone, dolomite, and marble strata which may develop permeability by
solution. These rocks also have been fractured and faulted during
recent intensive tectonic activity. Test drilling on the Nevada Test
Site has shown that similar bedrock units transmit substantial
quantities of water through fractures and possibly solution channels,
and there is no reason to believe that the bedrock beneath the Amargosa
Desert does not also transmit water. However, water in the bedrock
beneath the Beatty site is at great depth and greatly confined.

The valley fill has been derived from the weathering of adjacent
hills and mountain ranges. Its lithologic composition, grain size, and
other physical characteristics are highly variable. Available
information on the alluvial fill at the site indicates that the
sediments are in general poorly sorted mixtures of fine and coarse
grained materials such as clay and boulders or clay and gravel. Most of
the material is thus interpreted to be a fanglomerate, similar to the
material exposed on the surface. Two interesting intervals, however,
are primarily clay or fresh-water limestone altered to clay, indicating
deposition in still water, such as a lake. The clay layer from 81 to
99 m has considerable hydrologic significance.

B.1.3 Hydrology

There are very few wells around the Beatty site and, therefore,
groundwater occurrence and behavior is poorly known. Prior to opening
of the site, only two wells in the saturated zone were known within
13 km of the site. Nevertheless, information derived while surveying
and operating the site indicate the average direction of flow to be
southeast from the site for about 16 km. Following that, the flows are
more southerly. The two nearest producing wells down-gradient from the
proposed site are reported to be approximately 22 and 27 km east-

southeast and south-southeast of the site. The nearer well is near the site of Leeland, Nevada, and enters an aquifer about 45 m below the surface. The well 27 km from the site is 170 m deep and is used for irrigation.

There are no perennial streams or rivers within 16 km of the Beatty site. The Amargosa River channel, although dry, is the principal drainage channel. This river bed passes to within 3.5 km of the disposal site.

B.2 INPUT VARIABLES FOR DE MINIMIS SIMULATIONS

B.2.1 Options or control variables

Most input variables on the first four data cards are for code control or option selection (see Table B.1). Variables are defined in Table 3.

B.2.2 Site-description variables that are well-known

As with the Barnwell data set described in Appendix A, some input data describing Beatty are well known and not likely to change greatly.

Noncontrol variables which are considered well known include the following (refer to Table B.1): TAREA (trench area), TDEPTH (trench depth), OVER (overburden), DTRAQ (trench to aquifer depth), all variables on cards 15 and 17, BDENS (soil bulk density), SAREA (area of contaminated surface soil), and the radiological decay rate. References or notes on calculation are given for each of these in Table B.1.

B.2.3 Radionuclide-independent variables that are poorly known

A number of the input variables listed in Tables 3 and B.1 are poorly known or taken from limited data; that is to say, there may be a large amount of variation associated with the value listed in Table B.1. This is in spite of the fact that the values listed have been taken from referencable sources. This section will briefly describe the variation or sources of variation expected in each of these variables as listed in Table B.1.

Table B.1 Input data for Beatty, Nevada; refer to Table 3
for formats and definitions of variables

Card number	Variable	Value	Reference or note
1	TITLE		User option
2	LOCATE	Beatty NV	User option
3	MAXYR	1000	User option
	NONCLD	40	Must be 40 or less
	LEAOPT	2	User option
	NYR1	100	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	NYR2	200	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	IOPVWV	1	User option
	IOPSAT	1	User option
	IPRT1	0	User option
	IPRT2	1000	User option
	IDELT	100	User option
	IRRES1	0	User option
	IRRES2	0	User option
	LIND	1	User option
	IAVG1	0	User option
	IAVG2	1000	User option
4	IVAP	0	User option
	IBSMT	0	User option
	IAQSTR	0	User option
5	PCT1	0.01	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	PCT2	0.1	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	WATL	1.0	User option
	WATA	1.0	User option
	WATH	1.0	User option
	SATL	0.0	User option
	SATA	0.0	User option
	SATH	0.0	User option
6	PPN	0.171	Ruffner (1978)
	P	898.83	Ruffner (1978)
	XIRR	.646	Ruffner (1978)
	PHID	36.83	Ruffner (1978)
7	S	0.68	Ruffner (1978)
		0.70	Ruffner (1978)
		0.72	Ruffner (1978)
		0.73	Ruffner (1978)
		0.78	Ruffner (1978)
		0.85	Ruffner (1978)
		0.81	Ruffner (1978)
		0.84	Ruffner (1978)

Table B.1 Input data for Beatty, Nevada (cont.)

Card number	Variable	Value	Reference or note
8		0.86	Ruffner (1978)
		0.79	Ruffner (1978)
		0.70	Ruffner (1978)
		0.70	Ruffner (1978)
9	T	-0.6	Ruffner (1978)
		2.1	Ruffner (1978)
		5.2	Ruffner (1978)
		10.1	Ruffner (1978)
		15.2	Ruffner (1978)
		19.9	Ruffner (1978)
		24.7	Ruffner (1978)
		23.6	Ruffner (1978)
10		18.9	Ruffner (1978)
		12.3	Ruffner (1978)
		5.1	Ruffner (1978)
		0.6	Ruffner (1978)
11	TD	-8.9	Ruffner (1978)
		-6.9	Ruffner (1978)
		-7.6	Ruffner (1978)
		-4.6	Ruffner (1978)
		-3.2	Ruffner (1978)
		-1.7	Ruffner (1978)
		2.7	Ruffner (1978)
		3.3	Ruffner (1978)
12		-1.4	Ruffner (1978)
		-3.4	Ruffner (1978)
		-5.7	Ruffner (1978)
		-7.2	Ruffner (1978)
13	TAREA	1.8E4	Morton (1968)
	TDEPTH	6.7	Morton (1968)
	OVER	1.2	Morton (1968)
	PORT	0.2	Clebsch (1968) p. 91; set same as soil
	DENCON	2.0	Assumed
	RELFAC	0	User option
	FN	0.5	
	XINFI.	0.41	Calculated
14	PERMC	154	
15	DTRAQ	84	Clebsch (1968) p. 87
	DWELL	6700	Clebsch (1968) p. 88
	GWV	182	Personal Communication, C. Y. Pung to J. Broadway, March 18, 1983
	AQTHK	1.3	Clebsch (1968) p. 88
	AQDISP	0.3	Assumed
	PORA	0.2	Clebisch (1968)

Table B.1   Input data for Beatty, Nevada (cont.)

Card number	Variable	Value	Reference or note
	PORV	0.3	Clebisch (1968)
	PERMV	154	Clebisch (1968)
16	H	1.0	Assumed
	VG	0.027	Calculated from particle sizes
	U	4.48	Jackass Flats meteorology; National Climatic Center
	VD	0.027	Equal to VG
	XG	16,800	Clebsch (1968)
	HLID	300	Assumed
	ROUGH	0.01	Generic value
17	FTWIND	0.056	Jackass Flats meteorology; National Climatic Center
	CHIQ	7.0E-9	Computed with external code, AIRDOS-EPA Moore, et. al. (1979)
	RE1	1.0E-4	Anspaugh, et. al. (1975)
	RE2	-0.15	Anspaugh, et. al. (1975)
	RE3	1.0E-9	Anspaugh, et. al. (1975)
	RR	0	User option (>0 when farming)
	FTMECH	0	User option (>0 when farming)
18	IT	1	User option
	IS	4	Jackass Flats meteorology; National Climatic Center
19	RAINF	20	McElroy et al. (1976) p. 44 Fig. 3.2
	ERODF	0.5	McElroy et al. (1976) p. 46 Table C.2
	STPLNG	0.26	McElroy et al. (1976) Fig 3.8
	COVER	0.30	McElroy et al. (1976) Table 3.3
	CONTRL	0.40	McElroy et al. (1976) Table 3.7
	SEDELR	1.0	Assumed; see McElroy et al. (1976) p. 60-68
20	PORS	0.1	Clebsch (1968) p. 90
	BDENS	1.6	Assumed
	STFLOW	2000	Clebsch (1968) p. 73
	EXTENT	180	User option; set to trench length x 10
	ADEPTH	0.01	Assumed — user option

Table B.1   Input data for Beatty, Nevada (cont.)

Card number	Variable	Value	Reference or note
21	PD	3000	Clebsch (1968) p. 73
	RUNOFF	0.05	Jack Robertson, USGS (personal comm.)
22	Y1	0.04	Shor, Baes, and Sharp Appendix C (1982)
	Y2	0.76	Shor, Baes, and Sharp Appendix B (1982)
	PP	240	Assumed 15 cm plow depth
	XAMBWE	0.0021	USNRC (1977)
	TA	4380.	
	TE1	720	Generic, USNRC (1977) Table E-15
	TE2	1440	Generic, USNRC (1977) Table E-15
23	TH1	0	Generic, USNRC (1977) Table E-15
	TH2	2160	Generic, USNRC (1977) Table E-15
	TH3	24	Generic, USNRC (1977) Table E-15
	TH4	1440	Generic, USNRC (1977) Table E-15
	TH5	336	in 1 Generic, USNRC (1977) Table E-15
	TH6	336	Generic, USNRC (1977) Table E-15
	FP	0.47	Shor, Baes, and Sharp (1982)
	FS	1.0	Shor, Baes, and Sharp (1982)
24	QFC	50	Generic, USNRC (1977) Table E-15
	QFG	6	Generic, USNRC (1977) Table E-15
	TF1	48	Generic, USNRC (1977) Table E-15
	TF2	96	Generic, USNRC (1977) Table E-15
	TS	480	Generic, USNRC (1977) Table E-15
	ABSH	4.4	State average; Etnier (1980)
	P14	1.0	Assumed
	TW	5688.	Assumed
25	FI	0.65	Growing season length/8760
	WIRATE	0.114	Estimated from Baes et. al. (1982) and TW
	QCW	60	Generic, USNRC (1977)
	QGW	8	Generic, USNRC (1977)
	QBW	50	Generic, USNRC (1977)

Table B.1 Input data for Beatty, Nevada (cont.)

Card number	Variable	Value	Reference or note
26	ULEAFY	190	Generic, USNRC (1977)
	U.ROD	190	Generic, USNRC (1977)
	UCMILK	110	Generic, USNRC (1977)
	UGMILK	0	Generic, USNRC (1977)
	UMEAT	95	Generic, USNRC (1977)
	UWAT	370	Generic, USNRC (1977)
	UAIR	8000	Generic, USNRC (1977)
	POP	2000	1980 Census; Durfee (personal comm.)
27+			see Table A.2

WATL. Fraction of total irrigation water taken from well. The referenced value is a state average of groundwater use as a fraction of total water use for 1970. Value may vary over time and across state. The range in the United States is from 0.01 (West Virginia) to 0.83 (Kansas). The most common United Sta   range is 0.10-0.25.

SINFL. Nontrench annual rate of infiltration (m/y). County-wide value calculated by referenced workers. Site-specific differences in permeability, compaction, etc., may greatly reduce infiltration rate and increase runoff.

PORA,PORT,PORS. Porosity of aquifer, trench, and surface region. In Table B.1, these values are equal to each other. This is likely incorrect for PORT, the porosity used both within the trench. If total trench were tightly compacted, the value could be much lower. A more likely situation is that trench contents are variably porous due to heterogeneous materials and voids. Clebsch (1968) states that "the porosity of 20 percent is a reasonable value for material of this type, but it might be as low as 10%...." Nevertheless, it seems clear that the aquifer porosity should be relatively low.

PERMV. Permeability of trench bottom, permeability of surface region. Referenced value is probably reasonable for surface region, but as with porosity, the permeability inside trench is probably extremely heterogeneous.

DENCON. Density of the trench contents. The listed value is an assumption. For waste materials such as cardboard, clothing, gloves, and soil, assuming few voids, the number may be reasonable. However, given sizeable voids or large masses of highly dense materials, the value listed is probably too small. It could range as high as ten.

RELFAC. User-option annual release fraction for activity leaching from trench. It has been estimated (Dole and Fields, 1981) for at least three sites: Savannah River Plant (10^{-8}), Oak Ridge National Laboratory (10^{-6}), and West Valley (2.5×10^{-4}). Probably not constant from element to element.

DTRAQ, DWFLL. Depth from trench bottom to aquifer, distance from trench to well. Clebsch (1968) describes the locations of the two nearest producing wells. The nearer well is 22 km distant and draws water from an aquifer 240 m below surface. The farther well is 27 km

away and pumps from a depth of 912 m. The listed value of DTRAQ is set conservatively from these and other information in Clebsch (1968) as is the value of DWELL.

GWV. Groundwater velocity. Referenced value from C. Y. Hung, personal communication to Jon Broadway, March 18, 1983.

AQTHK. Thickness of the aquifer. Used for dilution calculations. For Beatty depends on the aquifer and the location at which thickness is measured. Value in Table B.1 based on the discussion by Clebsch (1968) which seems to indicate that aquifer thickness may vary from 4.3 to 10.4 m. A conservative value is listed.

AQDISP. Angle of pollutant dispersion in the aquifer plume. Value in Table B.1 is an assumption. Obviously a function of rate of flow, porosity, and permeability.

Card 19. Factors for use in the Universal Soil Loss Equation. Values listed in Table B.1 were calculated as prescribed by McElroy et al. (1976). However, the methods of McElroy et al. are generalized for large sections of the country. More detailed methods might yield a more precise value. Except for RAINF, all factors vary only from 0-1. RAINF ranges from 20 to 350, nationwide. Range in the area of southern Nevada appears to be about 15 to 20. The sediment delivery ratio (SEDELR) was set 1.0 because it is intended for use around construction sites, an assumption not justified after the trench has been closed and reseeded.

ADEPTH. The active depth of the surface soil. Used to calculate soil and water radionuclide concentration as a result of overflow. Values in table are assumed. We found no reference for depth of sub-surface runoff, etc., to substantiate ADEPTH. Could reasonably be set to plow depth, nominally 15 cm. Unlikely that ADEPTH would approach 1 m.

RUNOFF. Fraction of annual precipitation that runs off. Referenced value is probably too large Jack Robertson of USGS (personal communication) estimates no runoff on the average. Listed value is set at 0.05.

B.2.4 Radionuclide-specific parameters that are poorly known

TRAM. Initial inventory of each radionuclide. Values in Table B.3
for Beatty are simply the merger of the indicated values for Barnwell
and West Valley. If both Barnwell and West Valley had an inventory of a
given radionuclide, the larger of the two was used for Beatty. We know
of no referenceable radionuclide inventories for Beatty.

KD. See discussion in Appendix A.2.

SOAM. See discussion in Appendix A.2.

SOL. See discussion in Appendix A.2.

BR, BV. See discussion in Appendix A.2.

FMC, FMG. See discussion in Appendix A.2.

FF. See discussion in Appendix A.2.

B.3 ADDITIONAL SUPPORTING INFORMATION FOR INPUT DATA SET

Table B.2 lists the mean annual wind direction frequencies and
true-averaged wind speeds for Jackass Flats, Nevada. These or similar
data should be used to calculate CHIQ for input.

Table B.3 lists population determined by the 1980 Census for a
polar grid surrounding the Beatty site.

Table B.4 lists 1978 hourly precipitation for the Beatty, Nevada,
Site 260718.

Table B.2. Mean annual wind direction frequencies and true-average
wind speeds (Jackass Flats, NV)

Wind toward	Frequency	Wind speed for each stability class (m/s)						
		A	B	C	D	E	F	G
N	0.124	2.95	3.85	4.58	4.47	2.94	1.72	1.23
NNW	0.056	2.95	3.85	4.58	4.48	2.89	1.72	1.23
NW	0.020	2.89	3.77	4.58	4.38	2.95	1.71	1.23
WNW	0.013	2.88	3.75	4.49	4.59	2.81	1.73	1.24
W	0.036	2.92	3.75	4.57	4.43	2.90	1.78	1.21
WSW	0.065	2.97	3.86	4.55	4.50	2.94	1.81	1.22
SW	0.113	2.93	3.88	4.52	4.49	2.93	1.84	1.22
SSW	0.131	2.96	3.82	4.59	4.49	2.91	1.85	1.22
S	0.112	2.92	3.77	4.55	4.48	2.91	1.84	1.22
SSE	0.065	2.94	3.88	4.55	4.48	2.92	1.83	1.22
SE	0.033	2.72	4.04	4.58	4.46	2.92	1.77	1.21
ESE	0.012	2.78	3.78	4.49	4.54	2.81	1.73	1.24
E	0.013	2.78	5.55	4.51	4.42	2.84	1.59	1.25
ENE	0.036	2.93	3.85	4.63	4.49	2.81	1.66	1.20
NE	0.069	2.94	3.85	4.59	4.52	2.95	1.64	1.27
NNE	0.099	2.94	3.83	4.60	4.47	2.88	1.71	1.23

Table B.3. Population distribution by distance and direction for Beatty, NV

DIR	Distance from site trench (km)									
---	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
N	9	14	16	19	5	0	1	2	6	10
NNE	9	17	16	19	6	1	2	4	7	7
NE	10	21	21	26	28	17	19	20	20	22
ENE	8	25	31	32	38	44	33	41	50	55
E	10	30	30	50	62	55	54	49	67	69
ESE	8	26	40	52	74	92	174	231	252	500
SE	10	25	41	55	69	106	148	204	247	267
SSE	10	27	37	50	61	87	105	86	69	62
S	10	25	44	50	56	78	66	50	23	68
SSW	10	25	39	38	44	55	52	24	8	103
SW	8	28	25	33	41	49	45	32	23	62
WSW	8	17	24	31	44	51	46	40	43	49
W	11	16	11	15	22	33	24	16	24	21
WNW	7	12	5	3	8	3	11	10	7	16
NW	7	13	8	2	1	2	5	8	11	18
NNW	9	14	15	15	2	1	6	9	11	18
Total	144	335	412	290	561	674	791	826	868	1347

Table B.4. Hourly precipitation data for Beatty, NV (site 260718) *

Rainfall during indicated hours of day (hundreths of inches)

YR MO DA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOT
78 01 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 01 03	0	0	0	0	0	0	0	0	0	0	0	0	1	4	3	1	0	0	1	1	0	1	0	1	14
78 01 04	0	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
78 01 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 01 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0	35
78 01 14	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	7	6	1	0	0	1	0	0	20
78 01 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	6	14	1	1	2	4	1	94
78 01 19	0	0	0	0	0	1	3	1	1	3	2	2	1	1	0	0	0	0	0	0	0	0	0	0	15
78 02 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 02 05	0	0	0	0	0	0	0	0	0	0	5	8	2	1	0	0	0	0	0	0	0	0	0	0	16
78 02 06	0	0	0	1	1	2	1	0	0	0	0	3	1	2	0	0	0	0	0	0	0	0	0	0	11
78 02 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 02 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	0	0	0	0	0	0	0	133
78 02 27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 02 28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	5	70
78 03 01	4	10	21	1	1	4	7	8	2	1	1	4	5	2	1	1	0	0	0	1	1	0	0	0	75
78 03 02	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
78 03 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4
78 03 04	1	1	1	9	15	11	9	7	4	3	1	1	1	2	1	1	0	0	0	0	0	0	0	0	68
78 03 12	0	0	0	1	1	10	2	3	18	4	5	5	4	0	0	0	0	0	1	0	1	2	1	3	65
78 03 21	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
78 03 30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
78 03 31	1	1	6	5	13	13	7	15	1	0	0	4	2	1	0	0	0	0	0	0	0	0	0	0	69
78 04 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 04 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	10	0	0	0	0	0	50
78 04 07	50	130	20	0	10	10	10	20	200	30	10	0	10	0	50	0	0	0	0	0	0	0	0	0	550
78 04 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	20	10	70	30	0	10	10	10	260
78 04 25	0	0	0	0	0	0	0	0	0	130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	130
78 04 27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	100	0	0	0	0	0	200
78 04 29	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	100
78 05 01	0	0	0	0	0	0	0	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 06 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 07 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 07 27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	10
78 08 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 08 11	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 09 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 09 05	0	0	0	0	0	0	0	10	10	0	0	0	0	0	0	0	0	10	20	10	0	10	0	0	70
78 10 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 10 30	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200
78 10 31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 11 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 11 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 11 12	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	30
78 12 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	10
78 12 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	20	10	40
78 12 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	10

* Unlisted days had no rainfall

REFERENCES

Anspaugh, L. R., J. J. Shinn, P. L. Phelps, and N. C. Kennedy. 1975. "Resuspension and redistribution of plutonium in soils." Health Phys. 29:571-582.

Baes, C. F., III, R. D. Sharp, A. L. Sjoreen, and R. W. Shor. 1982. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture. ORNL-5786, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Clebsch, A., Jr. 1968. "Beatty facility - near Beatty, Nevada: Geology and hydrology of a proposed site for burial of solid radioactive waste southeast of Beatty, Nye County, Nevada," in Land Burial of Solid Radioactive Waste: Study of Commercial Operations and Facilities, pp. 70-103. WASH-1143.

Dole, L. R., and D. E. Fields. 1981. "Summary of release mechanisms workshop," in C. A. Little and L. E. Stratton (compilers), Modeling and Low-Level Waste Management: An Interagency Workshop, pp. 343-350. ORO-821, U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee.

McElroy, A. D., S. Y. Chin, J. W. Nebgen, A. Aleti, and F. W. Bennett. 1976. Loading Function for Assessment of Water Pollution from Nonpoint Sources. EPA-600/2-76-151, U. S. Environmental Protection Agency report, Midwest Research Institute, Kansas City, Missouri.

Moore, R. E., C. F. Baes III, L. M. McDowell-Boyer, A. P. Watson, F. O. Hoffman, J. C. Pleasant, and C. W. Miller. 1979. AIRDOS-EPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides. ORNL-5532, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Morton, R. J. 1968. Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities. WASH-1143, Atomic Energy Commission, Division of Reactor Development and Technology, Washington, D.C..

Olson, R. J., C. J. Emerson, and M. K. Nungesser. 1980. Geoecology: A County-Level Environmental Data Base for the Conterminous United States. ORNL/TM-7351, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Ruffner, J. A. 1978. Climates of the States, 1 and 2. Gale Research Co., Book Tower, Detroit, Michigan.

Shor, R. W., C. F. Baes III, and R. D. Sharp. 1982. Agricultural Production in the United States By County: A Compilation of Information From The 1974 Census of Agriculture For Use In

Terrestrial Food-Chain Transport And Assessment Models. ORNL-5768, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

U. S. Nuclear Regulatory Commission. 1977. _Regulatory Guide 1.109: Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I_. U.S. Nuclear Regulatory Commission, Washington, D.C.

C.1 GENERAL DESCRIPTION OF THE SITE[*]

C.1.1 Location and climate

The West Valley disposal ground is in Western New York approximately 55 km south-southeast of Buffalo, New York, in Cattaraugus County. The nearest village is Springville, about 2.5 km north of the northern site boundary. The low-level waste disposal ground is part of a larger site known as the Western New York Nuclear Service Center (WNYNSC).

The WNYNSC is located on a relatively level plateau just south of Cattaraugus Creek. Hills bound the site on all sides but the north. Buttermilk Creek, a tributary of Cattaraugus Creek, has cut a valley through the center of the plateau to a depth of about 30 m on the eastern boundary of the plant site. The valley walls of Buttermilk Creek and its tributaries are steep and badly eroded in places. The WNYNSC encompasses 1350 ha of which the low-level waste disposal site includes 10 ha.

The region surrounding West Valley is humid and greatly influenced by the presence of Lakes Erie and Ontario within 80 km. Precipitation (over 1.0 m per year) is evenly divided throughout the year, with heavy snowfall associated with cold air passage over Lake Erie. Winds at the site are generally from west and south and relatively strong (speeds of 4-8 m/s occur 59% of the time). The mean annual temperature of the site is 7.2°C with July being the warmest month (21.2°C) and January the coldest (-4.4°C).

The area around the disposal site has a low population density. The 1976 estimated population of Cattaraugus County was 86,000.

C.1.2 Geology and soils

The West Valley site is in the Glaciated Allegheny portions of the Appalachian Plateau physiographic province. The region is overlain by variable thicknesses of glacial deposits above Paleozoic sedimentation

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[*] Unless otherwise noted, information in this section is from USDOE (1978) or Giardina et al. (1977).

rocks. These strata dip slightly to the south (4-8 m/km). The combination of a tending northward erosion slope and southward dip has exposed several different formations in contiguous, irregular east-west bands.

The bedrock of the region is generally overlain by unconsolidated glacial and glacially related deposits consisting of till, sand, gravel, silts, and clays. Till consists of ground rock fragments containing cobbles and pebbles. At the WNYNSC, these deposits range in depth to 170 m. The mineralogy of the tills resembles that of the Paleozoic rocks that were once exposed to glacial action in the region. The clay and silt fractions are dominated by quartz, mica, and chlorite; lesser amounts of calcite and dolomite are detectable in the silt fraction. Soils of the area may be described by three general descriptions: fill, jointed-fractured weathered till, and unweathered till. Fill is silty, moist, gray and brown mottled, with firm to soft consistency. The jointed-fractured weathered fill is tough, homogeneous brown with scattered gravel bits, having joints and fractures throughout. Unweathered till is gray in color, plastic clay, with scattered gravel, occasional buff-colored spots and some pebbles. Sand lenses may be encountered variously in places throughout the till.

Both USDOE (1978) and Giardina et al. (1977) have much more detailed and scholarly descriptions of the geology and soils of the West Valley region and site.

C.1.3 Hydrology

The West Valley site is underlain by three, or possibly four, aquifers. The top aquifer ranges from 0-6 m thick and consists of granular fluvial materials which are found on the surface of much of the site. This aquifer is "probably charged by surface infiltration that is prevented from further downward migration by the underlying, impermeable, silty till" (USDOE, 1978). The aquifer crops out in marshy areas and at the edges of erosion gullies from streams within the site boundaries. Therefore, groundwater from the top aquifer is discharged as surface drainage within the site boundary.

The second aquifer is a thin sand layer about 5 m below grade. It is confined above and below by impermeable fill; water level is 1.5 to 5 m above the level of the aquifer. The third aquifer is confined in a range of 31.4 to 37.8 m depth and consists of pebbly to silty sand. The last aquifer occurs in a weathered and fractured zone at the top of the shale bedrock. This aquifer may produce useable quantities of water even though it has relatively low permeability. The depth of this aquifer varies greatly because of the buried bedrock valley that underlies the site area.

The site is drained of surface water by Cattaraugus Creek and Buttermilk Creek, its tributary. Cattaraugus Creek flows generally westerly and empties into Lake Erie about 65 km downstream. Buttermilk Creek is the major surface drainage system of the West Valley site. Although it originates south of the WNYNSC, the lower portions of Buttermilk Creek, including its confluence with Cattaraugus Creek, are completely within the site boundary. The mean annual flow of the Cattaraugus Creek part of the site is about 3.1×10^8 m^3/y of which Buttermilk Creek contributes about 4.1×10^7 m^3/y.

A more detailed description of the groundwater and surface hydrology is given by both USDOE (1978) and Giardina et al. (1977).

C.2   INPUT VARIABLES FOR PRESTO-II

C.2.1   Options or control variables

Most of the input variables on the first five data cards are for code control or option selection (see Table C.1). All code variables are defined in Table 3.

C.2.2   Site-description variables that are well known

As with the Barnwell and Beatty site data bases discussed earlier, some of the input data describing the site are very well known and will neither change greatly nor largely affect predictions.

Table C.1 Input data for West Valley, New York; refer to Table 3
for formats and definitions of variables

Card number	Variable	Value	Reference or note
1	TITLE		User option
2	LOCATE	West Valley, NY	User option
3	MAXYR	1000	User option
	NONCLD	40	Must be 40 or less
	LEAOPT	2	User option
	NYR1	100	Personal Communication. C. Y. Hung to J. Broadway, March 18, 1983
	NYR2	200	Personal Communication. C. Y. Hung to J. Broadway, March 18, 1983
	IOPVWV	1	User option
	IOPSAT	1	User option
	IPRT1	0	User option
	IPRT2	1000	User option
	IDELT	100	User option
	IRRES1	0	User option
	IRRES2	0	User option
	LIND	1	User option
	IAVG1	1	User option
	IAVG2	1000	User option
4	IVAP	0	User option
4	IBSMT	0	User option
4	IAQSTR	0	User option
5	PCT1	0.1	Personal Communication. C. Y. Hung to J. Broadway, March 18, 1983
	PCT2	0.2	Personal Communication. C. Y. Hung to J. Broadway, March 18, 1983
	WATL	1.0	User option
	WATA	1.0	User option
	WATH	1.0	User option
	SATL	0.0	User option
	SATA	0.0	User option
	SATH	0.0	User option
6	PPN	1.178	Ruffner (1978)
	P	966.93	Ruffner (1978)
	XIRR	0152	Ruffner (1978)
	PHID	42.25	Ruffner (1978)
7	S	0.35	Ruffner (1978)
		0.40	Ruffner (1978)
		0.47	Ruffner (1978)
		0.53	Ruffner (1978)
		0.58	Ruffner (1978)
		0.66	Ruffner (1978)
		0.68	Ruffner (1978)
		0.65	Ruffner (1978)

Table C.1 Input data for West Valley, New York (continued)

Card number	Variable	Value	Reference or note
8		0.59	Ruffner (1978)
		0.51	Ruffner (1978)
		0.30	Ruffner (1978)
		0.28	Ruffner (1978)
9	T	-4.4	Ruffner (1978)
		-4.0	Ruffner (1978)
		0.3	Ruffner (1978)
		7.3	Ruffner (1978)
		13.0	Ruffner (1978)
		18.7	Ruffner (1978)
		21.2	Ruffner (1978)
		20.1	Ruffner (1978)
10		16.5	Ruffner (1978)
		11.0	Ruffner (1978)
		4.5	Ruffner (1978)
		-2.0	Ruffner (1978)
11	TD	-6.8	Ruffner (1978)
		-6.9	Ruffner (1978)
		-3.6	Ruffner (1978)
		1.8	Ruffner (1978)
		7.4	Ruffner (1978)
		12.9	Ruffner (1978)
		15.2	Ruffuer (1978)
		15.2	Ruffner (1978)
12		11.6	Ruffner (1978)
		6.3	Ruffner (1978)
		0.7	Ruffner (1978)
		-4.8	Ruffner (1978)
13	TAREA	41500	Personal Communication, C. Y. Hung to J. Broadway. March 18, 1983
	TDEPTH	6.7	Morton (1968)
	OVER	2.4	Morton (1968)
	PORT	0.25	Clebsch (168) p. 91; set same as soil
	DENCON	2.0	Assumed
	RELFAC	0	User option
	FN	0.1	User option
	XINFIL	0.05	Calculated
14	PERMC	0.019	Personal Communication,
15	DTRAQ	31	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
	DWELL	6500	Assumed
	GWV	0.03	Prudic (1981)
	AQTHK	6.4	USDOE (1978) p. 2-10

Table C.1   Input data for West Valley, New York (continued)

Card number	Variable	Value	Reference or note
	AQDISP	0.3	Assumed
	PORA	0.25	Giardina et al. (1977) p. 100
	PORV	0.25	Giardina et al. (1977) p. 100
	PERM	0.019	Personal Communication, C. Y. Hung to J. Broadway, March 18, 1983
16	H	1.0	Assumed
	VG	0.01	Calculated from particle sizes; Giardina et. at (1977) p. 103
	U	4.2	Buffalo, NY meteorology
	VD	0.01	Equal to VG
	XG	6500	Clebsch (1968)
	HLID	300	Assumed
	ROUGH	0.01	Generic value
17	FTWIND	0.049	Buffalo, NY meteorology
	CHIQ	7.9E-9	Computed with external code, AIRDOS-EPA Moore, et. al. (1979)
	RE1	1.0E-6	Anspaugh, et. al. (1975)
	RE2	-0.15	Assumed lower than Anspaugh, et. al. (1975)
	RE3	1.0E-10	Assumed lower than Anspaugh, et. al. (1975)
	RR	0	User option (>0 when farming)
	FTMECH	0	User option (>0 when farming)
18	IT	1	User option
	IS	4	Buffalo, NY meteorology
19	RAINF	100	McElroy et al. (1976) p. 44 Fig. 3.2
	ERODF	0.19	McElroy et al. (1976) p. 46 Table C.2
	STPLNG	0.42	McElroy et al. (1976) Fig 3.8
	COVER	0.30	McElroy et al. (1976) Table 3.3
	CONTRL	0.50	McElroy et al. (1976) Table 3.7
	SEDELR	1.0	Assumed; see McElroy et al. (1976) p. 60-68
20	PORS	0.25	Giardina et at. (1977) p. 100
	BDENS	1.6	Assumed
	STFLOW	4.0E7	USDOE (1978) p. 2-10
	EXTENT	244	Set to maximum trench length
	ADEPTH	0.01	Assumed

Table C.1   Input data for West Valley, New York (continued)

Card number	Variable	Value	Reference or note
21	PD	380	Calculated from map in USDOE (1978)
	RUNOFF	0.53	Geraghty et. al. (1973) p. 21
22	Y1	0.14	Shor, Baes, and Sharp Appendix C (1982)
	Y2	0.56	Shor, Baes, and Sharp Appendix B (1982)
	PP	240	Assumed 15 cm plow depth
	XAMBWE	0.0021	USNRC (1977)
	TA	4380.	
	TE1	720	Generic, USNRC (1977) Table E-15
	TE2	1440	Generic, USNRC (1977) Table E-15
23	TH1	0	Generic, USNRC (1977) Table E-15
	TH2	2160	Generic, USNRC (1977) Table E-15
	TH3	24	Generic, USNRC (1977) Table E-15
	TH4	1440	Generic, USNRC (1977) Table E-15
	TH5	336	Generic, USNRC (1977) Table E-15
	TH6	336	Generic, USNRC (1977) Table E-15
	FP	0.49	Shor, Baes, and Sharp (1982)
	FS	0.31	Shor, Baes, and Sharp (1982)
24	QFC	50	Generic, USNRC (1977) Table E-15
	QFG	6	Generic, USNRC (1977) Table E-15
	TF1	48	Generic, USNRC (1977) Table E-15
	TF2	96	Generic, USNRC (1977) Table E-15
	TS	480	Generic, USNRC (1977) Table E-15
	ABSH	6.4	State average; Etnier (1980)
	P14	1.0	Assumed
	TW	4152.	Assumed
25	FI	0.47	Growing season length/8760
	WIRATE	0.042	Estimated from Baes et. al. (1982) and TW
	QCW	60	Generic, USNRC (1977)
	QGW	8	Generic, USNRC (1977)
	QBW	50	Generic, USNRC (1977)

Table C.1   Input data for West Valley, New York (continued)

Card number	Variable	Value	Reference or note
26	ULEAFY	190	Generic, USNRC (1977)
	UPROD	190	Generic, USNRC (1977)
	UCMILK	110	Generic, USNRC (1977)
	UGMILK	0	Generic, USNRC (1977)
	UMEAT	95	Generic, USNRC (1977)
	UWAT	370	Generic, USNRC (1977)
	UAIR	8000	Generic, USNRC (1977)
	POP	10,000	1980 Census; Durfee (personal comm.)
27+			see Table A.2

Noncontrol variables which are considered well known include the following (refer to Table C.1): TAREA (trench area), TDEPTH (trench depth), OVER (overburden), all variables on cards 15 and 17, BDENS (soil bulk density), STFLOW (stream flow), SAREA (area of contaminated surface soil), and the radiological decay rate. References or notes on calculation are given for each of these in Table C.1.

C.2.3 Radionuclide-independent variables that are poorly known

A number of the input variables listed in Table 3 and C.1 may have a large uncertainty associated with the value listed in Table C.1. This section will briefly describe the variation or source of variation expected in each of these variables as listed in Table C.1.

VATL. Fraction of total irrigation water taken from well. The referenced value is a state average of groundwater use as a fraction of total water use for 1970. Value may vary over time and across state. The mixture and poor quality of aquifers existing near the West Valley site would seem to make this parameter value even more uncertain. The United States range is from 0.01 (West Virginia) to 0.83 (Kansas). The most common United States range' is 0.10–0.25.

SINFL. Nontrench annual rate of infiltration (m/y). The listed value is a countywide figure calculated by the referenced workers. Site-specific differences in permeability, compaction, etc., may greatly reduce infiltration rate and increase runoff.

PORA, PORT, PORS. Porosity of aquifer, trench, and surface region.

PERMV. Permeability of trench bottom. The listed value in Table C.1 is from C. Y. Hung (Personal communication to Jon Broadway, March 18, 1983).

DENCON. Density of the trench contents. As with other sites, the value listed is strictly an assumption. For waste materials such as cardboard, clothing, gloves, and soil, assuming few voids, the number may be reasonable. However, given sizeable voids or large masses of highly dense materials, the value listed is probably too small and could range as high as 10.

RELFAC. User-option annual release faction for activity leaching from trench has been estimated (Dole and Fields, 1981) for at least three sites: Savannah River Plant (10^{-8}), Oak Ridge National Laboratory (10^{-6}), and West Valley (2.5×10^{-4}). These values are probably not constant between elements.

DTRAQ. Trench bottom to aquifer depth. The listed value in Table C.1 is from C. Y. Hung (Personal communication to Jon Broadway, March 18, 1983).

GWV. Groundwater velocity. The referenced value is from a series of computer simulations of the West Valley site. For this site, the value used for GWV is likely not very important due to the impermeable strata that minimize infiltration.

AQTHK. Thickness of the aquifer, used for dilution calculations. For West Valley, depends on the aquifer chosen for transport and the location at which thickness is measured. The value in Table C.1 is based on the second aquifer described by USDOE (1978).

AQDISP. Angle of pollutant dispersion in the aquifer plume. The value in Table C.1 is strictly an assumption since AQDISP is very much a function of rate of flow, porosity, and permeability. Because of slow flow rates, the value is probably larger for West Valley than for other sites.

Card 19. Factors for use in the Universal Soil Loss Equation. Values listed in Table C.1 were calculated as prescribed by McElroy et al. (1976). However, the methods of McElroy et al. are generalized for large sections of the country. More detailed methods might yield more precise values. Except for RAINF, all factors vary only from 0-1. RAINF ranges from 20-350, nationwide. The value of RAINF in western New York is roughly 90-100. The sediment delivery ratio (SEDELR) was set to 1.0 because it is intended to be used around large construction sites, an assumption that is not justified after the trench has been closed and reseeded.

ADEPTH. The active depth of the surface soil used to calculate soil and water radionuclide concentrations as a result of overflow from trench. Value in table is assumed. The value of ADEPTH could reasonably be set to plow depth, nominally 15 cm. It is unlikely that ADEPTH would approach 1 m. At West Valley, the impermeable soils may

smaller active region ex.spt for the shallow water table aquifer which leads to surface discharge.

C.2.4 Radionuclide-specific parameters that are poorly known

TRAM. Initial inventory of each radionuclide. Values in Table C.3 for West Valley are better than values for Beatty, i.e., better records were kept for the West Valley site. Nevertheless, the West Valley inventory data are probably incorrect because they are based on broadly classed groups of r.dionuclides and not actual measurements of materials received. By examining the shippers/generators of the waste materials in detail, the West Valley inventory estimate could be improved but not perfected.

KD. See discussion in Appendix A.2.

SOAM. See discussion in Appendix A.2.

SOL. See discussion in Appendix A.2.

BR, BV. See discussion in Appendix A.2.

FMC, FMG. See discussion in Appendix A.2.

FF. See discussion in Appendix A.2.

C.3 ADDITIONAL SUPPORTING INFORMATION FOR INPUT DATA SET

Table C.2 lists the mean annual wind direction frequencies and true-averaged wind speeds for the metropolitan Buffalo, New York, airport. These or similar data should be used to calculate CHIQ for input.

Table C.3 lists population determined by the 1980 census for a polar grid surrounding the West Valley site.

Table C.4 lists 1978 hourly precipitation for the weather station at Salamanca, New York.

Table C.2. Mean annual wind direction frequencies and true–average wind speeds (Buffalo, NY)

Wind toward	Frequency	Wind speed for each stability class (m/s)						
		A	B	C	D	E	F	G
N	0.124	2.95	3.85	4.58	4.47	2.94	1.72	1.23
NNW	0.056	2.95	3.85	4.58	4.48	2.89	1.72	1.23
NW	0.020	2.89	3.77	4.58	4.38	2.95	1.71	1.23
WNW	0.013	2.88	3.75	4.49	4.59	2.81	1.73	1.24
W	0.036	2.92	3.75	4.57	4.43	2.90	1.78	1.21
WSW	0.065	2.97	3.86	4.55	4.50	2.94	1.81	1.22
SW	0.113	2.93	3.88	4.52	4.49	2.93	1.84	1.22
SSW	0.131	2.96	3.82	4.59	4.49	2.91	1.85	1.22
S	0.112	2.92	3.77	4.55	4.48	2.91	1.84	1.22
SSE	0.065	2.94	3.88	4.55	4.48	2.92	1.83	1.22
SE	0.033	2.72	4.04	4.58	4.46	2.92	1.77	1.21
ESE	0.012	2.78	3.78	4.49	4.54	2.81	1.73	1.24
E	0.013	2.78	5.55	4.51	4.42	2.84	1.59	1.25
ENE	0.036	2.93	3.85	4.63	4.49	2.81	1.66	1.20
NE	0.069	2.94	3.85	4.59	4.52	2.95	1.64	1.27
NNE	0.099	2.94	3.83	4.60	4.47	2.88	1.71	1.23

Table C.3. Population distribution by distance and direction for West Valley, NY

DIR	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
N	1140	1468	4478	15369	49854	98103	38223	15792	17995	11910
NNE	907	986	2388	4425	4486	9277	10934	18828	11468	15577
NE	172	1716	1725	1611	2867	8373	7573	11394	12639	17255
ENE	137	1974	1849	1370	2598	5252	8480	12486	9477	10783
E	208	971	1239	1805	3108	1352	1928	7930	18973	5386
ESE	290	108C	1133	1387	2412	3728	8981	8028	4566	2956
SE	255	01?	1058	2202	4099	4045	4291	2703	2808	33!8
SSE	300	501	862	4173	26793	5114	3933	4956	2904	1679
S	230	779	2735	7824	3306	19375	3639	2335	4470	3672
SSW	270	612	1999	1932	604	553	1754	15380	7303	2330
SW	271	789	1448	2053	3920	16083	34964	9944	6065	7008
WSW	245	774	1235	1754	2102	3529	7733	6406	4426	8087
W	385	988	5653	2773	4434	31615	4554	3691	431	0
WNW	442	1377	3031	5610	6193	0	0	0	0	0
NW	562	875	5089	10694	1684	0	0	0	0	0
NNW	1557	1437	5501	35164	140551	659588	165353	79291	30752	2881
TOTAL	7371	17243	41423	100146	259010	865986	302340	209164	134277	92842

Table C.4. Hourly precipitation data for Salamanca, NY (site 307398) *

Rainfall during indicated hours of day (hundredths of inches)

YR MO DA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOT
78 01 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 01 02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 01 03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 01 04	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	20
78 01 08	0	0	0	0	0	0	0	0	10	0	0	0	0	0	10	0	0	10	0	20	10	10	10	0	80
78 01 09	10	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
78 01 10	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	10
78 01 13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	10
78 01 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	10
78 01 17	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	10	0	0	10	10	10	0	10	60
78 01 18	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 01 20	0	0	0	0	0	0	0	0	0	0	0	10	0	10	0	0	0	0	0	0	0	0	0	10	30
78 01 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10
78 01 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10
78 01 26	10	10	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50
78 01 28	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	20
78 02 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 02 02	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 02 05	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	10	20
78 02 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	10
78 02 07	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 02 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	10
78 02 25	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	20
78 03 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 03 03	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10
78 03 12	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 03 14	0	0	0	0	0	20	20	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	50
78 03 15	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 03 17	0	0	0	0	10	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	20
78 03 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	0	0	20
78 03 22	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	20
78 03 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10
78 03 26	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 04 01	0	0	10	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	20
78 04 03	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 04 04	0	0	0	0	0	0	0	0	0	0	0	10	0	0	20	10	10	0	10	30	20	10	0	0	120
78 04 06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	10	30
78 04 11	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	0	0	0	0	0	0	0	0	0	30
78 04 16	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 04 20	0	0	0	0	0	0	10	0	0	0	10	0	0	0	0	10	0	0	10	0	0	10	0	0	50
78 04 21	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 05 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 05 04	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10

Table C.4. Hourly precipitation data for Salamanca, NY (cont.)

Rainfall during indicated hours of day (hundredths of inches)

YR MO DA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOT
78 05 05	10	20	40	20	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	110
78 05 08	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	20	10	40
78 05 09	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	20
78 05 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	10
78 05 13	0	0	0	0	0	0	0	0	0	0	10	0	20	10	0	10	0	10	0	0	0	0	0	0	60
78 05 14	0	0	0	0	0	0	0	10	0	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	30
78 05 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10	10	30
78 05 17	10	0	20	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40
78 05 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	10	0	40
78 06 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 06 02	0	0	0	0	0	0	0	0	0	0	0	0	0	30	10	0	0	0	0	0	0	10	0	0	50
78 06 07	0	0	0	0	0	0	0	0	0	0	0	0	20	10	0	0	0	0	0	0	0	0	0	0	30
78 06 08	0	0	0	0	0	0	0	0	0	10	40	10	0	0	0	0	0	0	0	0	0	0	0	0	60
78 06 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	10	0	10	0	0	50
78 06 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	70	10	0	0	0	80
78 06 19	0	0	10	40	10	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80
78 06 21	0	0	0	0	0	0	0	0	20	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	30
78 06 27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	20
78 07 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 07 08	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	50	20	0	0	0	0	80
78 07 21	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	60	10	0	0	10	0	0	0	0	110
78 07 27	0	0	30	10	60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
78 07 29	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	10	30	20	0	0	0	0	70
78 07 31	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 08 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 08 03	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
78 08 06	0	0	10	0	0	0	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
78 08 07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	10
78 08 09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	10
78 08 10	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	10
78 08 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	20
78 08 19	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	20	20	30	10	0	0	90
78 08 28	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	10	40
78 08 30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	10
78 09 01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78 09 03	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 09 08	0	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
78 09 10	0	0	0	0	0	0	0	0	0	0	0	0	40	10	0	0	0	0	0	0	0	0	0	0	50
78 09 12	0	0	0	0	0	0	60	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90
78 09 15	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
78 09 16	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20

REFERENCES

Anspaugh, L. R., J. J. Shinn, P. L. Phelps, and N. C. Kennedy. 1975.
"Resuspension and redistribution of plutonium in soils." Health Phys.
29:571-582.

Baes, C. F., III, R. D. Sharp, A. L. Sjoreen, and R. W. Shor. 1982.
A Review and Analysis of Parameters for Assessing Transport of
Environmentally Released Radionuclides Through Agriculture. ORNL-
5786. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Dole, L. R., and D. E. Fields. 1981. "Summary of release mechanisms
workshop." In C. A. Little and L. E. Stratton (compilers), Modeling
and Low-Level Waste Management: An Interagency Workshop, pp. 343-350.
ORO-821, U.S Department of Energy, Oak Ridge Operations Office,
Oak Ridge, Tennessee.

Giardina, P. A., M. F. DeBonis, J. Eng, and G. L. Meyer. 1977. Summary
Report on the Low-Level Radioactive Waste Burial Site, West Valley,
New York (1963-1975). EPA-902/4-77-101, U.S. Environmental Protection
Agency, Region II, Regional Office of Radiation Programs, New York,
New York.

Kelleher, W. J. and E. J. Michael. 1973. Low Level Radioactive Waste
Burial Site Inventory for the West Valley Site, Cattaraugus County,
N.Y. New York State Department of Environmental Conservation, Albany,
New York.

McElroy, A. D., S. Y. Chin, J. W. Nebgen, A. Aleti, and F. W. Bennett.
1976. Loading Function for Assessment of Water Pollution from
Nonpoint Sources. USEPA report EPA-600/2-76-151 (Midwest Research
Institute, Kansas City, Missouri).

Moore, R. E., C. F. Baes III, L. M. McDowell-Boyer, A. P. Watson,
F. O. Hoffman, J. C. Pleasant, and C. W. Miller. 1979. AIRDOS-EPA:
A Computerized Methodology for Estimating Environmental Concentrations
and Dose to Man from Airborne Releases of Radionuclides. ORNL-5532.
Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Olson, R. J., C. J. Emerson, and M. K. Nungesser. 1980. Geoecology:
A County-Level Environmental Data Base for the Conterminous United
States. ORNL/TM-7351. Oak Ridge National Laboratory, Oak Ridge,
Tennessee.

Prudic, D. E. 1981. "Computer simulation of groundwater flow at a
commercial radioactive-waste landfill near West Valley, Cattaraugus
County, New York." In C. A. Little and L. E. Stratton (compilers),
Modeling and Low-Level Waste Management: An Interagency Workshop,
pp. 215-248. ORO-821, Department of Energy, Oak Ridge Operations
Office, Oak Ridge, Tennessee.

Ruffner, J. A. 1978. Climates of the States, 1 and 2. Gale Research Co., Book Tower, Detroit, Michigan.

Shor, R. W., C. F. Baes III, and R. D. Sharp. 1982. Agricultural Production in the United States By County: A Compilation of Information From The 1974 Census of Agriculture For Use In Terrestrial Food-Chain Transport And Assessment Models. ORNL-5768. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

U. S. Department of Energy. 1978. Western New York Nuclear Service Center Study: Companion Report. TID-28905-3. U.S. Department of Energy, Washington, D.C..

APPENDIX C

Input Data and Supporting Information for Example
Problem - West Valley, New York

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