Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant

Appendix PAR

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United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Area Office
Carlsbad, New Mexico

Parameters

CONTENTS

PARAMETER SHEETS

FIGURES

TABLES

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ACRONYMS

AIS	Air Intake Shaft
AMM	asphalt mastic mix
CCDF	complementary cumulative distribution function
CDF	cumulative distribution function
CH	contact-handled
DOE	Department of Energy
DRZ	disturbed rock zone
EPA	Environmental Protection Agency
FMT	fracture matrix transport
GTFM	Graph Theoretic Field Model
ID	identification number
LANL	Los Alamos National Laboratory
LHS	Latin hypercube sample
MB	marker bed
MU	map unit
PDF	probability distribution function
PNL	Pacific Northwest Laboratory
QA	quality assurance
QAP	Quality Assurance Procedure
RH	remote-handled
SMC	Salado Mass Concrete
SNL	Sandia National Laboratories
SSSPT	Small Scale Seal Performance Tests
SWCF	Sandia WIPP Central Files
TRU	transuranic
TWBIR	Transuranic Waste Baseline Inventory Report
WES	Waterways Experiment Station
WIPP	Waste Isolation Pilot Plant

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APPENDIX PAR

Appendix PAR contains documentation (that is, parameter sheets) for the 57 parameters which were sampled by the Latin hypercube sample (LHS) code during the performance assessment (see also Section 6.1.5 for discussion on probabilistic analyses and Section 6.1.5.2 for discussion on LHS). The results of the LHS sampling are contained in Appendix IRES (Intermediate Results). Additional information relevant to the parameters are contained in Appendices MASS, SOTERM, and WCA.

The parameter sheets for the sampled parameters appear in this appendix. In addition, fixed-value parameters used in the performance assessment codes are tabulated at the end of Appendix PAR. For additional information regarding all parameters, readers are referred to the parameter records packages which are contained in the Sandia National Laboratories (SNL) Waste Isolation Pilot Plant (WIPP) Central Files (SWCF).

PAR.1 Parameter Development Process

The development of parameter values is covered in Quality Assurance Procedure (QAP) *Quality Assurance Requirements for the Selection and Documentation of Parameter Values used in WIPP Performance Assessment* (QAP 9-2). The process includes documentation of parameter development by those responsible for completion of a particular experimental investigation, development of a system design, or by staff involved in the performance assessment modeling process. All of the references pertaining to parameter selection are contained within the three levels of parameter and data documentation: 1) WIPP Data Entry Form 464, 2) parameter records packages, and 3) supporting data records packages.

The WIPP Data Entry Form 464 is the highest level record documenting parameter development that includes application of statistics and interpretations. The WIPP Data Entry Form 464s include a source section which is a pointer to supporting information including, where applicable, the parameter records package(s). All values provided in Appendix PAR were derived from the WIPP performance assessment parameter database. These numbers may differ slightly from those contained in the Form 464s because of rounding.

The parameter records packages include a data and distribution summary, quality assurance (QA) status of the data and related interpretive numerical codes, references to related information, such as SAND reports, test plans, and related SWCF file codes, and, where applicable, a summary on the experimental data collection (that is, method used, assumptions made in testing, and interpretation). The parameter records packages point to the supporting data records packages. The data records packages contain information such as the raw data, analysis, and data interpretation.

Each WIPP Data Entry Form 464, parameter records package, and supporting data records packages are assigned unique WPO numbers. Copies of the Form 464s, parameter records package, and supporting data records packages are maintained in the SWCF.

WIPP performance assessment parameters are classified as follows:

Category 1) Parameters that do not fall into Categories 2 through 4 but are necessary to WIPP performance assessment calculations.

Category 2) Parameters representing the inventory of the waste to be emplaced in the WIPP as defined in the *Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report* (TWBIR) (DOE 1996) (included in this certification application as Appendix BIR).

Category 3) Parameters representing physical constants (for example, the half-life of a radionuclide, gravitational constant).

Category 4a) Parameters that are assigned based on an assumed correlation of properties between similar materials.

Category 4b) Parameters that are model configuration parameters.

PAR.2 Parameter Distributions

Probability distributions are used to characterize the uncertainty concerning the value of a parameter. Numbers that characterize a particular distribution include the range, the mean, median, and mode.

- *Range*. The range of a distribution can be denoted by (a,b), a pair of numbers in which a and b are minimum and maximum values of the parameter, respectively.

- *Mean*. Analogous to the arithmetic average of a series of numbers, the mean value of a probability distribution is one measure of the central tendency of a distribution. For nonsymmetrical distributions that are considerably skewed, the mean value may not lie near the median or mode (see below).

- *Median*. The median value of a probability distribution (denoted here by $x_{0.5}$) is the 50th percentile, the value in the distribution range at which 50 percent of all values lie above and below.

- *Mode*. The mode is the most probable value of the uncertain parameter; that is, the maximum value of the associated probability density function (PDF).

PAR.2.1 Distribution Types and Applications

Distributions used to characterize uncertainty in parameters of the performance assessment include: uniform, cumulative, triangular, Student's-t, delta, normal, loguniform, logcumulative, lognormal, and constant.

Uniform Distribution

Density Function: $f(x) = \dfrac{1}{B-A} \qquad A \le x \le B$

Distribution Function: $F(x) = \dfrac{x-A}{B-A} \qquad A \le x \le B$

Expected Value and Variance: $E(X) = \dfrac{A+B}{2} \qquad V(X) = \dfrac{(B-A)^2}{12}$

Median: $X_{0.5} = \text{mean}$

Use of the uniform distribution is appropriate when all that is known about a parameter is its range (a,b); the uniform distribution is the *Maximum Entropy* distribution under these circumstances (Tierney 1990).

Cumulative Distribution

A cumulative cistribution (also called a *constructed distribution*) is described by a set of N ordered pairs:

$$(x_1,0),\ (x_2,P_2),\ (x_3,P_3),\ \ldots,\ (x_N,1) \quad \{\text{i.e., } P_1 = 0 \text{ and } P_N = 1 \text{ always}\}$$

where $x_1 < x_2 < x_3 < \ldots < x_N$ and $0 < P_2 < P_3 < \ldots < P_{N-1} < 1$

Because of the nature of the data, the PDF for this distribution takes the form:

$$P(\xi) = \begin{cases} 0 & \text{if } \xi < x_i \\ \dfrac{P_n - P_{n-1}}{x_n - x_{n-1}} & \text{if } x_{n-1} \le \xi \le x_n,\ n = 2,3,\ldots,N \\ 0 & \text{if } \xi \ge x_N \end{cases}$$

and so the cumulative distribution function (CDF) takes the form:

$$P_r\,[X \le \xi] \approx \Pi(\xi) = \begin{cases} 0 & \text{if } \xi < x_i \\ P_{n-1} + \dfrac{(P_n - P_{n-1})(\xi - x_{n-1})}{(x_n - x_{n-1})} & \text{if } \dfrac{x_{n-1} \le \xi \le x_x}{n = 2,3,\ldots,N} \\ 1 & \text{if } \xi > x_N \end{cases}$$

Expected Value: $$E(X) = \sum_{n=2}^{N} (P_n - P_{n-1}) \frac{(x_n + x_{n-1})}{2}$$

Variance: $$V(X) = \sum_{n=2}^{N} (P_n - P_{n-1}) \frac{(x_n^2 + x_n x_{n-1} + x_{n-1}^2)}{3} - \{E(X)\}^2$$

Median: $$x_{0.50} = x_{m-1} + (x_m - x_{m-1} \frac{(0.50 - P_{m-1})}{(P_m - P_{m-1})} \quad \text{where } P_{m-1} \le 0.50 < P_m.$$

The cumulative distribution takes its name from the fact that it closely resembles the empirical CDF obtained by plotting the empirical percentiles of the data set (x_1,x_2,x_3, ..., x_N) (Blom 1989, 216). The cumulative distribution used here is the result of plotting the *subjectively determined* percentile points (x_1,P_1), (x_2,P_2), (x_3,P_3) ... , that arise in a formal elicitation of expert opinion concerning the form of the distribution of the parameter in question. A simple form of the cumulative distribution is used when the range (a,c) of the parameter is known and the analyst believes that his or her best estimate value, b, is also the median (or 50th percentile) of the unknown distribution. In this case, the subjectively determined percentile points take the form: (a, 0.0), (b, 0.5), (c, 1.0) (Tierney 1990).

The cumulative distribution is the *Maximum Entropy* distribution associated with a set of percentile points (x_1,P_1), (x_2,P_2), ..., (x_N, P_N), no matter how that set of percentile points is obtained (that is, independent of whether the points are empirically or subjectively derived) (Tierney 1990).

Triangular Distribution

Density Function: $$f(x) = \frac{2(x-a)}{(c-a)(b-a)} \qquad a \le x \le b$$

$$= \frac{2(c-x)}{(c-a)(c-b)} \qquad b \le x \le c$$

Distribution Function:

$$F(x) = \frac{(x-a)^2}{(c-a)(b-a)} \qquad a \le x \le b$$

$$= \frac{(b-a)}{(c-a)} - \frac{(x+b-2c)(x-b)}{(c-a)(c-b)} \qquad b \le x \le c$$

Expected Value:

$$E(X) = \frac{a+b+c}{3}$$

Variance:

$$V(X) = \frac{a(a-b)+b(b-c)+c(c-a)}{18}$$

Median:

$$X_{0.5} = a + \sqrt{\frac{(c-a)(b-a)}{2}} \qquad \text{if } b \ge \frac{a+c}{2}$$

$$= c - \sqrt{\frac{(c-b)(c-a)}{2}} \qquad \text{if } b \le \frac{a+c}{2}$$

The triangular distribution is defined on the range (a,c) and has mode b. The mode can equal either of the two boundary values, which may simplify the computations above (Iman and Shortencarier 1984).

Use of the triangular distribution is appropriate when the range, (a,c), of the parameter is known and the analyst believes that his or her best estimate value, b, is also the mode (or *most probable value*) of the unknown distribution.

Student's-t Distribution

A Student's-t distribution is a Bayesian distribution for the unknown mean value of a parameter. Its use is appropriate when one has *measured* values of the parameter available (in contrast to values obtained subjectively through elicitation of professional opinion). If N denotes the number of measurements available, and X_1, X_2, X_3, ... , X_N denote the values of the measurements, then the *expected value* or *mean* of the Student's-t distribution is the sample standard deviation divided by $\sqrt{N}$; the *median value* is equal to the mean value.

The Student's-t distribution applies when there are few measurements, say 3<N<10. For large N, say N>20, there is little difference between the t-distribution and a normal distribution (see below) with the same mean and standard deviation.

Delta Distribution

The delta distribution is used to assign probabilities to the elements of some set of objects. For example, if the set consists of four alternative mathematical models of some phenomena and each model is labeled with one of the integers {1,2,3,4}, in other words,

$$M_1, M_2, M_3, M_4$$

then we might assign the vector of probabilities (p_1, p_2, p_3, p_4), where each p_i is a number between 0 and 1 and

$$p_1 + p_2 + p_3 + p_4 = 1.$$

The CDF associated with this delta distribution can be symbolically expressed by

$$F(x) = \sum_{n=1}^{4} p_n u(x-n).$$

The graph of this CDF can be visualized as an ascending staircase starting at zero level for x less than one, and having steps of height p_n at the points $x = 1, 2, 3, 4$.

The notion of mean value and variance still apply to a delta distribution, but the meanings of these quantities may require careful interpretation. If the M_n represent four different functions (say, discharge as a function of pressure), then it makes sense to talk about mean and variance functions. For the example of the four alternative mathematical models, the mean mathematical model is the linear combination

$$\bar{M} = \sum_{n=1}^{4} p_n M_n$$

and the variance of the models is similarly defined:

$$\Sigma^2 = \sum_{n=1}^{4} p_n \left(\bar{M} - M_n\right)^2$$

The notion of median value is meaningless for a delta distribution.

Normal Distribution

Density function:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{\frac{-(x-\mu)^2}{2\sigma^2}\right\} \quad -\infty < x < \infty$$

Distribution function:

$$F(x) = \int_{-\infty}^{x} f(t)\,dt \quad -\infty < x < \infty$$

Expected value and variance: $E(X) = \mu$ and $V(X) = \sigma^2$.

The WIPP Performance Assessment Program employs a truncated normal distribution where data are concentrated within an interval (lowrange, hirange) (Iman and Shortencarier 1984). The parameters of the truncated distribution can be expressed as follows:

$$E(X) = \mu = \frac{(lowrange + hirange)}{2} \qquad V(X) = \sigma^2 = \left(\frac{hirange - lowrange}{6.18}\right)^2$$

Median = mean (μ) and *lowrange* = 0.01 quantile, *hirange* = 0.99 quantile. The range of the random variable is arbitrarily set to (*lowrange*, *hirange*). Alternatively, the expected value μ and the standard deviation σ can be specified by the user of this distribution; in this case, the random variable takes on the range $(-\infty, \infty)$ and will need to be truncated to a finite interval and renormalized.

Use of the normal distribution is appropriate when it is known that the parameter is the sum of independent, identically-distributed random variables (this is seldom the case in practice) and there are a sufficient number of measurements of the parameter (N > 10) to make accurate, unbiased estimates of the mean (μ) and variance (σ^2) (Sandia WIPP Project 1992; Tierney 1990).

Loguniform Distribution

If X has a loguniform distribution on the interval from A to B where B > A > 0, then $Y = \log_{10} X$ has a uniform distribution from $\log_{10} A$ to $\log_{10} B$ (Iman and Shortencarier 1984).

Density Function:

$$f(x) = \frac{1}{x}(\ln B - \ln A) \qquad A < x < B$$

Distribution Function: $$F(x) = \frac{\ln x - \ln A}{\ln B - \ln A} \qquad A < x < B$$

Expected Value: $$E(X) = \frac{B - A}{\ln B - \ln A}$$

Variance: $$V(X) = (B - A)\left[\frac{(\ln B - \ln A)(B + A) - 2(B - A)}{2(\ln B - \ln A)^2}\right]$$

Median: $$X_{0.5} = \sqrt{AB}$$

Use of the loguniform distribution is appropriate when all that is known about a parameter is its range (a,b) and B/A » 10; that is, the range (a,b) spans many orders of magnitude.

Logcumulative Distribution

In this case, the independent variable is Y, where Y = log X. As with the cumulative distribution, this distribution is described by a set of N ordered pairs:

$$(y_1,0),\ (y_2,P_2),\ (y_3,P_3),\ \ldots,\ (y_N,1) \quad \{\text{that is, } P_1 = 0 \text{ and } P_N = 1 \text{ always}\}$$

where $y_1 < y_2 < y_3 < \ldots < y_N$ and $0 < P_2 < P_3 < \ldots < P_{N-1} < 1$

Because of the nature of the data, the PDF for this distribution takes the form:

$$P(\xi) = \begin{cases} 0 & \text{if } \xi < x_i \\ \dfrac{P_n - P_{n-1}}{\ln x_n - \ln x_{n-1}}\,\dfrac{1}{\xi} & \text{if } x_{n-1} \le \xi \le x_n,\ n = 2, 3, \ldots, N \\ 0 & \text{if } \xi \ge x_N \end{cases}$$

and so the CDF takes the form:

$$P_r\, X \le \xi = \begin{cases} 0 & \text{if } \xi < x_1 \\ P_{n-1} + \dfrac{(P_n - P_{n-1})(\ln \xi - \ln x_{n-1})}{(\ln x_n - \ln x_{n-1})} & \text{if } \dfrac{x_{n-1} \le \xi \le x_x}{n = 2, 3, \ldots, N} \\ 1 & \text{if } \xi > x_N \end{cases}$$

Expected Value: $$E(X) = \sum_{n=2}^{N} (P_n - P_{n-1}) \frac{(x_n - x_{n-1})}{\ln x_n - \ln x_{n-1}}$$

Variance: $$V(X) = \sum_{n=2}^{N} \frac{1}{2} (P_n - P_{n-1}) \frac{(x_n^2 - x_{n-1}^2)}{(\ln x_n - \ln x_{n-1})} - \{E(X)\}^2$$

Median:

$$X_{0.5} = 10^{**} \left\{ x_{m-1} + (x_m - x_{m-1}) \frac{(0.50 - P_{m-1})}{(P_m - P_{m-1})} \right\} \quad \text{where } P_{m-1} \le 0.50 \le P_m.$$

Lognormal Distribution

If $X \sim N(\mu, \sigma^2)$ and $Y = e^X$, the Y has a lognormal distribution.

Density function: $$f(y) = \frac{1}{y\sigma\sqrt{2\pi}} \exp\left\{ \frac{-(\ln y - \mu)^2}{2\sigma^2} \right\} \quad y > 0$$

Distribution function: $$F(x) = \int_0^y f(t)\,dt \quad y > 0$$

Expected value and variance: $$E(Y) = \exp\left(\mu + \frac{\sigma^2}{2} \right) \qquad V(Y) = \exp(2\mu + \sigma^2)[\exp(\sigma^2) - 1]$$

Median: $$X_{0.5} = e^{\mu}$$

As with the normal distribution, the lognormal distribution requires lowrange and hirange values. These values are in logarithmic form and are utilized in a normal distribution to determine a mean (μ) and a variance (σ^2), which in turn are used to identify the expected value and variance for the lognormal distribution (Iman and Shortencarier 1984).

Constants

Parameters may also be assigned a constant value in the performance assessment parameter database. These parameters are tabulated at the end of the appendix.

PAR.3 Key to Parameter Sheets

The parameter sheets included in this appendix contain a variety of information, some of which is extracted from the WIPP performance assessment parameter database. Information presented in the parameter sheets is grouped into boxes labeled as follows:

Parameter(s): The name of the parameter and the disposal system feature with which it is associated.

Parameter Description: The Parameter Description box defines the parameter and, where appropriate, explains the role of the parameter in the modeling.

Material and Parameter Name(s): This box provides a link to the performance assessment parameter database. The parameter label listed first is taken from the performance assessment model parameter database field IDMTRL, which identifies the type of material in the disposal system being modeled (for example, S_MB139 means Salado Marker Bed [MB] 139). The second label describes the performance assessment model parameter name for the physical or operational meaning for the parameter (for example, SAT_RBRN means residual brine saturation). The number associated with a parameter is the unique identification number (ID) established in the WIPP performance assessment parameter database.

Computational Code(s): A list of the current computational models used by the Performance Assessment Department that require specification of the parameter.

Parameter Statistics: The box identifies the mean, median (or mode in the case of a triangular distribution), maximum, minimum, and standard deviation of the parameter distribution. All values provided in Appendix PAR were derived from the WIPP performance assessment parameter database. These numbers may differ slightly from those contained in the Form 464s because of rounding.

Units: The physical units of the parameters (usually expressed in metric units).

Distribution Type: This box identifies the type of parameter distribution (see Section PAR.2.1).

CDF/PDF Graph: This box contains graphs of an empirical CDF. The graphs were produced using the 100 values that were sampled with the LHS procedure used in the performance assessment calculations (note the irregularities in the curves owing to the finite sample size).

The mean, median, and the standard deviation of the parameter's distribution are plotted on the graph of the empirical CDF.

Data: The basis for the parameter values or parameter distribution is provided in this section. All values provided in Appendix PAR were derived from the WIPP performance assessment parameter database. These numbers may differ slightly from those contained in the Form 464s because of rounding. The parameters are derived from the following kinds of data and information:

- *Site-specific or waste-specific experimental data.* This data includes information obtained from in-situ experiments and research conducted at off-site laboratories (for example, permeability data, microbial gas generation). This category also includes simulated waste experiments and may indicate correlations made with other material regions based on professional judgment.

- *Waste-specific observational data.* This category includes data obtained through observation or empirical analysis, such as semi-quantitative and qualitative visual characterization or acceptable knowledge of transuranic (TRU) waste (for example, waste components).

- *Professional judgment.* This category of information may involve the use of experimental or observational data from other non-WIPP contexts; interpreting information obtained from the general literature; or may be based on general engineering knowledge (see below).

  Professional judgment is synonymous with performance assessment category 4 parameters; in some cases, professional judgment can be used in assigning values to category 1 parameters.

- *General Literature Data.* This category of information includes that obtained from reports, journal articles, or handbooks relevant to systems or processes being modeled in the performance assessment. It is often employed in conjunction with professional judgment.

- *General Engineering Knowledge.* This category of information identifies parameter values obtained from knowledge of standard engineering principles.

Readers are referred to parameter records packages and associated data packages maintained in the SWCF for additional information.

Discussion: This section identifies the source(s) of parameter value(s) and the rationale for the parameter distribution and may clarify use of a particular parameter. Other relevant background information is also included in this section, where clarification is appropriate.

References: All of the references pertaining to parameter selection are contained within the three levels of parameter and data documentation: 1) WIPP Data Entry Form 464, 2) parameter records packages, and 3) supporting data records packages. Selected references cited in the parameter records packages are included in the parameter sheets to establish data quality. In addition, selected memoranda cited in the parameter sheets are contained in Appendix MASS for convenience.

PAR.4 Parameter Correlation

Parameter correlations used in performance assessment are exclusively in LHS. Consequently, parameter correlations affect only sampled parameters described in the attached parameter sheets. Two types of parameter correlations are used, defined as explicit parameter correlation and induced parameter correlation. This section addresses the following criteria concerning parameter correlations, as specified in 40 CFR § 194.23(c)(6):

> (c) Documentation of all models and computer codes included as part of any compliance application performance assessment calculation shall be provided. Such documentation shall include, but shall not be limited to:
> (6) An explanation of the manner in which models and computer codes incorporate the effects of parameter correlation.

Explicit parameter correlations are introduced or prohibited in LHS by the restricted pairing technique of Iman and Conover (1982). Three parameter correlations are specified in this performance assessment through this technique. These correlations are all related to rock compressibility and permeability. In the MB139 material region in BRAGFLO, rock compressibility (COMP_RCK, ID # 580) and intrinsic permeability (PRMX_LOG, ID #591) are inverse-correlated with a correlation coefficient of -0.99. In the Salado impure halite material region in BRAGFLO, rock compressibility (COMP_RCK, ID #19) and intrinsic permeability (PRMX_LOG, ID #18) are inverse correlated with a correlation coefficient of −0.99 (BRAGFLO). In the Castile brine reservoir material region in BRAGFLO, rock compressibility (COMP_RCK, ID #29) and intrinsic permeability (PRMX_LOG, ID #28) are inverse correlated with a correlation coefficient of −0.75. Explicit parameter correlation is not used to correlate other sampled parameters.

Rock compressibilities and intrinsic permeabilities are correlated to be most consistent with interpretations of the hydraulic tests that have been performed in these units. In hydraulic testing, hydraulic diffusivity, the ratio of permeability to compressibility, is determined more precisely than either permeability or compressibility alone. Introducing the correlation of the permeability and compressibility parameters in performance assessment better represents the knowledge of the formation gained from hydraulic testing than specifying no correlation whatsoever.

An induced correlation in performance assessment is created when a parameter sampled in LHS (the underlying variable) is used to define the values of other parameters (defined variables). This is a prevalent method of correlation in this performance assessment. For example, uncertainty in dissolved actinide oxidation states is represented in LHS by sampling the OXSTAT parameter (ID #3417). The results of this sampling are used in part to determine actinide solubilities (NUTS and PANEL), colloidal actinide concentrations (NUTS and PANEL), and K_D values (SECOTP2D) used for a particular vector. Selected examples of other induced parameter correlations include:

- the underlying variable x-direction permeability and the defined variables y- and z-direction permeabilities in many materials (BRAGFLO),
- the underlying variable x-direction permeability and defined variable threshold pressure in many materials (BRAGFLO),
- the underlying variable americium properties and the defined variable curium properties (NUTS, PANEL, and SECOTP2D),
- the underlying variable Lower Salado Clay permeability and the defined variable permeabilities of other clay members of the shaft seal system (BRAGFLO),
- the underlying variable residual gas saturation (or other two-phase flow parameters) in many materials and the defined variable residual gas saturation (or other two-phase flow parameters) in other materials (BRAGFLO), and
- the underlying variable CUMPROB and the defined variables of time-dependent permeabilities of the compacted salt seal permeabilities in the shaft. Where relevant, parameter sheets in Appendix PAR contain information related to parameter correlation.

No correlations were used in this performance assessment for certain parameters used to describe transport in the Culebra for which the possibility of correlation might be suspected. The treatment in performance assessment is most consistent with available information, because, as discussed in Appendix MASS (Attachments MASS 15-10 and 15-6, 14), correlation of well-to-well transmissivity versus well-to-well advective porosity and matrix block length is not evident in existing data, nor is the correlation between advective porosity and matrix block length.

There are four additional ways in which parameter correlations may be considered to be used in this performance assessment, although they are not typically discussed as correlations *per se*. In a given LHS sample element, there is a correlation of 1 (100 percent) between the single observation of subjective uncertainty (the LHS sample for a complementary cumulative distribution function (CCDF) with all of the sequences of random future events (scenarios) used to construct a CCDF. This is discussed in Chapter 6.0, Section 6.1.

A correlation is made between the scenario being considered and the chemical properties (chemical composition) of brine in the repository (the physical properties viscosity and density are assumed to be the same for all scenarios). Brine composition affects actinide solubility. For undisturbed performance and E2 scenarios, brine composition is considered to be that of Salado brine. For the E1 and E1E2 scenarios, the brine composition is considered to be that of Castile brine. This is discussed in Chapter 6.0 (Section 6.4.3.4).

There are some correlations made in the construction of a CCDF regarding the similarity of events in a sequence of random future events. For example, the volume released by particulate spall and direct brine flow to the surface during an intrusion event are assumed to be the same for the third and subsequent intrusions into the repository as they were for the second intrusion. This is discussed in Chapter 6.0 (Section 6.4.13).

Finally, there are also correlations among model parameters developed explicitly by the governing equations of computational models used. For example, the porosity of nodal blocks in BRAGFLO is a function of the initial porosity, pressure change, and compressibility. These types of relationships among parameters are documented in the appendices for specific codes.

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Tierney, Martin. 1990. *Constructing Probability Distributions of Uncertain Variables in Models of the Performance of the Waste Isolation Pilot Plant: The 1990 Performance Simulations.* SAND90-2510, Sandia National Laboratories, Albuquerque, NM. WPO 23860.

Parameter 1: Inundated Corrosion Rate for Steel Without CO_2 Present

Parameter Description:

This parameter is used to describe the rate of anoxic steel corrosion under brine inundated conditions and with no CO_2 present (see Appendix BRAGFLO, Section 4.13).

Material and Parameter Name(s):

STEEL CORRMCO2 (#2907)

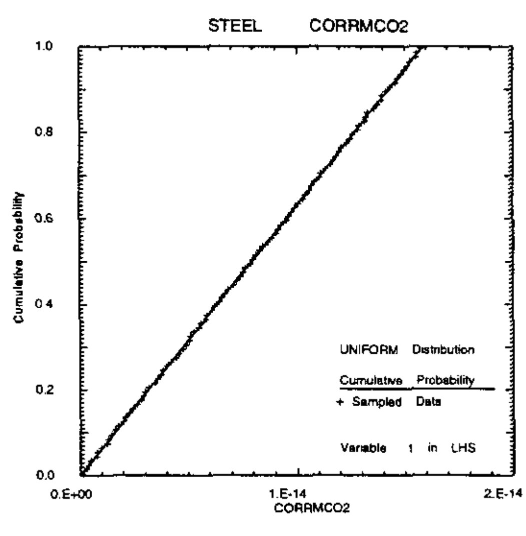
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
7.937×10^{-15}	7.937×10^{-15}	0	1.587×10^{-14}	0

Units: m/s

Distribution Type: Uniform

CDF/PDF Graph



Parameter 1: Inundated Corrosion Rate for Steel Without CO_2 Present (Continued)

Data: Site- Specific Experimental Data

The parameter records package associated with this parameter is located at SWCF-A:WBS1.1.09.1.1:PDD:QA:Estimates of Gas Generation (WPO 30819).

Discussion:

Without CO_2 present, anoxic steel corrosion will proceed via the reaction: $Fe^{\circ} + 2H_2O = Fe(OH)_2 + H_2$. The upper limit of the parameter is determined from long-term anoxic steel corrosion experiments. The minimum rate is set to zero because experimental work indicates that salt crystallization on the steel surface could potentially prevent steel corrosion (Wang and Brush 1996).

WIPP Data Entry Form #464 WPO#: 34357

References:

Wang, Y. and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996.

Parameter 2: Probability of Microbial Degradation of Plastics and Rubbers in the Waste in the Event of Significant Microbial Gas Generation

Parameter Description:

This parameter is used to index alternative models of microbial degradation of plastics and rubbers in the waste in the repository in the event of significant microbial gas generation. It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Parameter Name(s):

WAS_AREA	PROBDEG (#2823)
REPOSIT	PROBDEG (#2824)

Computational Code: BRAGFLO

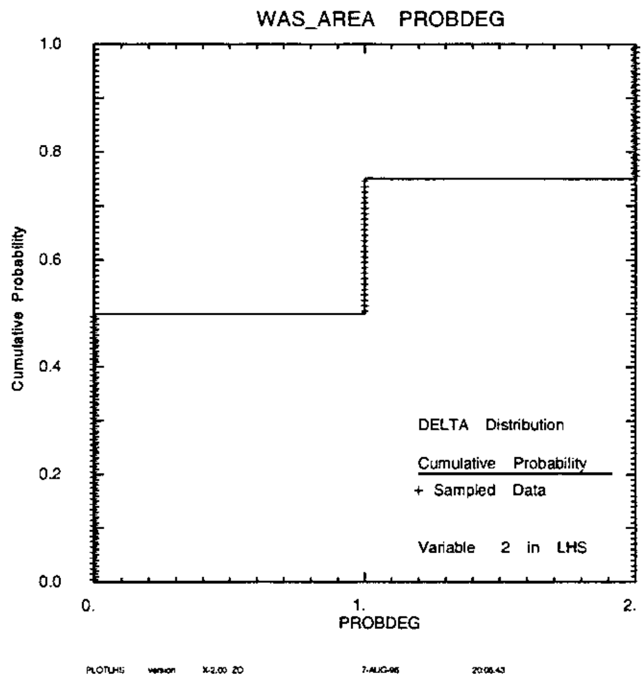
mean	median	minimum	maximum	std. deviation
n.a.	n.a.	0	2	n.a.

Units: None

Distribution Type: Delta (see Figure PAR-1 for values.)

Parameter 2: Probability of Microbial Degradation of Plastics and Rubbers in the Waste in the Event of Significant Microbial Gas Generation (Continued)

CDF/PDF Graph



Data: General Engineering Knowledge - Professional Judgment

A discussion of the data associated with this parameter may be found in Tierney (1996) and the following parameter records package: SWCF-A:WBS1.1.09.1.1:PDD:QA:Estimates of Gas Generation (WPO 30819).

Discussion:

Cellulosics, plastics, and rubbers have been identified as the major organic materials to be emplaced in the WIPP repository (DOE/CAO 1996) and could be degraded by microbes in 10,000 years. The occurrence of significant microbial gas generation in the repository will depend on: (1) whether microbes capable of consuming the emplaced organic materials will be present and active; (2) whether sufficient electron acceptors will be present and available; and (3) whether enough nutrients will be present and available. Considering uncertainties in evaluation of these factors and also in order to bracket all possible effects of gas generation on the WIPP performance assessment, a probability of 50 percent is assigned to the occurrence of significant microbial gas generation (Wang and Brush 1996).

Parameter 2: Probability of Microbial Degradation of Plastics and Rubbers in the Waste in the Event of Significant Microbial Gas Generation (Continued)

Discussion (Continued):

There are two factors that may potentially increase the biodegradability of these materials: long time scale and cometabolism. Over a time scale of 10,000 years, plastics and rubbers may change their chemical properties and therefore their biodegradability.

Cometabolism means that microbes degrade an organic compound, but do not use it or its constituent elements as a source of energy; these are derived from other substrates (Alexander 1994). In the WIPP repository, plastics and rubbers, which are resistant to biodegradation, may still be cometabolized with cellulosics and other more biodegradable organic compounds. Because of these uncertainties, a probability of 50 percent is assigned to the biodegradation of plastics and rubbers in the event of significant microbial gas generation (Wang and Brush 1996).

The distribution for PROBDEG parameter is illustrated in Figure PAR-1. The parameter value ranges over the integers from 0 (no significant microbial gas generation) to 2 (significant microbial gas generation with degradation of plastics and rubbers); the third choice, a parameter value of 1, represents significant microbial gas generation without degradation of plastics and rubbers. The default, or median, value is assumed to be 2 since it is the case of highest gas generation (Tierney 1996).

WIPP Data Entry Form #464 WPO#: 34881

References:

Alexander, M. 1994. *Biodegradation and Bioremediation.* Academic Press, N.Y. At New Mexico Tech. Still in print per BIP.

DOE/CAO. 1996. *Transuranic Waste Baseline Inventory Report* (Rev. 2). DOE/CAO-95-1121.

Tierney, M. 1996. Memorandum to File, Re: Reasons for choice of the PROBDEG parameter (id nos. 2824 and 2823) on February 22, 1996, March 29, 1996 (contained in WPO 34881).

Wang, Y., and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. WPO 31943.

Parameter 2: Probability of Microbial Degradation of Plastics and Rubbers in the Waste in the Event of Significant Microbial Gas Generation (Continued)

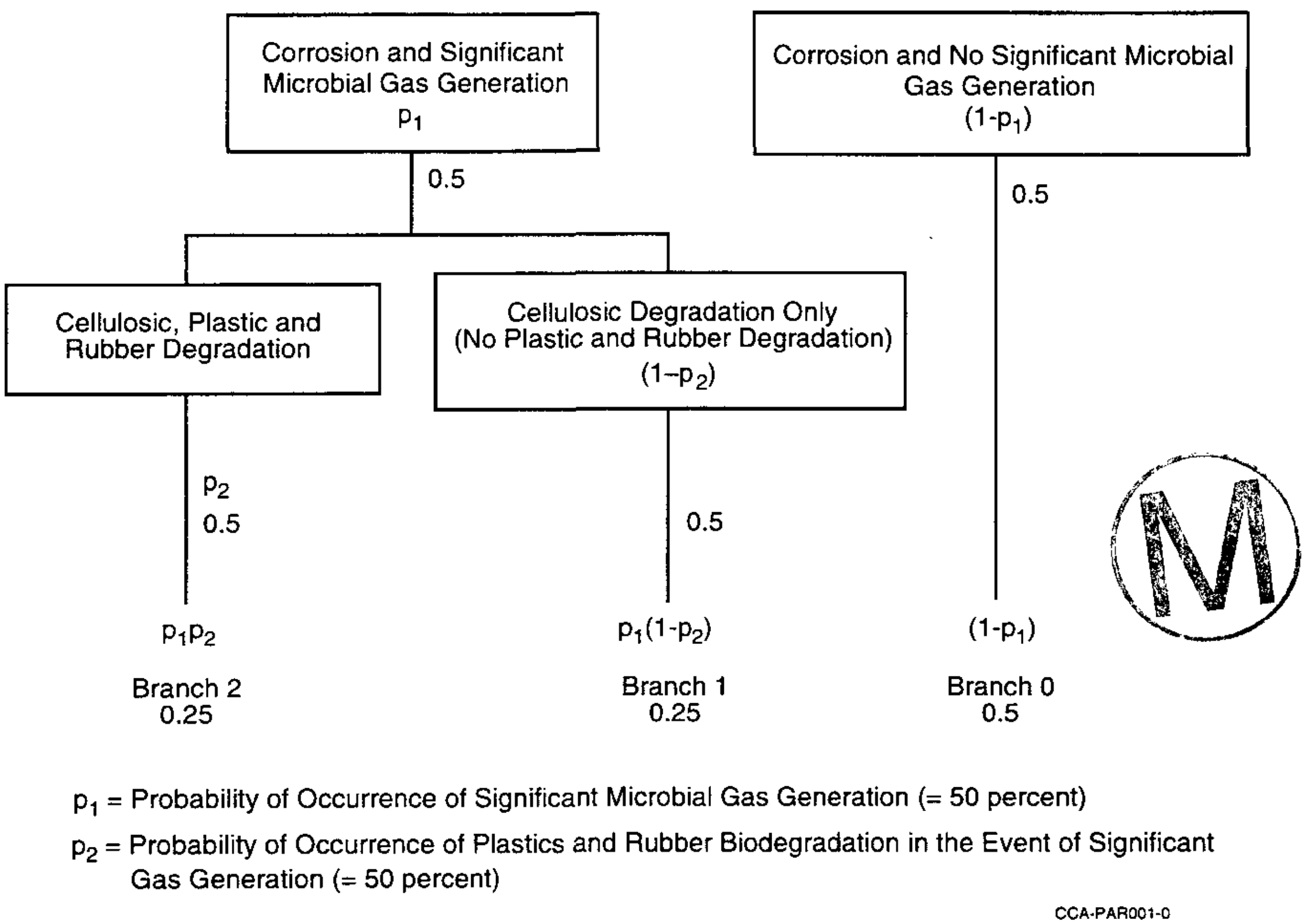


Figure PAR-1. Logic Diagram for Possible Outcomes and Probabilities for the Parameter PROBDEG (Modified From Tierney 1996)

Parameter 3: Biodegradation Rate of Cellulosics Under Brine-Inundated Conditions

Parameter Description:

This parameter is used to describe the rate of cellulosics biodegradation under anaerobic, brine-inundated conditions (see Appendix BRAGFLO, Section 4.13). It is a sampled parameter for the waste emplacement area and the waste and the values are then applied to the repository regions outside of the panel region.

Material and Parameter Name(s):

WAS_AREA	GRATMICI (#657)
REPOSIT	GRATMICI (#2128)

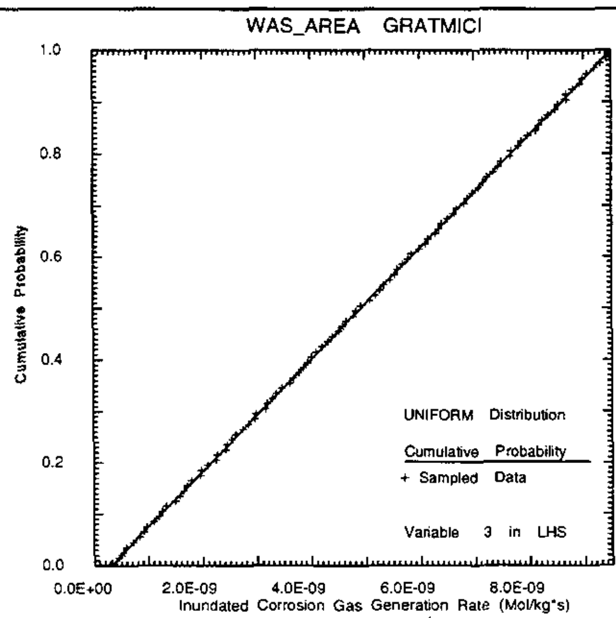
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
4.915×10^{-9}	4.915×10^{-9}	3.171×10^{-10}	9.5129×10^{-9}	0

Units: mol/kg*s

Distribution Type: Uniform

CDF/PDF Graph



Parameter 3: Biodegradation Rate of Cellulosics Under Brine-Inundated Conditions (Continued)

Data: Site-Specific Experimental Data

The parameter records package associated with this parameter is located at: SWCF-A:WBS1.1.09.1.1:PDD:QA:Estimates of Gas Generation (WPO 30819).

Discussion:

The maximum rate is estimated using the data obtained from both NO_3^- - and nutrients-amended experiments, whereas the minimum rate is derived using the data obtained from the inoculated-only experiments without any nutrient and NO_3^- amendment. The rates were calculated from the initial linear part of the experimental curve of CO_2 vs. time by assuming that cellulosics biodegradation in those experiments were nitrate- or nutrient-limited (Wang and Brush 1996).

WIPP Data Entry Form #464 WPO#: 34928

References:

Wang, Y. and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. WPO 31943.

Parameter 4: Biodegradation Rate of Cellulosics Under Humid Conditions

Parameter Description:

This parameter is used to describe the rate of cellulosics biodegradation under anaerobic, humid conditions (see Appendix BRAGFLO, Section 4.13). It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Parameter Name(s):

WAS_AREA GRATMICH (#656)
REPOSIT GRATMICH (#2127)

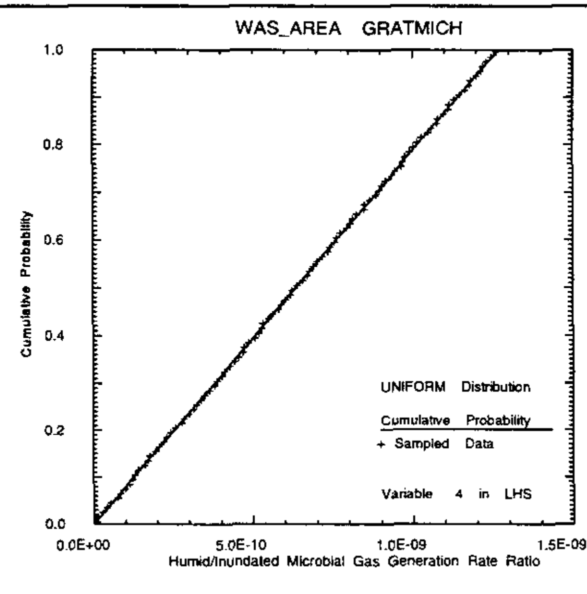
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
6.342×10^{-10}	6.342×10^{-10}	0.0	1.2684×10^{-9}	0

Units: mol/kg*s

Distribution Type: Uniform

CDF/PDF Graph



Parameter 4: Biodegradation Rate of Cellulosics Under Humid Conditions (Continued)

Data: Site-Specific Experimental Data

The parameter records package associated with this parameter is located at: SWCF-A:WBS1.1.09.1.1:PDD:QA:Estimates of Gas Generation (WPO 30819).

Discussion:

The maximum rate was estimated from cellulosics biodegradation experiments under anaerobic, humid conditions. The minimum rate is set to zero, corresponding to the cases where microbes become inactive because of water or nutrient stresses (Wang and Brush 1996).

WIPP Data Entry Form #464 WPO#: 34923

References:

Wang, Y. and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. WPO 31943.

Parameter 5: Factor β for Microbial Reaction Rates

Parameter Description:

Factor β is an index that characterizes the stoichiometry used to calculate the microbially-generated gas, accounting for interaction with gases reacting with steel and steel corrosion products (see Appendix BRAGFLO, Section 4.13).

Material and Parameter Name(s):

CELLULS FBETA (#2994)

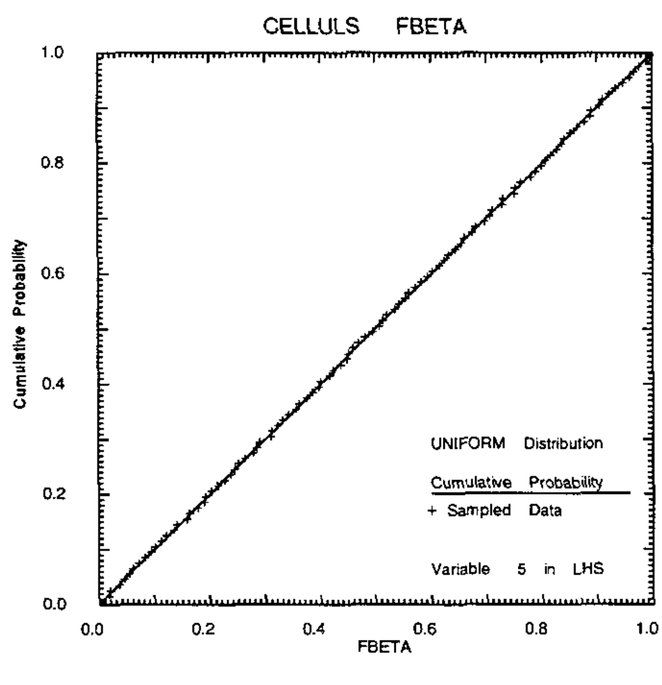
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.5	0.5	0	1.0	0.29

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 5: Factor β for Microbial Reaction Rates (Continued)

Data: Site-Specific Experimental Data

The parameter records package associated with this parameter is located at: SWCF-A:WBS1.1.09.1.1:PDD:QA:Estimates of Gas Generation (WPO 30819).

Discussion:

Microbially-generated gases CO_2 and H_2S may react with steel and steel corrosion products. Factor β characterizes the extent of CO_2 and H_2S consumption by those reactions: see Equation (18) in Wang and Brush 1996.

WIPP Data Entry Form #464 WPO#: 31826

References:

Wang, Y. and Brush, L. 1996. Memorandum to Martin Tierney, Re: Estimates of Gas-Generation Parameters for the Long-Term WIPP Performance Assessment, January 26, 1996. WPO 31943.

Parameter 6: Residual Gas Saturation - Repository

Parameter Description:

The residual (critical) gas saturation (S_{gr}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. S_{gr} corresponds to the degree of waste-generated gas saturation necessary to create an incipient interconnected pathway in porous material, a condition required for porous rock to be permeable to gas. Below values of the S_{gr}, gas is immobile. It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Parameter Name(s):

WAS_AREA SAT_RGAS (#671)
REPOSIT SAT_RGAS (#2137)

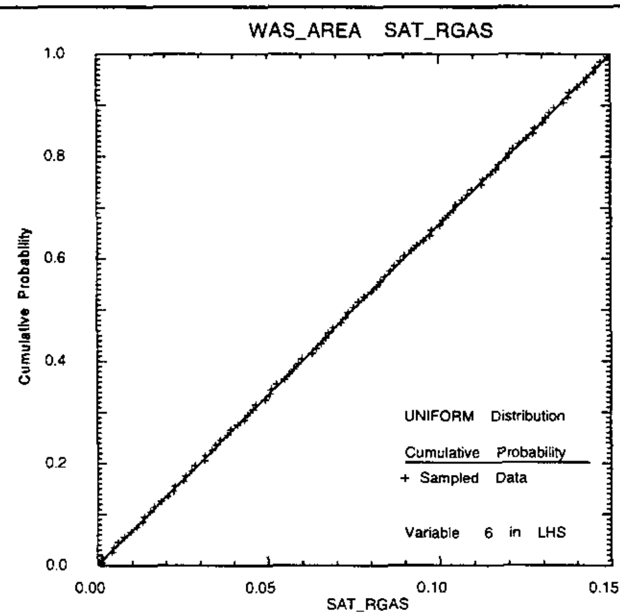
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.075	0.075	0	0.15	0.04

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 6: Residual Gas Saturation - Repository (Continued)

Data: General Literature and Professional Judgment

The parameter values are based on a November 15, 1995 Solutions Engineering letter report to D.M. Stoelzel of Sandia National Laboratories entitled "Critical (residual) Gas Saturation Recommendations for WIPP."

Discussion:

Under conditions of chemical and biochemical gas generation and repository closure, gas saturation may increase to a level where the pore network in repository material regions becomes connected and gas permeability begins to increase. The lowest gas saturation at which continuous gas flow will occur is the residual (critical) gas saturation (S_{gr}). In a review of studies involving S_{gr}, Solutions Engineering (1996) reports values ranging from 0 to 27 percent. The assigned range for S_{gr} between 0 to 15 percent is consistent with recommendations in the Solutions Engineering report.

WIPP Data Entry Form #464 WPO#: 34905

References:

Solutions Engineering. 1996. "Critical Gas Saturation Recommendations for WIPP." Letter Report to D.M. Stoelzel, Sandia National Laboratories, November 15, 1995, Albuquerque, New Mexico. WPO 38769.

Parameter 7: Residual Brine Saturation - Repository

Parameter Description:

The residual brine saturation (S_{br}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. Referred to also as S_{wr} (wetting phase) or S_{lr} (liquid phase), residual brine saturation is the point reached under high gas saturation conditions when brine is no longer continuous throughout the pore network and relative brine permeability becomes zero. Below the value of the S_{br}, brine is immobile. It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Parameter Name(s):

WAS_AREA SAT_RBRN (#670)
REPOSIT SAT_RBRN (#2741)

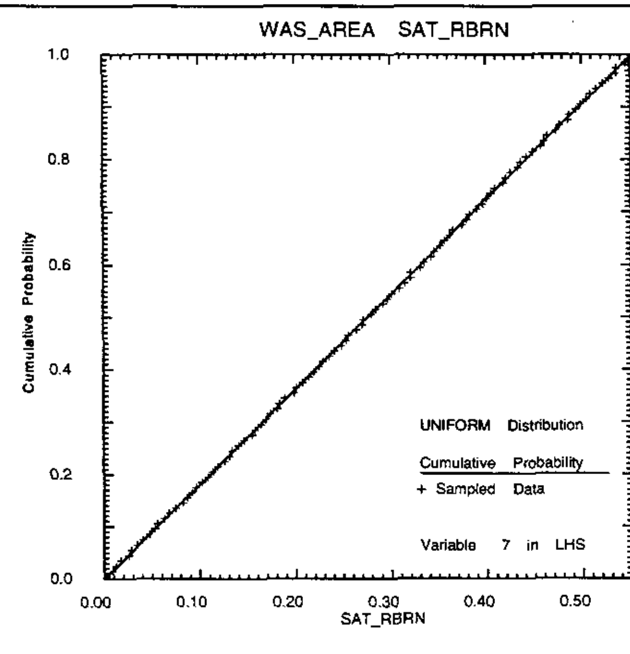
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.276	0.276	0	0.552	0.16

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 7: Residual Brine Saturation - Repository (Continued)

Data: General Literature and Professional Judgment

Two-phase flow parameters have not been measured for materials representing a collapsed empty, back-filled, or waste-filled room. Therefore, the parameter values are based on literature values for unconsolidated materials.

Discussion:

Brooks and Corey evaluated their two-phase characteristic equations against capillary pressure and relative permeability data obtained in laboratory experiments (Brooks and Corey 1964). Mualem (1976) proposed a modified procedure to that of Brooks and Corey for determining the wetting phase (S_{wr}) permeability curve by adding the constraint that the extrapolated curve should pass through the highest capillary pressure data point. Although their wetting phase relative permeability predictions are similar to each other and to the data, the Mualem procedure, in some cases, results in S_{wr} values less than those predicted by the Brooks and Corey model. Consequently, Table PAR-1 lists the Mualem (1976) residual wetting phase saturations to ensure that the potential for brine mobility is not underestimated. As indicated in Table PAR-1, single-phase liquid permeabilities of the Brooks and Corey materials are of the same order of magnitude as those assigned to waste disposal regions (10^{-13} square meters).

WIPP Data Entry Form #464 WPO#: 34902

References:

Brooks, R.H., and Corey, A.T. 1964. *Hydraulic Properties of Porous Media.* Hydrology Paper No. 3. Fort Collins, CO: Colorado State University. NWM Library.

Mualem, Y. 1976. *A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media.* Water Resources Research. Vol. 12, no. 3, 513-522.

Vaughn, Palmer. 1996. Memo to Martin Tierney. RE: WAS_AREA and REPOSIT/SAT_RBRN Distribution, February 13, 1996. WPO 34902.

Parameter 7: Residual Brine Saturation – Repository (Continued)

Table PAR-1. Brooks and Corey (1964) Materials Parameters - Unconsolidated Media[a]

Material	Permeability (square meters)[b]	Porosity	S_{wr}[c]
Volcanic Sand	1.1×10^{-11}	0.365	0.137
Fine Sand	2.85×10^{-12}	0.360	0.140
Glass Beads	1.05×10^{-11}	0.383	0.0783
Fragmented Mixture	1.50×10^{-11}	0.441	0.275
Fragmented Fox Hill Sandstone	1.61×10^{-11}	0.503	0.318
Touchet Silt Loam	5.00×10^{-13}	0.469	0.277
Poudre River Sand	2.26×10^{-11}	0.364	0.0824
Amarillo Silty Clay Loam	2.34×10^{-12}	0.455	0.242
Consolidated Berea Sandstone	4.81×10^{-13}	0.206	0.243
Consolidated Hygiene Sandstone	1.78×10^{-13}	0.250	0.560

a – Consolidated materials are identified in the material column
b – Single-phase liquid permeability
c – Mualem S_{wr} corrected for comparison to Brooks and Corey (1964)
S_{wr} - Wetting phase residual saturation

Parameter 8: Wicking Saturation

Parameter Description:

The wicking saturation in the waste is used in the gas generation model (see Appendix BRAGFLO, Section 4.13). It is a sampled parameter for the waste emplacement area and the waste, and the values are then applied to the repository regions outside of the panel region.

Material and Parameter Name(s):

WAS_AREA	SAT_WICK (#2231)
REPOSIT	SAT_WICK (#2138)

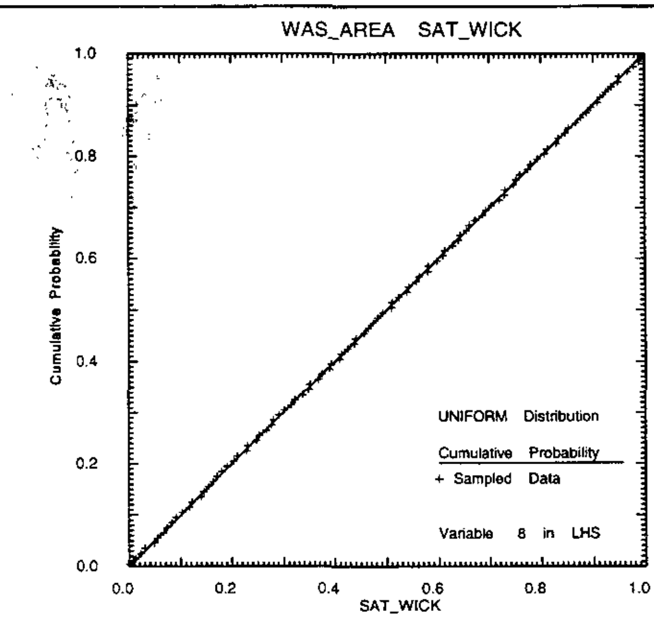
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.5	0.5	0.0	1.0	0.29

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 8: Wicking Saturation (Continued)

Data: Professional Judgment

The wicking parameter value varies from 0 (0 percent saturation) to 1.0 (100 percent saturation) and the parameter is assumed to be uniformly distributed.

Discussion:

Wicking is the ability of a material to carry a fluid by capillary action above the level it would normally seek in response to gravity. The use of a two-phase Darcy flow model in BRAGFLO includes possible effects of capillary action, but uncertainty remains about the extent to which the assumed homogeneous properties of the waste adequately characterize wicking. Because estimated rates of gas generation are higher for waste that is in direct contact with brine, brine saturation in the repository is adjusted in BRAGFLO to account for the possibility of wicking in the waste.

The adjustment is done as follows:

$S_b,eff = S_b + S_w,$

and

$S_b,eff \leq 1.0,$

where S_b is the brine saturation in the waste calculated by BRAGFLO, S_w is the wicking saturation that describes the additional amount of brine that may be present and in contact with the waste because of wicking, and S_b, eff is the effective brine saturation used to determine the gas generation rates used in the analysis.

WIPP Data Entry Form #464 WPO#: 34908

References:

N/A

Parameter 9: Log of Intrinsic Permeability - All Clay Shaft Materials

Parameter Description:

Log of the vertical and horizontal intrinsic permeability for the Rustler compacted clay, the lower Salado compacted clay, and the upper Salado compacted clay and the bottom clay column from 0 to 10,000 yrs. It is a sampled parameter for the Lower Salado Clay from T = 0 to 10 years used to calculate an effective permeability that is then applied to all other clay shaft materials and time periods.

Material and Parameter Name(s):

CL_L_T1	PRMX_LOG (#2334)
CL_L_T1	PRMY_LOG (#2335)
CL_L_T1	PRMZ_LOG (#2336)
CLAY_RUS	PRMX_LOG (#3009)
CLAY_RUS	PRMY_LOG (#3010)
CLAY_RUS	PRMZ_LOG (#3011)
CL_L_T2	PRMX_LOG (#2351)
CL_L_T2	PRMY_LOG (#2352)
CL_L_T2	PRMZ_LOG (#2353)
CL_L_T3	PRMX_LOG (#2368)
CL_L_T3	PRMY_LOG (#2369)
CL_L_T3	PRMZ_LOG (#2370)
CL_L_T4	PRMX_LOG (#3078)
CL_L_T4	PRMY_LOG (#3079)
CL_L_T4	PRMZ_LOG (#3080)
CL_M_T1	PRMX_LOG (#2385)
CL_M_T1	PRMY_LOG (#2386)
CL_M_T1	PRMZ_LOG (#2387)
CL_M_T2	PRMX_LOG (#2402)
CL_M_T2	PRMY_LOG (#2403)
CL_M_T2	PRMZ_LOG (#2404)
CL_M_T3	PRMX_LOG (#2419)
CL_M_T3	PRMY_LOG (#2420)
CL_M_T3	PRMZ_LOG (#2421)

Parameter 9: Log of Intrinsic Permeability - All Clay Shaft Materials (Continued)

Material and Parameter Name(s) (continued):

CL_M_T4	PRMX_LOG (#2436)
CL_M_T4	PRMY_LOG (#2437)
CL_M_T4	PRMZ_LOG (#2438)
CL_M_T5	PRMX_LOG (#2453)
CL_M_T5	PRMY_LOG (#2454)
CL_M_T5	PRMZ_LOG (#2455)
CLAY_BOT	PRMX_LOG (#2317)
CLAY_BOT	PRMY_LOG (#2318)
CLAY_BOT	PRMZ_LOG (#2319)

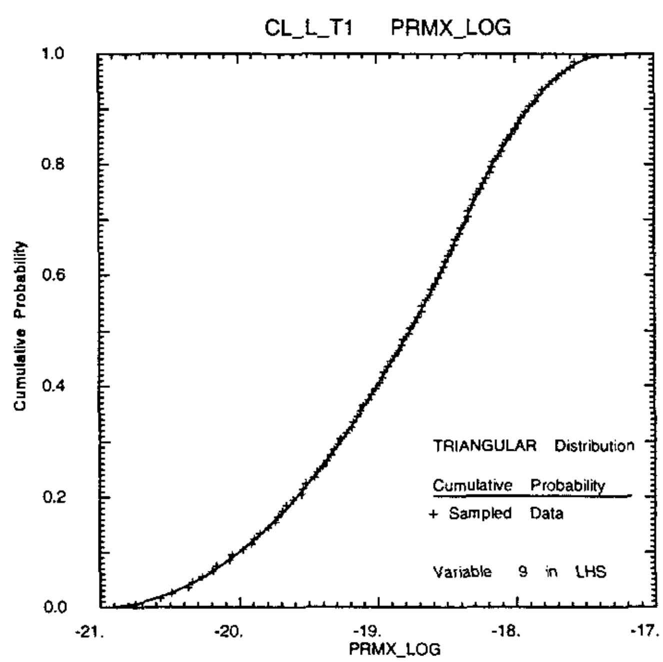
Computational Code: BRAGFLO

mean	mode	minimum	maximum	std. deviation
-18.8670	-18.3010	-21.0000	-17.3010	0.78

Units: log(square meters)

Distribution Type: Triangular

CDF/PDF Graph



Parameter 9: Log of Intrinsic Permeability - All Clay Shaft Materials (Continued)

Data: General Literature - Professional Judgment and Site-Specific Experimental Data

Data are based on a review of the available literature and a series of small-scale in-situ tests. The data associated with this parameter are summarized in the following parameter records package: SWCF-A:1.1.03.2.1:PDD:QA:Shaft Seals BRAGFLO Parameters (WPO 30640).

Discussion:

A significant body of literature regarding compacted bentonite permeability was reviewed. Most literature sources report hydraulic conductivity rather than intrinsic permeability. Hydraulic conductivity can be related to intrinsic permeability through the fluid density and viscosity and the acceleration of gravity. The permeability of reported bentonites ranges from 1×10^{-21} square meters to 1×10^{-15} square meters.

A series of in-situ tests were conducted to evaluate the feasibility of various candidate materials to be used for sealing materials at the WIPP site. These tests are referred to as the Small Scale Seal Performance Tests (SSSPT). Results from these tests support the use of compacted bentonite as a sealing material at the WIPP site and in the Salado Formation. Test Series D consisted of two seals with 100 percent bentonite cores. Each seal had a diameter of 0.91 meters and was approximately 3 meters in length, with bentonite cores 0.91 meters in length. Cores of the two bentonite seals had initial dry densities of 1.8 and 2.0 grams per cubic centimeters. Pressure differentials of 0.72 and 0.32 megapascals were maintained across the bentonite seals with a brine reservoir on the upstream (bottom) of the seals for several years. Over the course of the seal test, no visible brine was observed at the downstream end of the seals. Because the saturation state of the bentonite seals is unknown, determination of the absolute permeability of the bentonite seals cannot be estimated precisely. However, a bounding calculation of permeability by Knowles and Howard (1996) for the bentonite seals reported a value of 1×10^{-19} square meters.

The compacted bentonite material specification (SAND96-1326) specifies that the clay seals will be emplaced at a dry density of 1.8 to 2.0 grams per cubic centimeter. Based upon this information, a distribution function for clay permeability was developed. The basis for the proposed distribution is the following:

(1) A practical minimum for the distribution was specified at 1×10^{-21} square meters.

(2) Assuming that the effective dry density of the bentonite emplaced in the seals only varies from 1.8 to 2.0 grams per cubic centimeter, then a maximum expected permeability can be extrapolated as 1×10^{-19} square meters.

Parameter 9: Log of Intrinsic Permeability - All Clay Shaft Materials (Continued)

Discussion (continued):

(3) There is some uncertainty in the effective dry density of emplacement because of the difficulty of emplacing large columns of bentonite at high densities. To address this uncertainty, it is assumed that the compacted clay may be emplaced at a dry density as low as 1.6 grams per cubic centimeter. This actuality is not considered to be a high probability, but cannot be completely ruled out. At 1.6 grams per cubic centimeters, the maximum permeability for the clay would be approximately 5×10^{-19} square meters. Therefore, assuming no salinity effects, a range of permeability from 1×10^{-21} square meters to 5×10^{-19} square meters with a best estimate of less than 1×10^{-19} square meters is defined (assuming a best estimate emplacement density of 1.8 grams per cubic centimeter). It could be argued that the best estimate could be as low as 2×10^{-20} square meters.

(4) The literature reports that salinity increases permeability. However, these effects are greatly reduced at the emplacement densities specified for the shaft seal. At seawater salinity, Pusch et al. (1987) report the effects on permeability could be as much as a factor of 5 (one-half of a order of magnitude). It is expected that at the emplacement densities specified, the effect of salinity will be within an order of magnitude of the values reported in the literature measured with fresh pore water. To account for salinity effects, the maximum permeability was increased from 5×10^{-19} square meters to 5×10^{-18} square meters. The best estimate permeability was increased by one-half order of magnitude to 5×10^{19} square meters. The lower limit was held at 1×10^{-21} square meters. Because salinity effects are greatest at higher densities, the maximum was adjusted one full order of magnitude while the best estimate (assumed to reside at a density of 1.8 grams per cubic centimeters) was adjusted one-half of an order.

The disturbed rock zone (DRZ) permeability adjacent to the compacted clay column was calculated explicitly and then combined with the clay seal permeability in the BRAGFLO model.

In order to obtain an effective DRZ permeability, an estimate of the radius of the DRZ around the shaft was provided. Structural calculations were performed to estimate the radial extent of the DRZ as a function of time and depth adjacent to the upper and lower compacted clay seals, the compacted crushed salt seal, and the asphalt seal (SAND96-1326). The times considered were 0, 10, 25, 50, and 100 years after seal emplacement. Table PAR-2 shows the extent of the DRZ in terms of normalized radius at the mid-height of each component.

Parameter 9: Log of Intrinsic Permeability - All Clay Shaft Materials (Continued)

Discussion (Continued):

At the shaft seal materials, the effective permeability of composite seal and DRZ for the BRAGFLO model was calculated from the equation:

$$k_{model} = \frac{k_s\, A_s + k_d\, A_d}{A_{model}}$$

where:

k_{model}	=	effective composite permeability used in BRAGFLO
A_{model}	=	effective shaft area modeled in BRAGFLO (equal to the shaft area, A_s)
k_s,A_s	=	summation of the shaft seal permeability multiplied by the shaft seal area for the four shafts
k_d,A_d	=	summation of the DRZ permeability multiplied by the DRZ area for the four shafts

Assuming that the change in permeability within the DRZ is log linear, the effective DRZ permeability, k_d, for each shaft was calculated from:

$$k_{d_n} = \frac{2}{r_0 + r_i}\left[\left(\frac{r_0(\ln(k_0) - \ln(k_i)) - \Delta r}{(\ln(k_0) - \ln(k_i))^2}\right) k_0 - \left(\frac{r_i(\ln(k_0) - \ln(k_i)) - \Delta r}{(\ln(k_0) - \ln(k_i))^2}\right) k_i\right]$$

where:

n	=	shaft index (1, 2, 3, or 4)
r_i	=	inner radius (shaft excavation radius)
r_0	=	outer DRZ radius
Δr	=	outer DRZ radius minus the inner DRZ radius
k_i	=	inner skin permeability (DRZ permeability at the shaft/DRZ interface)
k_0	=	intact halite permeability

The summation of DRZ permeability multiplied by the DRZ area for all four shafts is equal to:

$$k_d A_d = k_{d1} A_{d1} + k_{d2} A_{d2} + k_{d3} A_{d3} + k_{d4} A_{d4}$$

where:

d1	=	air-supply shaft
d2	=	salt-handling shaft
d3	=	waste-handling shaft
d4	=	air-exhaust shaft

and the summation of shaft permeability multiplied by the shaft area for all four shafts is equal to:

Parameter 9: Log of Intrinsic Permeability - All Clay Shaft Materials (Continued)

Discussion (continued):

$$k_s A_s = k_{s1} A_{s1} + k_{s2} A_{s2} + k_{s3} A_{s3} + k_{s4} A_{s4}$$

The resulting permeabilities are presented in Appendix IRES.

(See also Parameter 12)

WIPP Data Entry Form #464 WPO#: 31908

References:

Knowles, M.K, and Howard, C.L. 1996. "Field and Laboratory Testing of Seal Materials Proposed for the Waste Isolation Pilot Plant," *Proceedings of the Waste Management 1996 Symposium. Tucson, AZ, February 25-29, 1996.* SAND95-2082C. Albuquerque, NM: Sandia National Laboratories. WPO 30945

Pusch, R., Borgesson, L. and Ramqvist, G. 1987. *Final Report of the Borehole, Shaft, and Tunnel Sealing Test -- Volume I: Borehole Plugging*. SKB 87-01. Stockholm, Sweden: Swedish Nuclear Fuel and Waste Management Co.

Repository Isolation Systems Department. 1996. Waste Isolation Pilot Plant Shaft Sealing System Compliance Submittal Design Report. SAND96-1326. Sandia National Laboratories, Albuquerque, NM. August, 1996.

Parameter 9: Log of Intrinsic Permeability - All Clay Shaft Materials (Continued)

Table PAR-2. Extent of the DRZ in Terms of Normalized Radius at Mid-Height of Component

Seal Material and Associated DRZ Zone	DRZ Extent -- Normalized Radius Time Reference of Instantaneous Emplacement of Seal Materials				
	0 yrs	10 yrs	25 yrs	50 yrs	100 yrs
Asphalt Column DRZ-1	1.629	1.629	1.629	1.629	1.629
Upper Salado Compacted Clay DRZ-2	1.709	1.469	1.283	1.107	1.000
Reconsolidated Salt DRZ-3	1.814	1.110	1.000	1.000	1.000
Lower Salado Compacted Clay DRZ-4	1.858	1.162	1.002	1.000	1.000

Parameter 10: Log of Intrinsic Permeability - Concrete (T = 0-400 yrs)

Parameter Description:

Log of the vertical and horizontal intrinsic permeability for the concrete column during the first 400 years. It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Parameter Name(s):

CONC_T1	PRMX_LOG (#2470)
CONC_T1	PRMY_LOG (#2471)
CONC_T1	PRMZ_LOG (#2472)

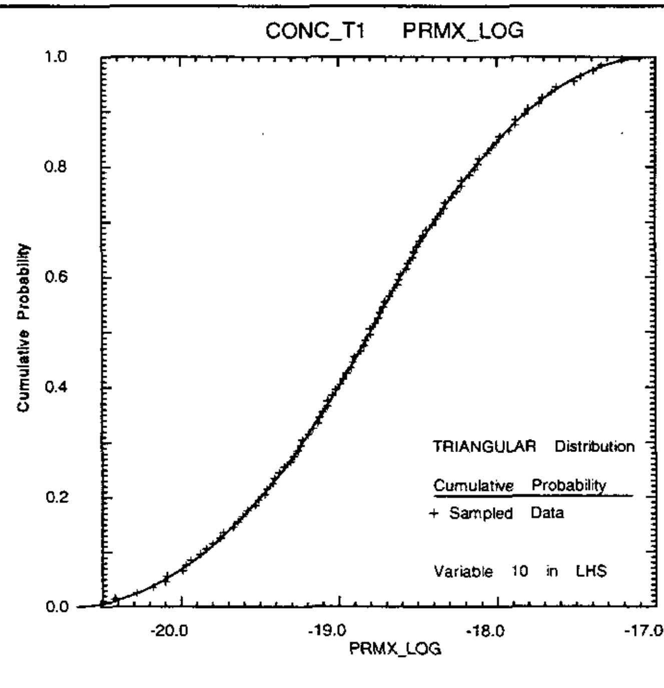
Computational Code: BRAGFLO

mean	mode	minimum	maximum	std. deviation
-18.8160	-18.750	-20.699	-17.000	0.76

Units: log(square meter)

Distribution Type: Triangular

CDF/PDF Graph



Parameter 10: Log of Intrinsic Permeability - Concrete (T = 0-400 yrs) (Continued)

Data: Site-Specific Experimental Data

The intrinsic permeability of the concrete column is based on laboratory and in-situ data. The data associated with this parameter are summarized in the following parameter records package: SWCF-A:1.1.03.2.1:PDD:PPD/1.1.03.2.2:Shaft Seals BRAGFLO Parameters (WPO 30640).

Discussion:

As reported by Repository Isolation Systems Department (1996), traditional freshwater concrete has been widely used for hydraulic applications such as water storage tanks, water and sewer systems, and massive dams because it has exceptionally low permeability (less than 10^{-20} square meters upon hydration). Salado Mass Concrete (SMC) is a specially-designed salt-saturated concrete mix that was developed only recently (Wakeley et al. 1994; Wakeley et al. 1995).

Pfeifle, et al. (1996) performed two permeability tests on concrete specimens prepared from cores recovered from the WIPP SSSPT field experiments and one test on an SMC specimen prepared from a sample batched by the Waterways Experiment Station (WES). The specimens were tested as received with no attempts made to dry the specimens or to determine their moisture contents. Each test was performed using nitrogen gas as the permeant, flowmeters to measure gas flow, and fluid pressure gradients of either 0.3, 0.6, or 0.75 megapascals. Attempts were made to apply Klinkenberg corrections to measured values of permeability, but the range in pressure gradients used in the testing was not large enough to establish any particular trend when the permeability data were plotted as a function of reciprocal mean fluid pressure.

A total of 18 permeability measurements were made on the three specimens. Permeability of the SMC and SSPT specimens are all very low with a range from 2.1×10^{-21} square meters to 7.51×10^{-21} square meters with an average of 4.71×10^{-21} square meters. Permeability of the SSSPT specimens ranged from 3.00×10^{-20} square meters to 5.04×10^{-19} square meters with and average of 2.18×10^{-19} square meters. Knowles and Howard (1996) presented results of field permeability tests performed in the WIPP SSSPT boreholes during 1985-1987 and 1993-1995. Although individual seal system component material permeabilities for concrete, DRZ salt, and salt were not determined, overall seal system permeabilities were determined and ranged from 1.0×10^{-20} square meters to 1.0×10^{-17} square meters and from 1.0×10^{-23} square meters to 1.0×10^{-19} square meters for the 1985–1987 tests and the 1993-1995 tests, respectively. These ranges encompass the laboratory values measured by Pfeifle, et al. (1996).

The data described above were derived from gas permeability measurements in which no Klinkenberg corrections were applied to the measured values. The Klinkenberg corrections were expected to be small because of the low mean pressure gradients used in the tests.

Parameter 10: Log of Intrinsic Permeability - Concrete (T = 0-400 yrs) (Continued)

Discussion (Continued):

Magnesium-rich brines are known to cause degradation of cementitious materials, such as SMC (Wakeley et al. 1994). Degradation is expected to increase the permeability of SMC components. It was assumed that the asphalt column extending from the Rustler/Salado contact into the Salado salt will protect the SMC seal components from contacting Mg-rich brines during the specified performance period.

The interface between the Salado salt and the SMC components may provide a flow path around the SMC components. This flow path is possible if a small aperture develops as the concrete is curing or if the interface degrades because of corrosive brines. If such a flow path occurs, the effective permeability of the SMC will increase. Because of this uncertainty, the upper bound permeability was assigned to a value of -17 which corresponds to a permeability of 1.0×10^{-17} square meters. This value was selected after an effective permeability calculation was performed. In this calculation, the interface zone was assumed to have a permeability of 1.0×10^{-14} square meters and concrete permeabilities were varied from 1.0×10^{-23} to 1.0×10^{-19} square meters. Assuming the interface zone had a thickness of 0.001 times the shaft radius or smaller, the effective permeability of the concrete was about 1.0×10^{-17} square meters regardless of the value selected for the permeability of the SMC seal.

No DRZ was specified adjacent to the concrete component because of the healing affects of the stiffness of the concrete and the ability of the asphalt waterstops to cut off the DRZ.

WIPP Data Entry Form #464 WPO#: 32583

References:

Knowles, M.K. and Howard, C.L. 1996. "Field and Laboratory Testing of Seal Materials Proposed for the Waste Isolation Pilot Plant," *Proceedings of the Waste Management 1996 Symposium. Tucson, AZ, February 25-29, 1996.* SAND95-2082C. Albuquerque, NM: Sandia National Laboratories. WPO 30945.

Pfeifle, T.W., Hansen, F.D., and Knowles, M.K. 1996. "Salt-Saturated Concrete Strength and Permeability," Proceedings of the ASCE Fourth Materials Engineering Conference, Washington, DC, November, 1996 (accepted for publication).

Repository Isolation Systems Department. 1996. Waste Isolation Pilot Plant Shaft Sealing System Compliance Submittal Design Report. SAND96-1326. Sandia National Laboratories. Albuquerque, NM. August, 1996.

Parameter 10: Log of Intrinsic Permeability - Concrete (T = 0-400 yrs) (Continued)

References (Continued):

Wakeley, L.D., Poole, T.S. and Burkes, J.P. 1994. *Durability of Concrete Materials in High-Magnesium Brine*. SAND93-7073. Albuquerque, NM: Sandia National Laboratories. WPO 10674.

Wakeley, L.D., Harrington, P.T., and Hansen, F.D. 1995. *Variability in Properties of Salado Mass Concrete*. SAND94-1495. Albuquerque, NM: Sandia National Laboratories. WPO 22744.

Parameter 11: Log of Intrinsic Permeability - Asphalt Shaft Material

Parameter Description:

Log of the vertical and horizontal intrinsic permeability for the asphalt shaft material. It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Parameter Name(s):

ASPHALT PRMX_LOG (#2283)
ASPHALT PRMY_LOG (#2284)
ASPHALT PRMZ_LOG (#2285)

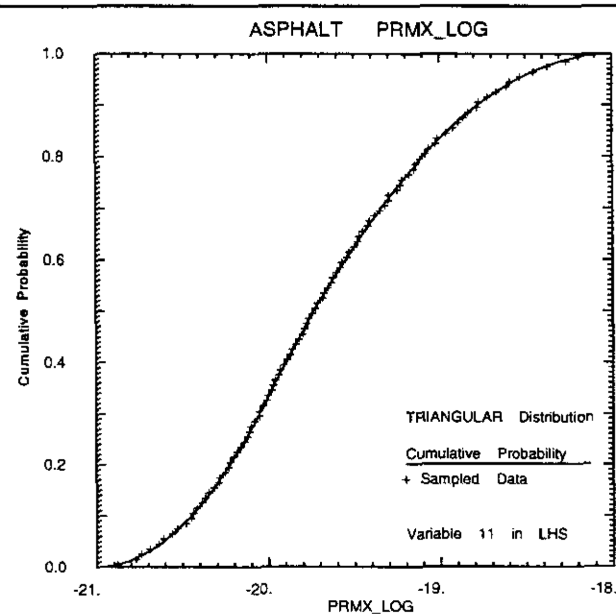
Computational Code: BRAGFLO

mean	mode	minimum	maximum	std. deviation
-19.667	-20.000	-21.000	-18.000	0.62

Units: log(square meters)

Distribution Type: Triangular

CDF/PDF Graph



Parameter 11: Log of Intrinsic Permeability - Asphalt Shaft Material (Continued)

Data: Professional Judgment

The parameter distribution is based on literature values and professional judgment. The parameter records package associated with this parameter is located at: SWCF-A:1.1.03.2.1: PDD:QA:Shaft Seals BRAGFLO Parameters (WPO 30640).

Discussion:

Asphalt mastic mix (AMM) is a mix of asphalt cement, sand, and other mineral fillers. The mix design specifies that the air void volume be between 1 and 2 percent and the mix will consist of 20 weight percent asphalt cement (AR-4000 graded asphalt), 70 weight percent aggregate (silica sand), and 10 weight percent hydrated lime. The high asphalt content along with the very fine-grained aggregate will result in a material with virtually no voids. The aggregate will resist settling and will provide a filter cake along the host rock contact to prevent excessive loss of asphalt to the formation. Hydrated lime is included to increase the stability of the material, to decrease moisture susceptibility, and to act as an anti-microbial agent.

Several sources were reviewed to find relevant information on the permeability of asphalt and asphaltic based construction materials. A large body of literature exists on applications of using asphalt as a barrier to water flow such as in the case of dams. Asphalt is routinely referred to in the literature as being impermeable, waterproof, etc. However, very little quantitative information exists regarding the permeability of asphalt. No permeability values were found for an AMM which shares the expected low void volume and high asphalt content that will exist in the shaft seal. However, literature on a few similar asphalt mixes was found and used in the development of the PDF. Myers and Duranceau (1994) reported on the asphalt concrete as a high-asphalt content product design to minimize the void spaces. The reported hydraulic conductivity of the asphalt concrete was estimated to be 1×10^{-9} meters per second (equivalent to an intrinsic permeability of approximately 1×10^{-16} assuming freshwater). Myers and Duranceau (1994) reported that the hydraulic conductivity of fluid applied asphalt was estimated to be 1.0×10^{-11} to 1.0×10^{-10} centimeters per second (equivalent to an intrinsic permeability of approximately 1.0×10^{-20} to 1.0×10^{-19} square meters, assuming freshwater).

In addition, Robert Romine, a Research Scientist in the Environmental Technology Division of Pacific Northwest Laboratories (PNL) and technical expert to SNL in the design and development of the specifications for the shaft seal AMM was consulted. Based on his experience designing and testing asphalt engineered barriers, the expected permeability for the WIPP AMM seal is less than 1×10^{-20} square meters.

Parameter 11: Log of Intrinsic Permeability - Asphalt Shaft Material (Continued)

Discussion (Continued):

The DRZ permeability adjacent to the compacted clay column was calculated explicitly and then combined with the clay seal permeability in the BRAGFLO model.

In order to obtain an effective DRZ permeability, an estimate of the radius of the DRZ around the shaft was provided. Repository Isolation Systems Department (1996) performed structural calculations to estimate the radial extent of the DRZ as a function of time and depth adjacent to the Upper and Lower compacted clay seals, the compacted crushed salt seal, and the asphalt seal. The times considered were 0, 10, 25, 50, and 100 years after seal emplacement. Table PAR-3 shows the extent of the DRZ in terms of normalized radius at the mid-height of each component.

For the shaft seal materials, the effective permeability of the composite seal and DRZ for the BRAGFLO model was calculated from the equation:

$$k_{model} = \frac{k_s\ A_s + k_d\ A_d}{A_{model}}$$

where:

k_{model} = effective composite permeability used in BRAGFLO

A_{model} = effective shaft area modeled in BRAGFLO (equal to the shaft area, A_s)

k_s, A_s = summation of the shaft seal permeability multiplied by the shaft seal area, for the four shafts

k_d, A_d = summation of the DRZ permeability multiplied by the DRZ area for the four shafts

Assuming that the change in permeability within the DRZ is log linear, the effective DRZ permeability, k_{d_n}, for each shaft was calculated from:

$$k_d = \frac{2}{r_0 + r_i}\left[\left(\frac{r_0(\ln(k_0) - \ln(k_i)) - \Delta r}{(\ln(k_0) - \ln(k_i))^2}\right) k_0 - \left(\frac{r_i(\ln(k_0) - \ln(k_i)) - \Delta r}{(\ln(k_0) - \ln(k_i))^2}\right) k_i\right]$$

where:

n = shaft index (1, 2, 3, or 4)

r_i = inner radius (shaft excavation radius)

r_0 = outer DRZ radius

Δr = outer DRZ radius minus the inner DRZ radius

Parameter 11: Log of Intrinsic Permeability - Asphalt Shaft Material (Continued)

Discussion (Continued):

k_i = inner skin permeability (DRZ permeability at the shaft/DRZ interface)
k_0 = intact halite

The summation of DRZ permeability multiplied by the DRZ area for all four shafts is equal to:

$$k_d A_d = k_{d1} A_{d1} + k_{d2} A_{d2} + k_{d3} A_{d3} + k_{d4} A_{d4}$$

where:
d1 = air-supply shaft
d2 = salt-handling shaft
d3 = waste-handling shaft
d4 = air-exhaust shaft

and the summation of shaft permeability multiplied by the shaft area for all four shafts is equal to:

$$k_s A_s = k_{s1} A_{s1} + k_{s2} A_{s2} + k_{s3} A_{s3} + k_{s4} A_{s4}$$

The resulting permeabilities are presented in Appendix IRES.

(See also Parameter 12)

WIPP Data Entry Form #464 WPO#: 31390

References:

Myers, D.R., and Duranceau, D.A. 1994. "Prototype Hanford Surface Barrier: Design Basis Document" BHI-00007. Bechtel Hanford, Inc., Richland, WA.

Repository Isolation Systems Department. 1996. Waste Isolation Pilot Plant Shaft Sealing System Compliance Submittal Design Report. SAND96-1326. Sandia National Laboratories. Albuquerque, NM. August, 1996.

Parameter 11: Log of Intrinsic Permeability - Asphalt Shaft Material (Continued)

Table PAR-3. Extent of the DRZ in Terms of Normalized Radius at Mid-Height of Component

Seal Material and Associated DRZ Zone	DRZ Extent -- Normalized Radius Time Reference of Instantaneous Emplacement of Seal Materials				
	0 yrs	**10 yrs**	**25 yrs**	**50 yrs**	**100 yrs**
Asphalt Column DRZ-1	1.629	1.629	1.629	1.629	1.629
Upper Salado Compacted Clay DRZ-2	1.709	1.469	1.283	1.107	1.000
Reconsolidated Salt DRZ-3	1.814	1.110	1.000	1.000	1.000
Lower Salado Compacted Clay DRZ-4	1.858	1.162	1.002	1.000	1.000

Parameter 12: Intrinsic Permeability - Shaft Disturbed Rock Zone

Parameter Description:

The shaft DRZ permeability is used to obtain the effective seal/DRZ permeability for the shaft materials affected by a DRZ, including the clay, salt, and asphalt shaft materials.

Material and Parameter Name(s):

SHFT_DRZ PRMX_LOG (#3133)

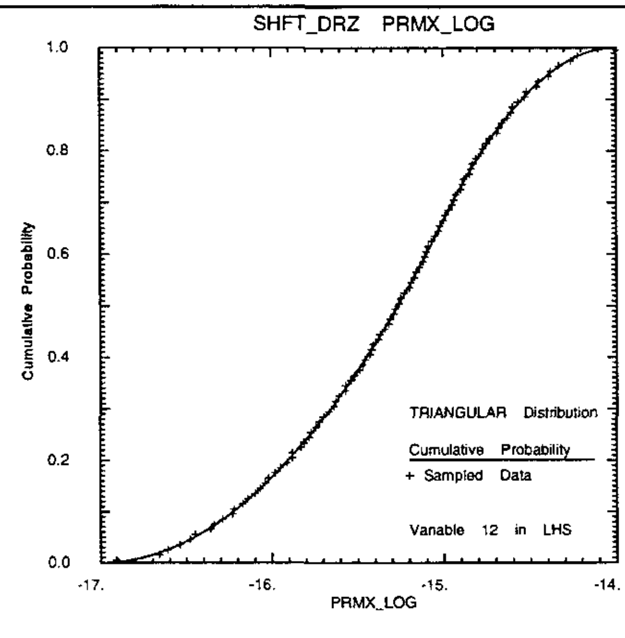
Computational Code: BRAGFLO

mean	mode	minimum	maximum	std. deviation
-15.333	-15.00	-17.00	-14.00	0.62

Units: log(square meters)

Distribution Type: Triangular

CDF/PDF Graph



Parameter 12: Intrinsic Permeability - Shaft Disturbed Rock Zone (Continued)

Data: Site-Specific Experimental Data

The data for the DRZ around the shaft come from field and laboratory data.

The data associated with this parameter are summarized in the following parameter records package: SWCF-A:WBS:1.1.03.2.1:PDD:QA:Shaft Seals BRAGFLO Parameters (WPO 30640).

Discussion:

The shaft DRZ permeability is used to obtain the effective composite permeability for the shaft materials affected by a DRZ, including the clay, salt, and asphalt shaft materials (see Figure PAR-2).

The zone of disturbed salt around the excavation is termed the DRZ. The DRZ in the bedded halite of the Salado Formation forms immediately upon passage of the mining tools and progressively develops over time with the unloading of the formation as it creeps into excavations. From a sealing perspective, the most important and controlling characteristic of the DRZ is its enhanced permeability which results from the dilatant deformation and the increased pore volume.

When the shaft seals are emplaced, back pressures in the shaft sealing material will develop with time as the surrounding salt creeps into the shaft. These back pressures both induce higher mean stress and reduce the magnitude of the stress difference in the DRZ which, ultimately, causes the microfracturing mechanism to become inactive (Brodsky and Munson 1994). The higher mean stresses also induce healing of the DRZ as shown by Brodsky (1990). Healing is a time-dependent process; eventually, the permeability of the DRZ will return to that of intact salt. Because the creep rate of the salt surrounding the shaft depend on depth, back pressures in the shaft sealing materials develop more quickly at depth. Therefore, the rate of healing increases with depth, and depends on the stiffness of the seal material.

A significant number of laboratory and, to a lesser extent, field studies have been performed to characterize the DRZ and to determine the mechanics of DRZ development. DRZ development has been documented in almost all horizontal rectangular excavations of the WIPP underground facility by gas permeability testing, visual observations, and other methodologies (Knowles, et al. 1996). However, no definitive studies in vertical excavations were conducted at the WIPP until recently. Field testing was conducted to estimate the permeability and radial extent of the DRZ in the halite of the Salado Formation surrounding the AIS (Dale and Hurtado 1996). Two horizons were investigated: 345.9 meters and 629.4 meters below ground surface. Gas and/or brine permeability tests were performed at each level in three 10.2 centimeters diameter boreholes. The testing protocol for all six boreholes

Parameter 12: Intrinsic Permeability - Shaft Disturbed Rock Zone (Continued)

Discussion (Continued):

called for gas flow testing followed by brine infection testing. The resulting field data provided insight into the variation of permeability in the DRZ and the extent of the DRZ.

In addition, field testing designed to characterize the DRZ around partially sealed boreholes was recently completed at the WIPP site. Gas flow measurements were obtained as a function of radial distance from a seal emplacement borehole located in the floor of Room M of the WIPP underground repository. Experiments conducted in support of the Room D DRZ program measured fluid flow and geophysical parameters along this seal emplacement borehole (Knowles, et al. 1996). Measurements were taken to evaluate the formation permeability as a function of depth into the rib of Room D and radial distance from the open borehole and concrete seal. Analysis of gas flow data obtained in Room M indicates that the permeability of the DRZ near the excavation surfaces ranged from 1.0×10^{-12} to 1.0×10^{-14} square meters (Van Pelt 1995). Results of the Room D DRZ were within the same range, in spite of the difference in geometry between the two testing configurations. Gas and brine permeability measurements taken in the immediate vicinity of concrete seal conclusively show that no DRZ existed in this region.

The PDF for the permeability of the DRZ for all time was constructed based on the information obtained from these recent field test programs.

The DRZ permeability adjacent to the compacted clay column, the crushed salt column and the asphalt column was calculated explicitly and then combined with the seal permeability in the BRAGFLO model.

In order to obtain an effective DRZ permeability, an estimate of the radius of the DRZ around the shaft was provided. Structural calculations to estimate the radial extent of the DRZ as a function of time and depth adjacent to the Upper and Lower compacted clay seals, the compacted crushed salt seal, and the asphalt seal. The times considered were 0, 10, 25, 50, and 100 years after seal emplacement. Table PAR-3 shows the extent of the DRZ in terms of normalized radius at the mid-height of each component.

Assuming that the change in permeability within the DRZ is log linear, the effective DRZ permeability, k_d, is calculated from:

$$k_{d_n} = \frac{2}{r_0 + r_i}\left[\left(\frac{r_0(\ln(k_0) - \ln(k_i)) - \Delta r}{(\ln(k_0) - \ln(k_i))^2}\right) k_0 - \left(\frac{r_i(\ln(k_0) - \ln(k_i)) - \Delta r}{(\ln(k_0) - \ln(k_i))^2}\right) k_i\right]$$

Parameter 12: Intrinsic Permeability - Shaft Disturbed Rock Zone (Continued)

Discussion (Continued):

where:

n = shaft index (1, 2, 3, or 4)
r_i = inner radius (shaft excavation radius)
r_0 = outer DRZ radius
Δr = outer DRZ radius minus the inner DRZ radius
k_i = inner skin permeability (DRZ permeability at the shaft/DRZ interface)
k_0 = intact halite

For the shaft seal materials, the effective permeability of composite seal and DRZ for the BRAGFLO model was calculated from the equation:

$$k_{model} = \frac{k_s A_s + k_d A_d}{A_{model}}$$

where:

k_{model} = effective composite permeability used in BRAGFLO.
A_{model} = effective shaft area modeled in BRAGFLO (equal to the shaft area, A_s).
k_s,A_s = summation of the shaft seal permeability multiplied by the shaft seal area, for the four shafts.
k_d,A_d = summation of the DRZ permeability multiplied by the DRZ area for hte four shafts.

The summation of DRZ permeability multiplied by the DRZ area for all four shafts is equal to:

$$k_d A_d = k_{d1} A_{d1} + k_{d2} A_{d2} + k_{d3} A_{d3} + k_{d4} A_{d4}$$

where:

d1 = air-supply shaft
d2 = salt-handling shaft
d3 = waste-handling shaft
d4 = air-exhaust shaft

and the summation of shaft permeability multiplied by the shaft area for all four shafts is equal to:

Parameter 12: Intrinsic Permeability - Shaft Disturbed Rock Zone (Continued)

Discussion (Continued):

$$k_s A_s = k_{s1} A_{s1} + k_{s2} A_{s2} + k_{s3} A_{s3} + k_{s4} A_{s4}$$ (Kelley et al., 1996a)

(See also Parameters 9 and 11 and Appendix IRES.)

WIPP Data Entry Form #464 WPO#: 36563

References:

Brodsky, N.S. 1990. *Crack Closure and Healing Studies in WIPP Salt Using Compressional Wave Velocity and Attenuation Measurements: Test Methods and Results.* SAND90-7076. Sandia National Laboratories, Albuquerque, NM. 1990. WPO 25755

Brodsky, N.S. and Munson, D.E. 1994. "Thermomechanical Damage Recovery Parameters for Rock-Salt From the Waste Isolation Pilot Plant," Proceedings of the First North American Rock Mechanics Symposium, University of Texas, Austin, TX. June 1994. pp. 731-738. SAND93-2067C. WPO 27175

Dale T.F., and Hurtado, L.D. 1996. "WIPP Air Intake Shaft Disturbed Rock Zone Study" Proceedings of the 4th Conference on the Mechanical Behavior of Salt, Montreal, Quebec, Canada, June 1996. SAND96-1327C.

Kelley, Van, Jones, T., and Ogintz, J. 1996. Memorandum to Diane Hurtado, Re: WIPP Seal System Parameters for Performance Assessment BRAGFLO Compliance Calculations, January 15, 1995. WPO 30995

Knowles, M.K., Borns, D., Dale, T.F., Fredrich, J.T., Holcomb, D., Price, R., Van Pelt, R.S., Zeuch, D. 1996. "Testing the Disturbed Zone Around a Rigid Inclusion in Salt," Proceedings of the 4th Conference on the Mechanical Behavior of Salt: Montreal, Quebec, Canada: June, 1996. SAND95-1151C.

Van Pelt, S. Technical Memorandum to M.K. Knowles, "Permeability Estimates from Borehole MGFO8 and MGFO9," November 20, 1995. WPO 39631.

Parameter 12: Intrinisic Permeability - Shaft Disturbed Rock Zone (Continued)

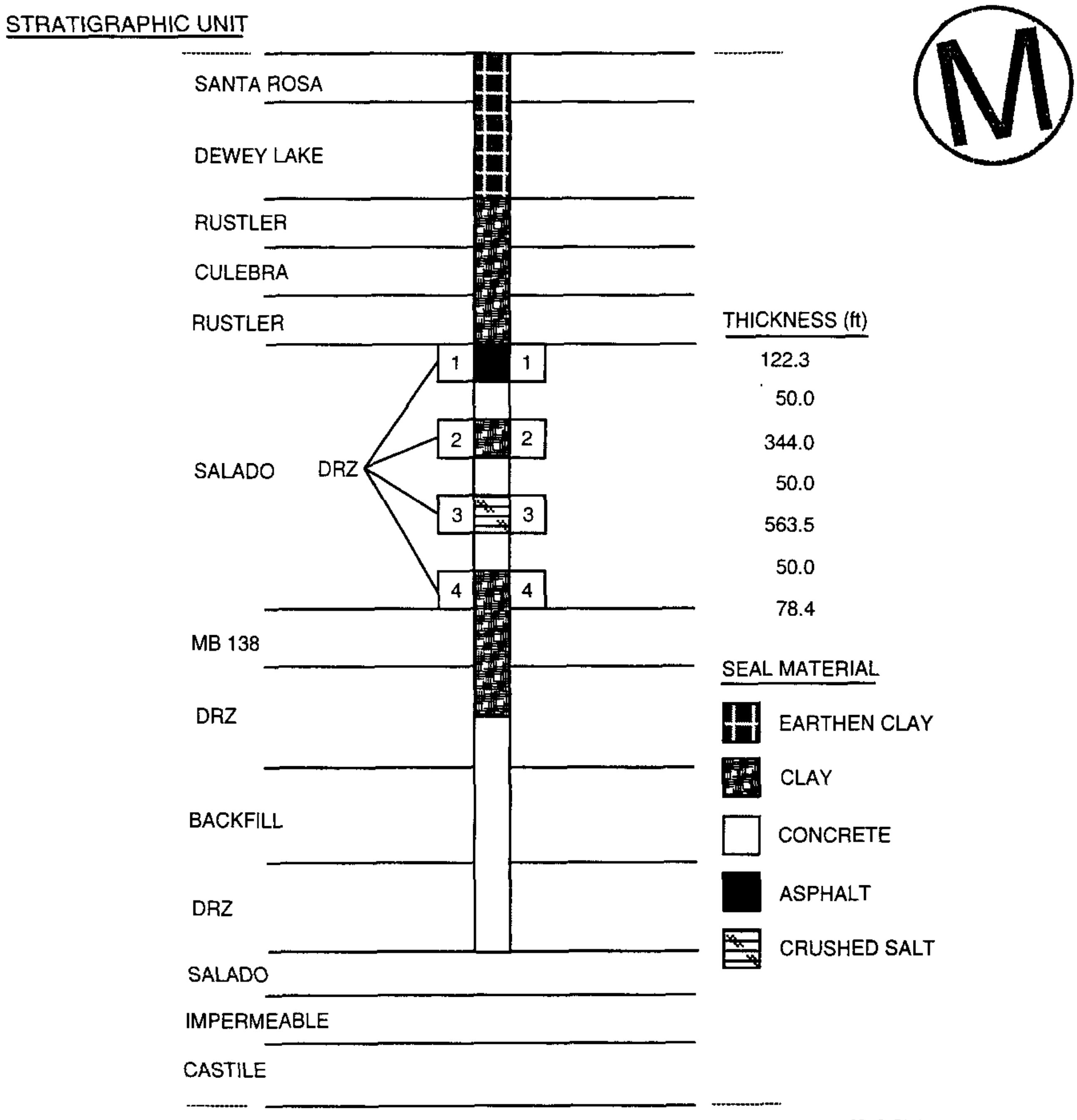


Figure PAR-2. Shaft-Seal System Conceptual Framework

Parameter 13: Cumulative Probability - Salt Shaft Material

Parameter Description:

This parameter represents the index for selecting the salt shaft material permeabilities at different time steps. The distributions for these permeabilities have regions of overlap which could result in an increasing permeability over time if the distributions are independently sampled. The parameter CUMPROB ensures that the salt shaft material permeability decreases in time proportional to the decreasing range of permeability and does not increase as a result of random sampling (Vaughn and McArthur 1996). It is a sampled parameter for the salt shaft material at time T = 0 to 10 years and the values are then applied to all of the other salt shaft material permeability distributions.

Material and Parameter Name(s):

SALT_T1 CUMPROB (#2939)

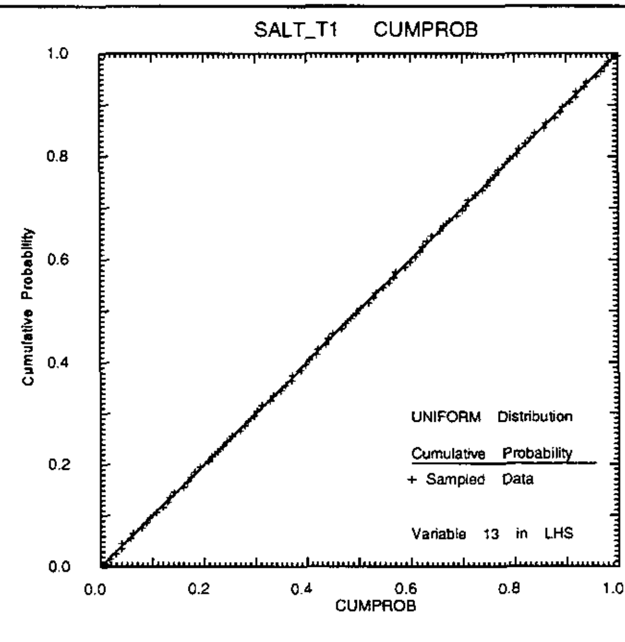
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.50	0.50	0.00	1.00	0.29

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 13: Cumulative Probability - Salt Shaft Material (Continued)

Data: Professional Judgment

No experimental data is associated with the cumulative probability parameter. The parameter is an index for selecting shaft salt material permeabilities at different time steps. It varies uniformly from 0 to 1.

Discussion:

The value of CUMPROB gives the cumulative probability for a distribution of permeability. Six materials (SALT_T1, SALT_T2, SALT_T3, SALT_T4, SALT_T5, and SALT_T6) are used to represent the time-dependent permeability of the salt sealing material and its surrounding DRZ. Two of these materials are required by changes in the normalized radius of the DRZ. The other four materials are associated with the four overlapping ranges of permeability associated with the salt as it consolidates over a period of 200 years. CUMPROB is a cumulative probability which is sampled once for each vector. The salt permeability is represented by a log-triangular distribution with upper and lower endpoints and a permeability value at which the permeability peaks. The same CUMPROB value is used with each of the four log-triangular distributions to define a value for the salt permeability for the particular time period (0 to 50 years, 50 to 100 years, 100 to 200 years, and 200 to 10,000 years). This use of the same CUMPROB value ensures that the salt sealant permeability will decrease in time proportionally to the decreasing ranges of permeability, and not increase because of random sampling (Vaughn and McArthur 1996).

The permeability of the crushed salt seal component was obtained from laboratory data and model predictions. The parameter records package associated with the permeability of crushed salt is located at SWCF-A:1.1.03.2.1:PDD:QA:Shaft Seals BRAGFLO Parameters (WPO 30640). Brodsky (1994) measured permeability as part of a comprehensive study to characterize both the consolidation characteristics and permeability of WIPP crushed salt. Hansen and Ahrens (1996) reported gas permeability measurements for WIPP crushed salt from tests performed as part of a large-scale dynamic compaction demonstration. In addition, permeability tests were recently performed by Brodsky et al. (1996) on samples prepared from cores recovered from the large-scale dynamic compaction test and from two small-scale dynamic compaction tests performed by SNL (Hansen et al. 1995).

The development of probability distribution functions for the permeability of compacted crushed salt required a model relating permeability and density because the permeability is known to increase with density and the density of the crushed salt in the column seal increases with time during reconsolidation.

Parameter 13: Cumulative Probability - Salt Shaft Material (Continued)

Discussion (Continued):

Because of the limited experimental data available and the large uncertainty associated with the data, a conservative approach was implemented in relating permeability and density. Data from permeability tests on dynamically compacted crushed salt were included in the development of a permeability versus density relationship, even though physical evidence (microscopy) indicated the permeability determined from these tests may be biased. That is, the permeability may be higher than the permeability determined for specimens whose primary consolidation mechanism is pressure solution/redeposition.

A loglinear model relating permeability (transformed into logarithmic space) and fractional density was used to approximate the lab data. A linear least squares fit was performed. A high degree of uncertainty was included in the distribution function for crushed salt permeability to ensure that all measured values of permeability had a finite probability of being included in the performance assessment calculations. Three prediction intervals were determined for the empirical model. Each of these intervals was superimposed on the data. Since the 90 percent prediction interval contained nearly all of the laboratory and in situ measurements of permeability, it was selected.

Model predictions were used to predict density of the crushed salt column as a function of time. Some uncertainty exists in these constitutive models because of the uncertainty associated with the model parameters.

Distribution functions were given for five specific time including 0, 50, 100, 200, and 400 years after seal emplacement. These PDFs incorporated the uncertainty inherent in the constitutive material models and the empirical model relating permeability to density, as well as that of the data.

The DRZ permeability adjacent to the crushed salt column was explicitly calculated and then combined with the crushed salt seal permeability in the performance assessment model.

WIPP Data Entry Form #464 WPO#: 33361

References:

Brodsky, N.S. 1994. *Hydrostatic and Shear Consolidation Tests With Permeability Measurements on Waste Isolation Pilot Plant Crushed Salt.* SAND93-7058. Albuquerque, NM: Sandia National Laboratories. WPO 10087

Parameter 13: Cumulative Probability - Salt Shaft Material (Continued)

References (Continued):

Brodsky, N.S., Hansen, F.D., and Pfeifle, T.W. 1996. *Properties of Dynamically Compacted WIPP Salt.* Proceedings of the 4th Conference on the Mechanical Behavior of Salt. Montreal, Quebec, Canada, June. SAND96-0838C.

Hansen, F.D. and Ahrens, E.H. 1996. *Large-Scale Dynamic Compaction of Natural Salt, the 4th Conference on the Mechanical Behavior of Salt, Montreal, Quebec, Canada, June.* SAND96-0792C.

Hansen, F.D., Ahrens, E.H., Tidwell, V.C., Tillerson, J.R., and Brodsky, N.S. 1995. *Dynamic Compaction of Salt: Initial Demonstration and Performance Testing.* Proceedings of the 35th U.S. Symposium on Rock Mechanics, University of Nevada. Reno, NV, June 5-7. SAND94-2313C. WPO 23813.

Vaughn, Palmer and McArthur, David. 1996. Memo to Martin Tierney, Re: CUMPROB Parameter Definition and Usage, May 20, 1996. WPO 37542.

Parameter 14: Residual Gas Saturation - All Shaft Materials

Parameter Description:

The residual (critical) gas saturation (S_{gr}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. S_{gr} corresponds to the degree of waste-generated gas saturation necessary to create an incipient interconnected pathway in porous material, a condition required for porous rock to be permeable to gas. It is a sampled parameter for the salt shaft material at time T = 0 to 10 years and the values are then applied to all of the other shaft materials and time periods.

Material and Parameter Name(s):

SALT_T1	SAT_RGAS (#2529)
SALT_T2	SAT_RGAS (#2546)
SALT_T3	SAT_RGAS (#2563)
SALT_T4	SAT_RGAS (#2580)
SALT_T5	SAT_RGAS (#2597)
SALT_T6	SAT_RGAS (#2993)
EARTH	SAT_RGAS (#2512)
CLAY_RUS	SAT_RGAS (#3015)
CL_L_T1	SAT_RGAS (#2343)
CL_L_T2	SAT_RGAS (#2360)
CL_L_T3	SAT_RGAS (#2377)
CL_L_T4	SAT_RGAS (#3083)
CL_M_T1	SAT_RGAS (#2394)
CL_M_T2	SAT_RGAS (#2411)
CL_M_T3	SAT_RGAS (#2428)
CL_M_T4	SAT_RGAS (#2445)
CL_M_T5	SAT_RGAS (#2462)
CLAY_BOT	SAT_RGAS (#2326)
CONC_T1	SAT_RGAS (#2479)
CONC_T2	SAT_RGAS (#2495)
CONC_MON	SAT_RGAS (#3064)
ALPHALT	SAT_RGAS (#2292)

Parameter 14: Residual Gas Saturation - All Shaft Materials (Continued)

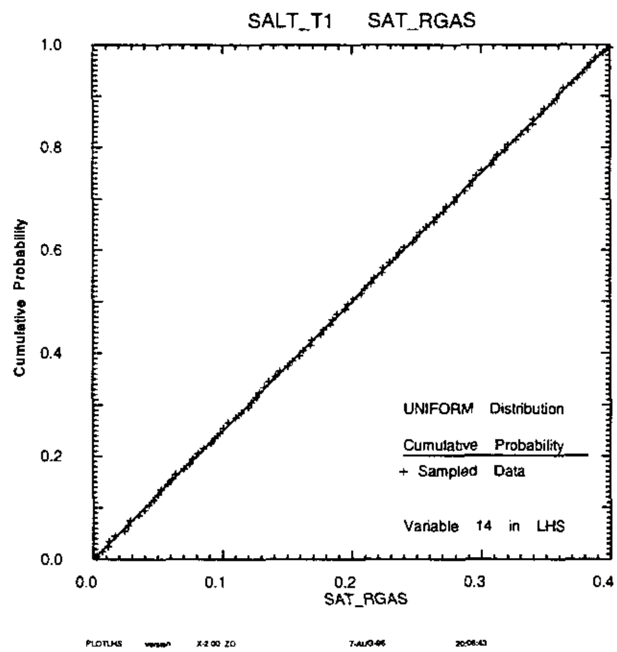
Computational Code(s): BRAGFLO

mean	median	minimum	maximum	std. deviation
0.20	0.20	0	0.40	0.12

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Data: General Literature - Professional Judgment

Data are based on a review of the available literature. The parameter records package associated with this parameter is located at SWCF-A:1.1.03.2.1:PDD:QA:Shaft Seals BRAGFLO Parameters (WPO 30640).

Discussion:

A literature search was conducted to obtain residual saturation values for consolidated geologic materials, concrete, and asphalt.

Parameter 14: Residual Gas Saturation - All Shaft Materials (Continued)

Discussion (Continued):

A single value of 0.18 was found for normal concrete (Mayer et al. 1992). Based on this value, a distribution was assumed for the seal components. The recommended value was 0.2, and the recommended range was 0.0 to 0.4 with a uniform distribution for all shaft seal materials.

WIPP Data Entry Form #464 WPO#: 33420

References:

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," *Nuclear Engineering and Design*. Vol. 138, no. 2, 171-177.

Parameter 15: Residual Brine Saturation - All Shaft Materials

Parameter Description:

The residual brine saturation (S_{br}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. Referred to also as S_{wr} (wetting phase) or S_{lr} (liquid phase), residual brine saturation is the point reached under high gas saturation conditions when brine is no longer continuous throughout the pore network and relative brine permeability becomes zero.

Material and Parameter Name(s):

SALT_T1	SAT_RBRN (#2528)
SALT_T2	SAT_RBRN (#2545)
SALT_T3	SAT_RBRN (#2562)
SALT_T4	SAT_RBRN (#2579)
SALT_T5	SAT_RBRN (#2596)
SALT_T6	SAT_RBRN (#2992)
EARTH	SAT_RBRN (#2511)
CLAY_RUS	SAT_RBRN (#3014)
CL_L_T1	SAT_RBRN (#2342)
CL_L_T2	SAT_RBRN (#2359)
CL_L_T3	SAT_RBRN (#2376)
CL_L_T4	SAT_RBRN (#3082)
CL_M_T1	SAT_RBRN (#2393)
CL_M_T2	SAT_RBRN (#2410)
CL_M_T4	SAT_RBRN (#2444)
CL_M_T5	SAT_RBRN (#2461)
CLAY_BOT	SAT_RBRN (#2325)
CONC_T1	SAT_RBRN (#2478)
CONC_T2	SAT_RBRN (#2494)
CONC_MON	SAT_RBRN (#3063)
ASPHALT	SAT_RBRN (#2291)

Parameter 15: Residual Brine Saturation - All Shaft Materials (Continued)

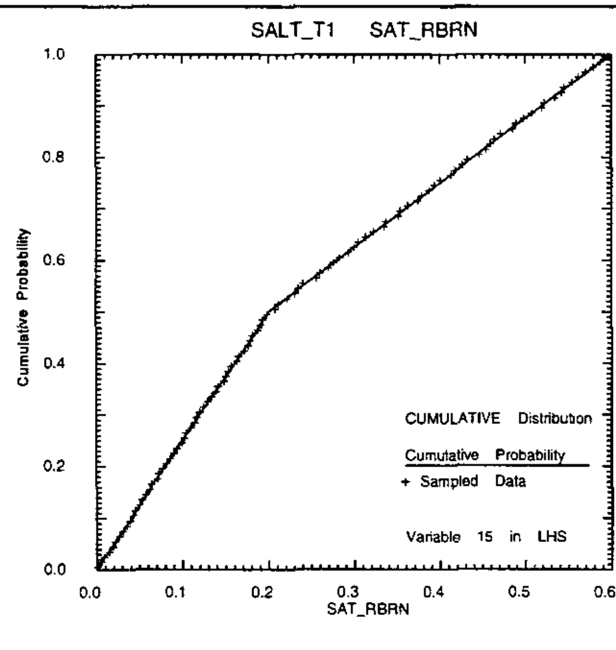
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.25	0.20	0	0.60	0.18

Units: None

Distribution Type: Cumulative

CDF/PDF Graph



Data: General Literature - Professional Judgment

Data are based on a review of the available literature. The parameter records package associated with this parameter is located at SWCF-A:1.1.03.2.1:PDD:QA:Shaft Seals BRAGFLO Parameters (WPO 30640).

Discussion:

A literature search was conducted to obtain residual liquid saturation values for consolidated geologic materials, concrete, and asphalt. Residual liquid saturations for geologic materials

Parameter 15: Residual Brine Saturation - All Shaft Materials (Continued)

Discussion (Continued):

were found in four references (Brooks and Corey 1964; Lappala et al. 1987; Parker et al. 1987; and Rawls et al. 1982). Brooks and Corey (1964) determined residual saturations for five unconsolidated samples based on measured values of liquid saturation as a function of capillary pressure. Lappala et al. (1987) determined residual moisture content for 11 soils by obtaining best fits to measured moisture content versus pressure head data using three models. The residual moisture contents determined for each soil using the three models were averaged and divided by the reported porosity to obtain a residual liquid saturation for each soil. Parker et al. (1987) fit their saturation-pressure relationship to observed data to obtain residual saturations for a sandy and clayey porous media. Residual water contents reported by Rawls et al. (1982) for 11 soil texture classes were divided by the reported porosity to obtain residual saturations.

Mayer et al. (1992) reported a residual liquid saturation for normal concrete of 0.30. Data regarding residual liquid saturations in asphalt materials were not found in the literature.

The literature values of residual liquid saturation for geologic materials and concrete fall within the range of 0.0 to 0.6 with all but two values falling within the range of 0.0 to 0.4. It was recommended that a value of 0.2 be used for the residual liquid saturation of all seal components. The recommended range was 0.0 to 0.6 with a uniform distribution.

WIPP Data Entry Form #464 WPO#: 33418

M

References:

Brooks, R.H., and Corey, A.T. 1964. *Hydraulic Properties of Porous Media.* Hydrology Paper No. 3. Fort Collins, CO: Colorado State University.

Lappala, E.G., Healy, R.W., and Weeks, E.P. 1987. *Documentation of Computer Program VS2D to Solve the Equations of Fluid Flow in Variably Saturated Porous Media.* Water-Resources Investigations Report 83-4099. Denver, CO: U.S. Geological Survey. Tech Library books collection: PC173.4.P67L31987.

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," *Nuclear Engineering and Design.* Vol. 138, no. 2, 171-177.

Parameter 15: Residual Brine Saturation - All Shaft Materials (Continued)

References (Continued):

Parker, J.C., Lenhard, R.J., and Kuppusamy, T. 1987. "A Parametric Model for Constitutive Properties Governing Multiphase Flow in Porous Media," *Water Resources Research.* Vol. 23, no. 4, 618-624.

Rawls, W.J., Brakensiek, D.L., and Saxton, K.E. 1982. "Estimation of Soil Water Properties," *Transactions of the ASAE.* St. Joseph, MI: American Society of Agricultural Engineers. 1316-1328.

Parameter 16: Pore Distribution - All Shaft Materials

Parameter Description:

The Brooks-Corey pore size distribution parameter (λ) is used to calculate capillary pressure and relative permeabilities for gas and brine flow in the two-phase flow model. It is a sampled parameter for the salt shaft material at time T = 0 to 10 years and the values are then applied to all of the other shaft materials and time periods.

Material and Parameter Name(s):

SALT_T1	PORE_DIS (#2516)
SALT_T2	PORE_DIS (#2533)
SALT_T3	PORE_DIS (#2550)
SALT_T4	PORE_DIS (#2567)
SALT_T5	PORE_DIS (#2809)
SALT_T6	PORE_DIS (#2989)
EARTH	PORE_DIS (#2499)
CLAY_RUS	PORE_DIS (#3006)
CL_L_T1	PORE_DIS (#2330)
CL_L_T2	PORE_DIS (#2347)
CL_L_T3	PORE_DIS (#2364)
CL_L_T4	PORE_DIS (#3076)
CL_M_T1	PORE_DIS (#2381)
CL_M_T2	PORE_DIS (#2398)
CL_M_T3	PORE_DIS (#2415)
CL_M_T4	PORE_DIS (#2432)
CL_M_T5	PORE_DIS (#2449)
CLAY_BOT	PORE_DIS (#2313)
CONC_T1	PORE_DIS (#2466)
CONC_T2	PORE_DIS (#2483)
CONC_MON	PORE_DIS (#3057)
ASPHALT	PORE_DIS (#2279)

Computational Code: BRAGFLO

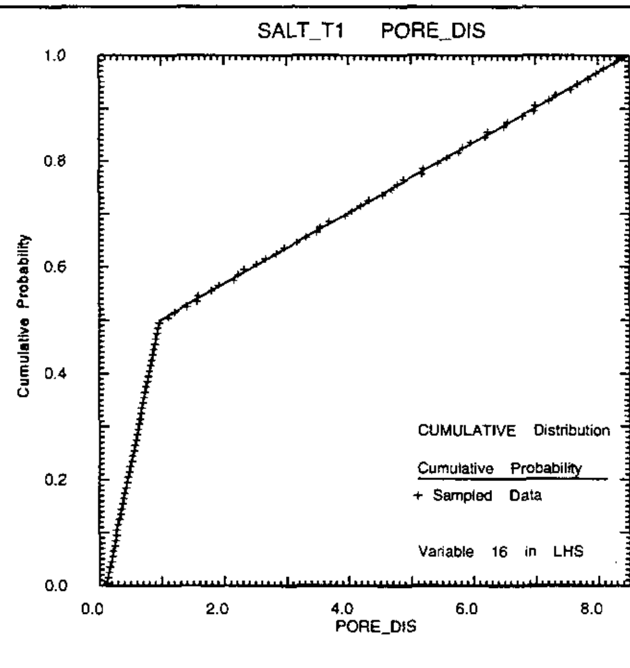
Parameter 16: Pore Distribution - All Shaft Materials (Continued)

mean	median	minimum	maximum	std. deviation
2.52	0.94	0.11	8.1	2.48

Units: None

Distribution Type: Cumulative

CDF/PDF Graph



Data: General Literature - Professional Judgment

Data are based on a review of the available literature. The parameter records package associated with this parameter is located at: SWCF-A:WBS1.1.03.2.1:PDD:QA:Shaft Seal BRAGFLO Parameters (WPO 30640).

Discussion:

A literature search was conducted to find pore distribution (that is, lambda) values for geologic materials and concrete. For geologic materials, 81 lambda values were found in five

Parameter 16: Pore Distribution - All Shaft Materials (Continued)

Discussion (Continued):

references (Brooks and Corey 1964; Mualem 1976; Rawls et al. 1982; Haverkamp and Parlange 1986; and Lappala et al. 1987). In addition, 38 lambda values were calculated from values of the van Genuchten parameter n found in six references (van Genuchten 1980; van Genuchten and Nielsen 1985; Hopmans and Overmars 1986; Parker et al. 1987; Stephens et al. 1988; and Wösten and van Genuchten 1988).

The total number of lambda values found in the literature or calculated from n values found in the literature was 119. In a few cases, different literature sources reported different values of lambda and/or n for the same materials. For this situation, the different lambda values were arithmetically averaged to obtain a single value for the material. This procedure yielded lambda values for a total of 85 different geologic materials.

The lambda values range from 0.11 to 11.67 and have a median of 0.94. Based on the shape of the histogram and CDF, it appears that the lambda values are lognormally distributed. The Lilliefors test for normality (Iman and Conover 1983) was applied to the data to verify that the logarithm of the lambda values can be described by a normal distribution. The mean of the log lambda values was found to be −0.064 with a standard deviation of 1.08. The Lilliefors bounds represent the region within which 95 percent of normally distributed values will fall.

For concrete, a literature search yielded only one reference (Mayer et al. 1992). This reference indicates that the Corey (1954) relationships are appropriate for describing the two-phase characteristic curves for the normal concretes they tested. For asphalt materials, data regarding lambda values were not found in the literature.

Both a lognormal and cumulative distribution for this parameter were recommended for the seal components constructed from granular earth materials (that is, earthen fill, compacted clay, and reconsolidated crushed salt). A cumulative distribution is appropriate when the range (a, c) of the parameter is known and the best estimate value, b, is the median. The value recommended was 0.94, which is the median of the literature values for geologic materials. The recommended range for the distribution was 0.11 to 8.1. Consequently, a cumulative distribution is assigned. In the absence of literature data, the same lambda distribution type, value, and range were also recommended for the concrete and asphalt seal components.

WIPP Data Entry Form #464 WPO#: 33380

Parameter 16: Pore Distribution - All Shaft Materials (Continued)

References:

Brooks, R.H., and Corey, A.T. 1964. *Hydraulic Properties of Porous Media.* Hydrology Paper No. 3. Fort Collins, CO: Colorado State University.

Corey, A.T. 1954. "The Interrelation Between Gas and Oil Relative Permeabilities," *Producer's Monthly.* Vol. XIX, no. 1, 38–41.

Haverkamp, R., and Parlange, J.Y. 1986. "Predicting the Water-Retention Curve From Particle-Size Distribution: 1. Sandy Soils Without Organic Matter," *Soil Science.* Vol. 142, no. 6, 325-339.

Hopmans, J.W., and Overmars, B. 1986. "Presentation and Application of an Analytical Model to Describe Soil Hydraulic Properties," *Journal of Hydrology.* Vol. 87, no. 1-2. 135-143.

Iman, R.L., and Conover, W.J. 1983. *Modern Business Statistics.* New York, NY: John Wiley & Sons, Inc.

Lappala, E.G., Healy, R.W., and Weeks, E.P. 1987. *Documentation of Computer Program VS2D to Solve the Equations of Fluid Flow in Variably Saturated Porous Media.* Water-Resources Investigations Report 83-4099. Denver, CO: U.S. Geological Survey.

Mayer, G., Jacobs, F., and Wittmann, F.H. 1992. "Experimental Determination and Numerical Simulation of the Permeability of Cementitious Materials," *Nuclear Engineering and Design.* Vol. 138, no. 2, 171-177.

Mualem, Y. 1976. "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media," *Water Resources Research.* Vol.12, no. 3, 513-522.

Parker, J.C., Lenhard, R.J., and Kuppusamy, T. 1987. "A Parametric Model for Constitutive Properties Governing Multiphase Flow in Porous Media," *Water Resources Research.* Vol. 23, no. 4, 618-624.

Rawls, W.J., Brakensiek, D.L., and Saxton, K.E. 1982. "Estimation of Soil Water Properties," *Transactions of the ASAE.* St. Joseph, MI: American Society of Agricultural Engineers. 1316-1328.

Parameter 16: Pore Distribution - All Shaft Materials (Continued)

References (Continued):

Stephens, D.B., Unruh, M., Havlena, J., Knowlton, R.G., Jr., Mattson, E., and Cox, W. 1988. "Vadose Zone Characterization of Low-Permeability Sediments Using Field Permeameters," *Ground Water Monitoring Review*. Vol. 8, no. 2, 59-66.

van Genuchten, M. Th. 1980. "A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils," *Soil Science Society of America Journal.* Vol. 44, no. 5, 892-898.

van Genuchten, M. Th., and Nielsen, D.R. 1985. "On Describing and Predicting the Hydraulic Properties of Unsaturated Soils," *Annales Geophysicae*. Vol. 3, no. 5, 615-628.

Wösten, J.H.M., and van Genuchten, M. Th. 1988. "Using Texture and Other Soil Properties to Predict the Unsaturated Soil Hydraulic Functions," *Soil Science Society of America Journal.* Vol. 52, no. 6, 1762-1770.

Parameter 17: Effective Porosity - Halite

Parameter Description:

The effective porosity of Salado Formation halite and polyhalite refers to the ratio of the interconnected pore volume to the bulk volume.

Material and Parameter Name(s):

S_HALITE POROSITY (#544)

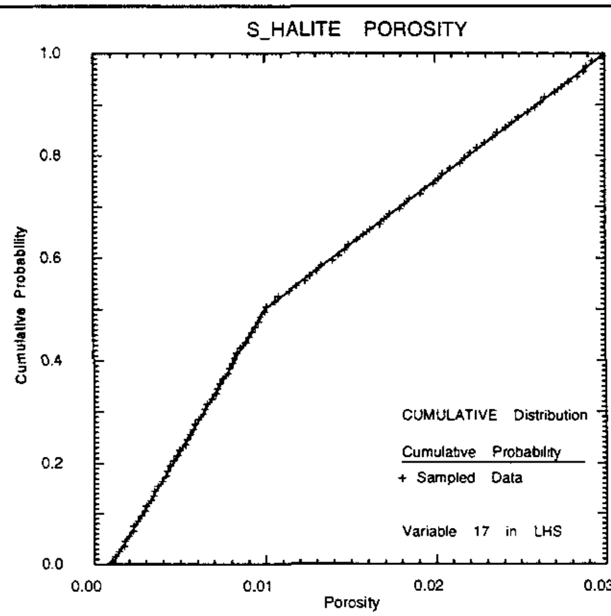
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.0128	0.01	0.001	0.03	0.01

Units: cubic meters/cubic meters

Distribution Type: Cumulative

CDF/PDF Graph



Parameter 17: Effective Porosity - Halite (Continued)

Data: Site-Specific Experimental Data

The effective porosity distribution of Salado halite is supported by three separate porosity calculations: 1) Skokan et al. (1989; p. 15) determined from electromagnetic and DC resistivity experiments, 2) drying experiments described in Powers et al. (1978; p. 7-30), and 3) drying experiments reported in Deal et al. (1993). The parameter records package associated with this parameter is as follows: SCWF-A:WBS 1.2.07.1:PDD:QA:SALADO: PKG8:POROSITY: effective porosity/hal (WPO 30601).

Discussion:

The high value (0.03) for the range of porosity is suggested in Skokan et al. (1989; p.6,13), based on the low end (10 ohm) of the DC resistivity measurements registered in the underground repository. The low value (0.001) is suggested in Powers et al. (1978) based on drying experiments. The median value of 0.01 is suggested in Skokan et al.(1989; p.15). Deal et al. (1993) found an average value of 0.016 for total porosity from a different series of drying experiments.

WIPP Data Entry Form #464 WPO#: 34387

References:

Deal, D.E., Abitz, R.J., Myers, J., Martin, M.L., Millgan, D.J., Sobocinski, R.W., Lipponer, P.P.J., and Belski, D.S. 1993. *Brine Sampling and Evaluation Program, 1991 Report.* DOE-WIPP-93-026. Carlsbad, NM: Westinghouse Electric Corporation, Waste Isolation Division.

Powers, D.W., Lambert, S.J., Shaffer, S.E., Hill, L.R., and Weart, W.D., eds. 1978. *Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico.* SAND78-1596. Albuquerque, NM: Sandia National Laboratories. Vols. 1-2. V. 1 - WPO 5448; V.2 - WPO 26829 – 26830, original photos - WPO 26859.

Skokan, C.K., Pfeifer, M.C., Keller, G.V., and Andersen, H.T. 1989. *Studies of Electrical and Electromagnetic Methods for Characterizing Salt Properties at the WIPP Site, New Mexico.* SAND87-7174. Albuquerque, NM: Sandia National Laboratories. WPO 24033.

Parameter 18: Log of Intrinsic Permeability - Halite

Parameter Description:

The Salado Formation halite is assigned an intrinsic permeability intended to reflect the stratigraphic variability of Salado halite and far-field hydraulic conditions. It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Parameter Name(s):

S_HALITE PRMX_LOG (#547)
S_HALITE PRMY_LOG (#548)
S_HALITE PRMZ_LOG (#549)

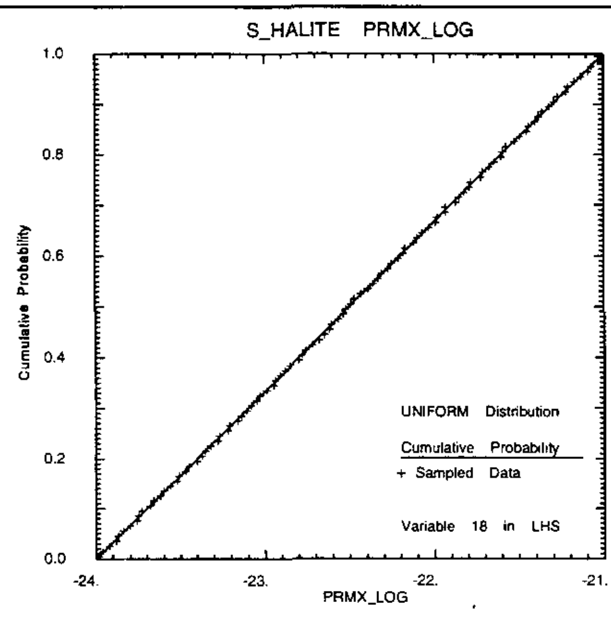
Computational Code: BRAGFLO

mean	median	low	high	std. deviation
-22.5	-22.5	-24.0	-21.0	0.87

Units: log(square meters)

Distribution Type: Uniform

CDF/PDF Graph



Parameter 18: Log of Intrinsic Permeability - Halite (Continued)

Data: Site-Specific Experimental Data

The reported permeability range of undisturbed impure halite is based on four selected in-situ hydraulic tests: three flow tests believed representative of far-field permeability and one flow test that measured permeability in a zone which included a range of halite lithologies. Computer-derived permeabilities based upon brine inflow data from Room Q fall within the range derived from flow tests. The reader is referred to the relevant parameter record package for more detail; the following parameter records packages are located at: SCWF-A: WBS1.2.07.1:PDD:QA:SALADO:PKG 7:Halite Permeability (x,y,z) (WPO 31218) SCWF-A:WBS1.2.07.1:PDD:QA: SALADO:PKG 7:Salado Halite Permeability (WPO 30721).

Discussion:

Impure halite denotes a broad range of lithologic types ranging from pure halite to lithologies with various degrees of impurities, including polyhalite, argillaceous and anhydritic halite. Far-field tests of the pure halite exist; however, far-field hydraulic tests data do not exist for relatively impure halites, which tend to show higher permeabilities in the near-field. Thus a range of permeability is specified, bounded by rounded low and high permeability values determined from the testing program.

Three hydraulic tests believed representative of far-field pure halite permeability were conducted in the present location of Room Q in map units with relatively low impurities: a halite with less than 0.5 percent impurity, a halite containing approximately 1 percent impurity and a halite and polyhalite zone with a 1-2 percent impurity. These tests are believed to represent the lower end of the permeability range for Salado halite (see Table PAR-4). These units were tested before the large-scale brine inflow excavation was mined and at stratigraphic intervals located over 66 feet (20 meters) from the excavation.

Although probably located within the influence of the DRZ, one flow test (C2H01-BGZ) measured within map units 0-4. This permeability value in conjunction with Room Q model analysis determination of far-field permeability are used to bound the maximum permeability of Salado halite containing relatively high impurities.

A summary of selected interpretative results of these four flow and pressure tests is compiled in the attached table. A schematic representation of Salado map units near the disposal area horizon, adapted from Deal et. al. (1989), is attached for information purposes (see Figure PAR-3).

WIPP Data Entry Form #464 WPO#: 34397

Parameter 18: Log of Intrinsic Permeability - Halite (Continued)

References:

Beauheim, R.L., Saulnier, G.J., Jr., and Avis, J.D. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant Site: First Interim Report.* SAND90-0083. Albuquerque, NM: Sandia National Laboratories. WPO 26033.

Beauheim, R.L., Roberts, R.M., Dale, T.F., Fort, M.D., and Stensrud, W.A. 1993. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretive Report.* SAND92-0533. Albuquerque, NM: Sandia National Laboratories. WPO 23378.

Davies, Peter and Rick Beauheim. 1996. Memo to Martin Tierney. RE: Changes to the parameter records package and form #464 for far-field permeability of Salado halites (id#s: 547, 548, and 549; idmtrl: S_HALITE; idpram: PRMX_LOG, PRMY_LOG, and PRMZ_LOG, respectively). March 7, 1996. WPO 36772.

Deal, D.E., Abitz, R.J., Belski, D.S., and Case, J.B. 1989. *Brine Sampling and Evaluation Program, 1988 Report.* DOE-WIPP-89-015. Carlsbad, NM: Westinghouse Electric Corporation.

Jensen, A.L., Howard, C.L., Jones, R.L., and Peterson, T.P. 1993. *Room Q Data Report: Test Borehole Data from April 1989 through November 1991.* SAND92-1172. Albuquerque, NM: Sandia National Laboratories. WPO 23548.

Saulnier, G.J., Jr., Domski, P.S., Palmer, J.B., Roberts, R.M., Stensrud, W.A., and Jensen, A.L. 1991. *WIPP Salado Hydrology Program Data Report #1.* SAND90-7000. Albuquerque, NM: Sandia National Laboratories. WPO 25746

Stensrud, W.A., Dale, T.F., Domski, P.S., Palmer, J.B., Roberts, R.M., Fort, M.D., Saulnier, G.J., Jr., and Jensen, A.L. 1992. *Waste Isolation Pilot Plant Salado Hydrology Program Data Report #2.* SAND92-7072. Albuquerque, NM: Sandia National Laboratories. WPO 26432.

Table PAR-4. Summary of Permeability Test-Interpretations Results from In Situ Permeability Tests Representing Undisturbed Impure Halite

Test Interval (meters from excavation)	Hole	Map unit(s)	Analysis Method	Permeability k (square meters)
20.13-21.03	QPPO5	MU 6	GTFM6.0	1.12×10^{-24}
23.35-24.20	QPP12	H3	GTFM6.0	2.69×10^{-22}
20.19-21.09	QPP15	MU O - MU PH-4	GTFM6.0	5.5×10^{-24}
4.50-5.58	C2H01-BGZ	MU O - MU 4	GTFM6.0	1.38×10^{-21}

Note: See Record Parameter Package for additional detail.

Parameter 18: Log of Intrinsic Permeability - Halite (Continued)

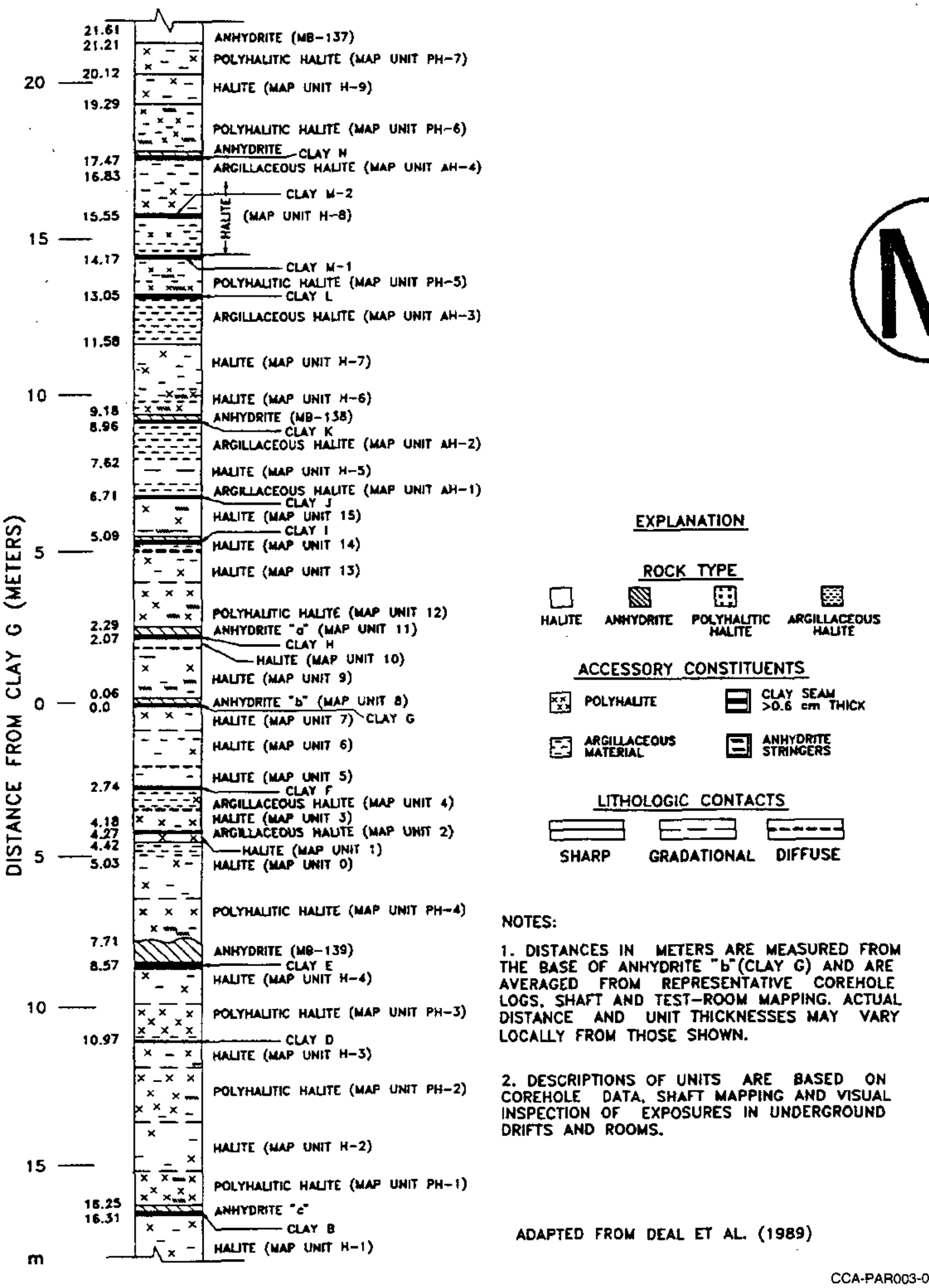


Figure PAR-3. Detailed Stratigraphy Near the WIPP Site (Deal et al. 1989)

Parameter 19: Rock Compressibility - Halite

Parameter Description:

The rock (or bulk) compressibility of the Salado Formation halite is used to calculate the pore compressibility that is used in BRAGFLO. Pore compressibility is used to predict the effect of material compressibility on porosity and mass storage in the equation of state for flow through porous media as follows:

$$\phi = \phi_o \exp\left(c_p(p - p_o)\right)$$

where,

ϕ = porosity of solid matrix (cubic meters/cubic meters)
ϕ_o = porosity at reference pressure p_o
c_p = pore compressibility (pascals^{-1})
p = pore pressure (pascals)
p_o = reference pore pressure (pascals)

The rock compressibility is divided by effective porosity to calculate pore compressibility.

Material and Parameter Name(s):

S_HALITE COMP_RCK (#541)

Computational Code: BRAGFLO

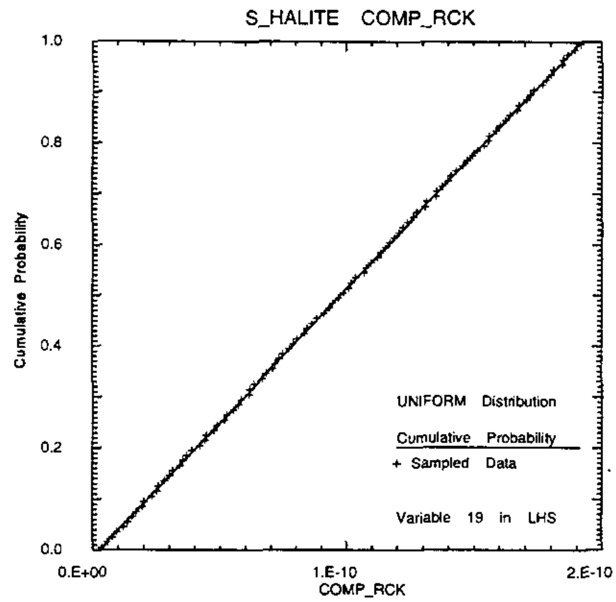
mean	median	minimum	maximum	std. deviation
9.75×10^{-11}	9.75×10^{-11}	2.94×10^{-12}	1.92×10^{-10}	0

Units: Pa^{-1}

Distribution Type: Uniform

Parameter 19: Rock Compressibility - Halite (Continued)

CDF/PDF Graph



Data: Site-Specific Experimental Data

The parameter distribution for halite rock compressibility is based upon data from two hydraulic tests in Room Q: QPP05 and QPP15. Another data point calculated from sensitivity studies using brine inflow data from Room Q is within the range driven from the hydraulic tests. Parameter records packages associated with this parameter are located at SCWF-A:WBS1.2.07.1:PDD:QA: SALADO:PKG 5: Salado Halite Rock Compressibility (WPO 31220) and SCWF-A.WBS1.2.07.1:PDD:QA: SALADO:PKG 5: Salado Halite Rock Compressibility (WPO 30598).

Discussion:

The two in situ hydraulic tests were conducted in the location of Room Q before the large-scale brine inflow excavation was mined. Test intervals were located over 65 feet (20 meters) from the excavation. Map units (MU) represented included MU 6 (halite) and MU 0 (halite)/MU PH-4 (polyhalite) within a radius of about 3.3 feet (one meter) of each borehole. Raw data included pressure, fluid volume, temperature, axial test-tool movement, and radial borehole closure.

Parameter 19: Rock Compressibility - Halite (Continued)

Discussion (Continued):

Interpretation of all flow tests in the WIPP facility is based on the assumption that Darcy flow and borehole closure are the only forms of pressure/flow transmission during hydraulic tests. References related to data collection and interpretation are listed in the references section.

WIPP Data Entry Form #464 WPO#: 34210

References:

Beauheim, R.L., Saulnier, G.J., Jr., and Avis, J.D. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Watts Isolation Pilot Plant Site: First Interim Report.* SAND90-0083. Albuquerque, NM: Sandia National Laboratories. WPO 26003.

Beauheim, R.L., Roberts, R.M., Dale, T.F., Fort, M.D., and Stensrud, W.A. 1993. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretive Report.* SAND92-0533. Albuquerque, NM: Sandia National Laboratories. WPO 23378.

Jensen, A.L., Howard, C.L., Jones, R.L., and Peterson, T.P. 1993. *Room Q Data Report: Test Borehole Data from April 1989 through November 1991.* SAND92-1172. Albuquerque, NM: Sandia National Laboratories. WPO 23548

Saulnier, G.J., Jr., Domski, P.S., Palmer, J.B., Roberts, R.M., Stensrud, W.A., and Jensen, A.L. 1991. *WIPP Salado Hydrology Program Data Report #1.* SAND90-7000. Albuquerque, NM: Sandia National Laboratories. WPO 25746

Stensrud, W.A., Dale, T.F., Domski, P.S., Palmer, J.B., Roberts, R.M., Fort, M.D., Saulnier, G.J., Jr., and Jensen, A.L. 1992. *Waste Isolation Pilot Plant Salado Hydrology Program Data Report #2.* SAND92-7072. Albuquerque, NM: Sandia National Laboratories. WPO 26432.

Table PAR-5. Summary of Rock Compressibility Test-Interpretations Results from In Situ Permeability Tests for Undisturbed Halite and Polyhalite Map Units

Test Interval (meters from excavation)	Hole	Zone	Map Unit(s)	Analysis Method	Rock Compressibility C_r (1/pascal)	Formation Pore Pressure (megapascal)*
20.13-21.03 down	QPPO5 Room Q	undisturbed	MU 6	GTFM6.0	2.94×10^{-12}	13.89
20.19-21.09 down	QPP15 Room Q	undisturbed	MU 0 MU PH-4	GTFM6.0	1.92×10^{-10}	11.04

* - Mean

Note: See Record Parameter Package for additional detail.

Parameter 20: Log of Intrinsic Permeability - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139

Parameter Description:

The intrinsic permeabilities for MB138, Anhydrite Layers a & b, and MB139 are set equal to the values for MB139. It is a sampled parameter for MB139 and the values are then applied to MB138 and Anhydrite Layers a & b.

Material and Parameter Name(s):

S_MB139 PRMX_LOG (#591)
S_MB139 PRMY_LOG (#592)
S_MB139 PRMZ_LOG (#593)

S_ANH_AB	PRMX_LOG	(#531)	S_MB138	PRMX_LOG	(#570)
S_ANH_AB	PRMY_LOG	(#532)	S_MB138	PRMY_LOG	(#571)
S_ANH_AB	PRMZ_LOG	(#533)	S_MB138	PRMZ_LOG	(#572)

Computational Code: BRAGFLO

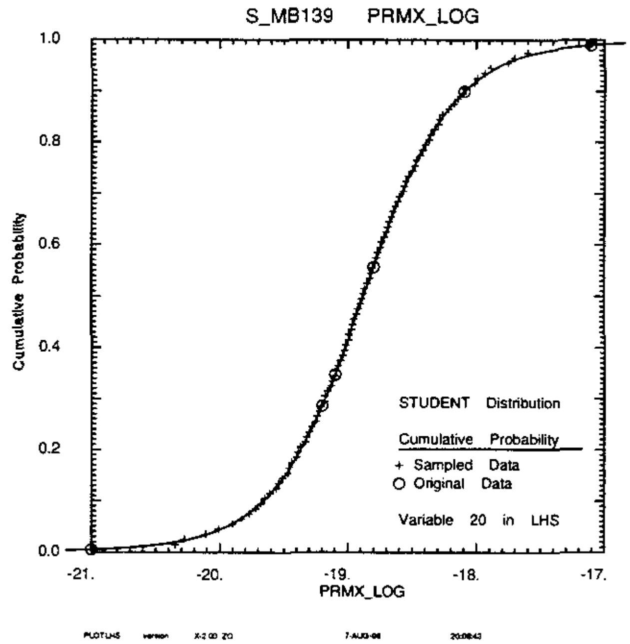
mean	median	minimum	maximum	std. deviation
-18.89	-18.89	-21.0	-17.1	1.20

Units: log(square meters)

Distribution Type: Student's-t

Parameter 20: Log of Intrinsic Permeability - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

CDF/PDF Graph



Data: Site-Specific Experimental Data and Laboratory-Measured Data

The reported parameter range of undisturbed Salado anhydrite permeabilities is based upon selected data collected from in situ hydraulic tests and measurements conducted in the laboratory: 1) five hydraulic tests conducted in the underground experimental area; and 2) 31 Klinkenberg-corrected gas permeabilities measured in the laboratory on specimens collected from MB139 core samples. Summary data tables are attached for both in situ and laboratory tests (see Tables PAR-6 and PAR-7). Parameter records packages associated with this parameter are located at: SCWF-A:WBS1.2.07.1:PDD:QA: SALADO: PKG 13:Anhydrite Permeability (x,y,z) (WPO 31217); SWCF-A:WBS1.2.07.1:PDD:QA: SALADO:PKG 13:PRMX_LOG.Log of Permeability in x direction/anh (WPO 30603); SWCF-A:WBS1.2.07.1:PDD:QA: SALADO:PKG13:PRMY_LOG Log of Permeability in y direction/anh (WPO 30605); SWCF-A:WBS1.2.07.1:PDD:QA:SALADO: PKG13: PRMZ_LOG Log of Permeability in the z direction/anh (WPO 30606).

Parameter 20: Log of Intrinsic Permeability - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

Discussion:

Out of 15 borehole and field permeability tests conducted in MB140, MB139, MB138 and anhydrites a & b, five in situ hydraulic tests are considered representative of undisturbed anhydrite permeability. Located from about 33 to 79 feet (10 to 24 meters) from the excavation, the test intervals for these five boreholes were outside of the DRZ; the radius of visibility ranged from 13 to 82 feet (4 to 25 meters). The five successful tests are summarized as follows:

Borehole	Location	Map Unit	Testing Period	
QPP03	Room Q	Anhydrite b	4/89	11/91
QPP13	Room Q	MB 139	4/89	11/91
C2H02	Room C2	MB 139	4/89	12/89
L4P51-C1	Room L4	MB 140	4/92	6/94
SCP01-A	Core Storage	MB 139	4/90	10/90

Klinkenberg-corrected gas permeability measured in the laboratory can be used as an equivalent measure of liquid permeability. Klinkenberg-corrected test specimen data exist from six whole cores taken from MB139 in the northern experimental area: E1X07, E1X08, E1X10, E1X11 (E140 Drift), P3X10, and P3X11 (Room L3).

For purposes of parameterization, in situ test data are treated differently than laboratory-derived data. Uncertainty exists in regards to the spatial representativeness of the core samples. In situ hydraulic tests are considered representative of expected permeability conditions on the scale of the grid system used in the BRAGFLO mesh. Consequently, for the parameter distribution above, laboratory data from the 6 megapascals net effective stress are averaged as one data point, whereas each of the five hydraulic tests is considered an individual data point.

WIPP Data Entry Form #464 WPO#: 34865

References:

Beauheim, R.L., Saulnier, G.J., Jr., and Avis, J.D. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant Site: First Interim Report.* SAND90-0083. Albuquerque, NM: Sandia National Laboratories. WPO 26003.

Parameter 20: Log of Intrinsic Permeability - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

References (Continued):

Beauheim, R.L., Roberts, R.M., Dale, T.F., Fort, M.D., and Stensrud, W.A. 1993. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretive Report.* SAND92-0533. Albuquerque, NM; Sandia National Laboratories. WPO 23378.

Howarth S.M., and Christian-Frear, T. 1996. (WIPP Central Files WPO 38019). *Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant.*

Jensen, A.L., Howard, C.L., Jones, R.L., and Peterson, T.P. 1993. *Room Q Data Report: Test Borehole Data from April 1989 through November 1991.* SAND92-1172. Albuquerque, NM: Sandia National Laboratories. WPO 23548.

Saulnier, G.J., Jr., Domski, P.S., Palmer, J.B., Roberts, R.M., Stensrud, W.A., and Jensen, A.L. 1991. *WIPP Salado Hydrology Program Data Report #1.* SAND90-7000. Albuquerque, NM: Sandia National Laboratories. WPO 25746.

Stensrud, W.A., T.F. Dale, P.S. Domski, J.B. Palmer, R.M. Roberts, M.D. Fort, G.J. Saulnier, Jr., and A.L. Jensen. 1992. *Waste Isolation Pilot Plant Salado Hydrology Program Data Report #2.* SAND92-7072. Albuquerque, NM: Sandia National Laboratories. WPO 26432.

Table PAR-6. Summary of Test-Interpretations Results from In Situ Permeability Tests for Undisturbed Anhydrite Map Units

Test Interval (meters from excavation)	Hole	Zone	Map Unit	Analysis Method	Permeability k (square meters)	Formation Pore Pressure (megapascals)*
10.68-14.78 down	SCP01-A	undisturbed	MB139	GTFM6.0	1.4×10^{-19}	12.27
9.47-10.86 down	C2H02	undisturbed	MB139	GTFM6.0	1.0×10^{-21}	11.11
20.50-21.40 up	QPPO3	undisturbed	anhydrite b	GTFM6.0	7.6×10^{-20}	12.9
20.62-21.52 down	QPP13	undisturbed	MB139	GTFM6.0	6.0×10^{-20}	12.43
17.44-22.20 down	L4P51-C1	undisturbed	MB140	GTFM6.0	8.7×10^{-18}	9.38

* - Mean

Note: See Record Parameter Package for additional detail.

Parameter 20: Log of Intrinsic Permeability - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

Table PAR-7. Summary of MB139 Permeability Laboratory Test Results

	Permeability (pressure values are net effective stress)					
	Gas (Klinkenberg Corrected)			Log of Permeability		
	3.4 megapascals (square meters)	6 megapascals (square meters)	10 megapascals (square meters)	2 megapascals (square meters)	6 megapascals (square meters)	10 megapascals (square meters)
Minimum	1.5E-19	5.9E-20	5.0E-20	-18.84	-19.23	-19.30
Maximum	8.3E-16	3.0E-16	1.5E-16	-15.08	-15.52	-15.82
Sum	9.0E-16	3.4E-16	1.8E-16	-552.29	-524.43	-402.17
Points	31	29	22	31	29	22
Mean	2.9E-17	1.2E-17	8.0E-18	-17.82	-18.08	-18.28
Median	1.3E-18	5.7E-19	3.1E-19	-17.89	-18.24	-18.51
Std Deviation	1.5E-16	5.6E-17	3.2E-17	0.67	0.69	0.83
Variance	2.2E-32	3.2E-33	1.1E-33	0.45	0.48	0.69

Parameter 21: Rock Compressibility - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139

Parameter Description:

The rock (or bulk) compressibility of the Salado Formation Anhydrite Layers a & b and MB138 and MB139 is used to calculate the pore compressibility that is used in BRAGFLO. Pore compressibility is used to predict the effect of material compressibility on porosity and mass storage in the equation of state for flow through porous media as follows:

$$\phi = \phi_o \exp(c_p(p - p_o))$$

where,

ϕ = porosity of solid matrix (cubic meters/cubic meters)
ϕ_o = porosity at reference pressure p_o
c_p = pore compressibility ($pascals^{-1}$)
p = pore pressure (pascals)
p_o = reference pore pressure (pascals)

The rock compressibility is divided by effective porosity to calculate pore compressibility. It is a sampled parameter for MB139 and the values are then applied to MB138 and Anhydrite Layers a & b.

Material and Parameter Name(s):

S_MB139	COMP_RCK (#580)
S_ANH_AB	COMP_RCK (#521)
S_MB138	COMP_RCK (#560)

Computational Code: BRAGFLO

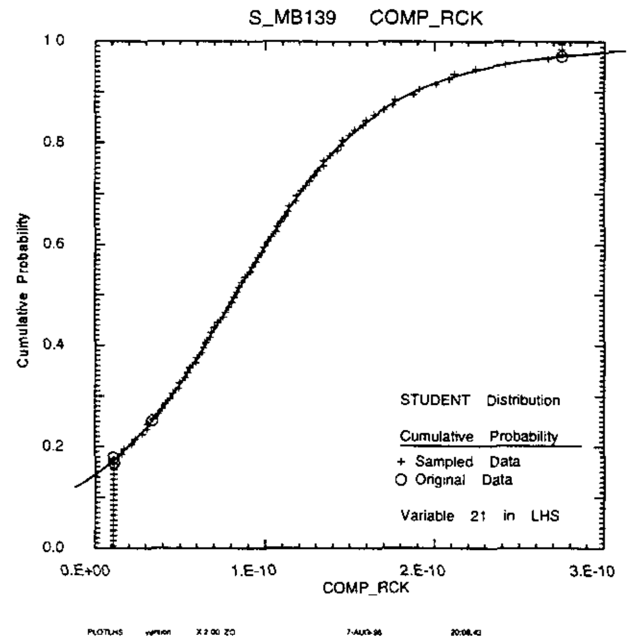
mean	median	minimum	maximum	std. deviation
8.26×10^{-11}	8.26×10^{-11}	1.09×10^{-11}	2.75×10^{-10}	0

Units: $pascals^{-1}$

Distribution Type: Student's-t

Parameter 21: Rock Compressibility - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

CDF/PDF Graph



Data: Site-Specific Experimental Data

The parameter distribution for anhydrite rock compressibility is based upon data from four hydraulic tests in the underground WIPP facility. The boreholes and map units tested include: C2H02 (MB139); QPP03 (Anhydrite b); QPP13 (MB139); and SCP01 (MB139). The parameter records package associated with this parameter is located at: SCWF-A: WBS1.2.07.1:PDD: QA:SALADO:PKG 19:Rock Compressibility (WPO 31186).

Discussion:

The four successful tests include:

Borehole	Location	Start Date of Testing	End Date of Testing
QPP03	Room Q	4/89	11/91
QPP13	Room Q	4/89	11/91
C2H02	Room C2	4/89	11/89
SCP01-A	Core Storage	4/90	10/90

Parameter 21: Rock Compressibility - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

Discussion (Continued):

Raw data collected during hydraulic tests include pressure, fluid volume, temperature, axial test-tool movement, and radial borehole closure. Pressure/flow transmission during hydraulic tests is assumed to be a result of Darcy flow and borehole closure. The reader is referred to the anhydrite rock compressibility parameter record package for more detail.

WIPP Data Entry Form #464 WPO#: 34574

References:

Beauheim, R.L., Saulnier, Jr., G.J., and Avis, J.D. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant Site: First Interim Report.* SAND90-0083. Albuquerque, NM: Sandia National Laboratories. WPO 26003.

Beauheim, R.L., Roberts, R.M., Dale, T.F., Fort, M.D., and Stensrud, W.A. 1993. *Hydraulic Testing of Salado Formation Evaporites at the Waste Isolation Pilot Plant Site: Second Interpretive Report.* SAND92-0533. Albuquerque, NM: Sandia National Laboratories. WPO 23378.

Jensen, A.L., Howard, C.L., Jones, R.L., and Peterson, T.P. 1993. *Room Q Data Report: Test Borehole Data from April 1989 through November 1991.* SAND92-1172. Albuquerque, NM: Sandia National Laboratories. WPO 23548.

Saulnier, Jr., G.J., Domski, P.S., Palmer, J.B., Roberts, R.M., Stensrud, W.A., and Jensen, A.L. 1991. *WIPP Salado Hydrology Program Data Report #1.* SAND90-7000. Albuquerque, NM: Sandia National Laboratories. WPO 25746.

Stensrud, W.A., Dale, T.F., Domski, P.S., Palmer, J.B., Roberts, R.M., Fort, M.D., Saulnier, G.J., Jr., and Jensen, A.L. 1992. *Waste Isolation Pilot Plant Salado Hydrology Program Data Report #2.* SAND92-7072. Albuquerque, NM: Sandia National Laboratories. WPO 26432.

Parameter 21: Rock Compressibility - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

Table PAR-8. Summary of Rock Compressibility Test-Interpretations Results from In Situ Permeability Tests for Undisturbed Anhydrite Marker Beds

Test Interval (meters from excavation)	Hole and Location	Zone	Map Unit(s)	Analysis Method	Rock Compressibility C_r (1/pascals)	Formation Pore Pressure (megapascals)
9.47–10.86 down	C2H02	undisturbed	MB 139	GTFM6.0	1.09×10^{-11}	11.11
20.62–21.52 down	QPP13	undisturbed	MB 139	GTFM6.0	3.37×10^{-11}	12.43
10.68–14.78 down	SCP01	undisturbed	MB 139	GTFM6.0	1.09×10^{-11}	12.27
20.50–21.40 up	QPP03	undisturbed	Anhydrite b	GTFM6.0	2.75×10^{-10}	12.94

* - Mean
Note: See Record Parameter Package for additional detail.

Parameter 22: Relative Permeability Model Number

Parameter Description:

The relative permeability model number parameter is the flag used to select two-phase flow model for use in BRAGFLO. It is a sampled parameter for MB139 and the values are then applied to MB138 and Anhydrite Layers a & b. All other material regions use the second modified Brooks-Corey two-phase flow model.

Material and Parameter Name(s):

S_MB139 (#596) RELP_MOD
S_ANH_AB (#536) RELP_MOD
S_MB138 (#575) RELP_MOD

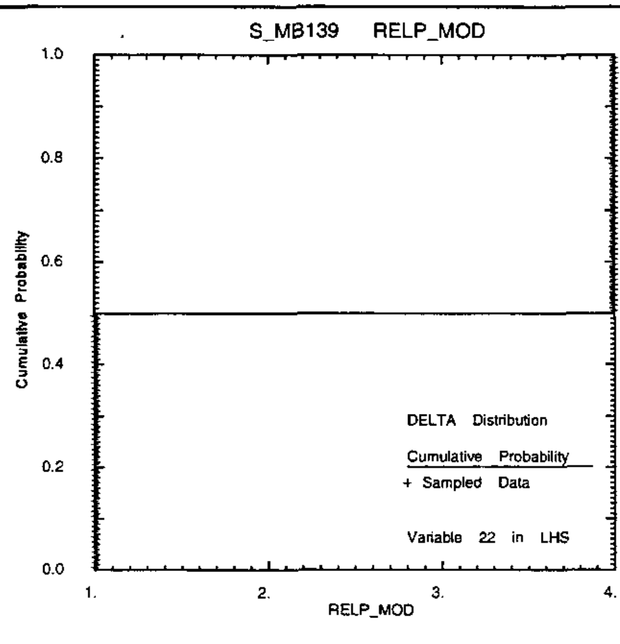
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
n.a.	n.a.	1	4	n.a.

Units: None

Distribution Type: Delta

CDF/PDF Graph



Parameter 22: Relative Permeability Model Number (Continued)

Data: Site-Specific Experimental Data

Site-specific experimental data was collected from whole core taken from six underground boreholes at the WIPP. The specimens first underwent permeability and porosity testing, then subsequent capillary pressure tests. Test data from MB139 was applied to MB138 and Anhydrite Layers a & b. All other material regions use the second modified Brooks-Corey two-phase flow model.

Assumptions made during testing were:

1) Cores were 100 percent saturated at initiation of capillary pressure tests.
2) Use of a 140° contact angle was appropriate for correcting mercury-air data to brine-air repository conditions.
3) Although tests were conducted at ambient conditions (no stress), the data are adequate to describe two-phase conditions at stress.

The following parameter records package is associated with the tests: SWCF-A:1.2.07.1:PDD:QA:SALADO:PKG 10:Salado Anhydrite Two-Phase Parameters (WPO 30643).

Discussion:

There are several two-phase relative permeability models described in Appendix BRAGFLO, including the van Genuchten-Parker and the second modified Brooks-Corey. Interpretation of the experimental test results showed that either the second modified Brooks-Corey or the van Genuchten-Parker two-phase flow models could be used to describe the data.

WIPP Data Entry Form #464 WPO#: 34500

References:

Howarth S.M., and Christian-Frear, T.. 1996. (WIPP Central Files WPO 38019). *Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant.*

Webb, S.W. 1991. "Sensitivity Studies for Gas Release from the Waste Isolation Pilot Plant," Chapter 4.0 in *Waste-Generated Gas at the Waste Isolation Pilot Plant: Papers Presented at the Nuclear Energy Agency Workshop on Gas Generation and Release from the Radioactive Waste Repositories*, P.B. Davies et al., eds., SAND91-2378, November 1991.

Parameter 23: Residual Brine Saturation - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139

Parameter Description:

The residual brine saturation (S_{br}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. Referred to also as S_{wr} (wetting phase) or S_{lr} (liquid phase), residual brine saturation is the point reached under high gas saturation conditions when brine is no longer continuous throughout the pore network and relative brine permeability becomes zero. It is a sampled parameter for MB139 and the values are then applied to MB138 and Anhydrite Layers a & b.

Material and Parameter Name(s):

S_MB139	SAT_RBRN (#598)
S_MB138	SAT_RBRN (#577)
S_ANH_AB	SAT_RBRN (#538)

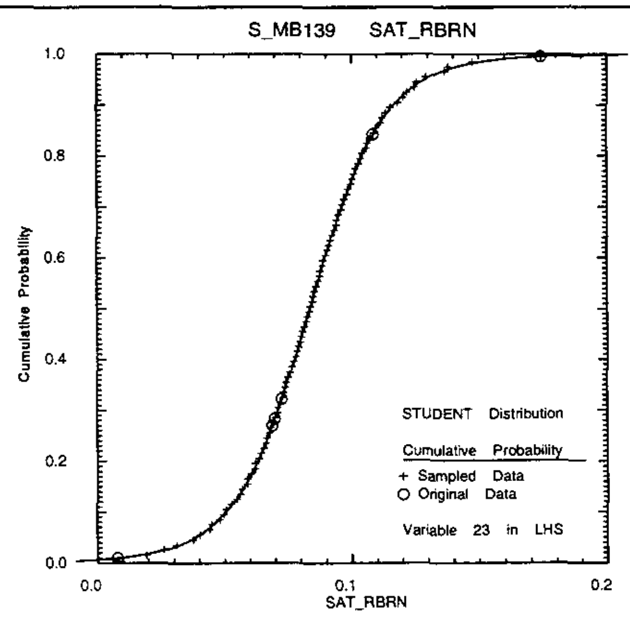
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.08363	0.08363	0.007846	0.17400	0.05

Units: None

Distribution Type: Student's-t

CDF/PDF Graph



Parameter 23: Residual Brine Saturation - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

Data: Site-Specific Experimental Data

Residual brine saturation parameter values for the marker beds are based on curve fit parameter values predicted from laboratory measurements of capillary pressure. The parameter records package associated with this parameter is retained in SWCF: SWCF-A 1.2.07.1:PDD:QA:SALADO:PKG 10:Salado Anhydrite Two-Phase Parameters (WPO 30643).

Discussion:

Parameter values are based on curve fit capillary pressure data measured using a mercury injection technique. The two-phase flow program reports the results of curve-fitted measurements of capillary pressure on six marker bed samples (Howarth and Christian-Frear 1996). Specimens were collected from intact MB139 core samples taken from the experimental area of the repository.

WIPP Data Entry Form #464 WPO#: 34506

References:

Howarth S.M., and Christian-Frear, T. 1996. (WIPP Central Files WPO 38019). *Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant.*

Parameter 24: Residual Gas Saturation - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139

Parameter Description:

The residual (critical) gas saturation (S_{gr}) is required in the two-phase flow model to define the relative permeability and capillary pressure curves. S_{gr} corresponds to the degree of waste-generated gas saturation necessary to create an incipient interconnected pathway in porous material, a condition required for porous rock to be permeable to gas. It is a sampled parameter for MB139 and the values are then applied to MB138 and Anhydrite Layers a & b.

Material and Parameter Name(s):

S_MB139 SAT_RGAS (#599)
S_ANH_AB SAT_RGAS (#539)
S_MB138 SAT_RGAS (#578)

Computational Code: BRAGFLO

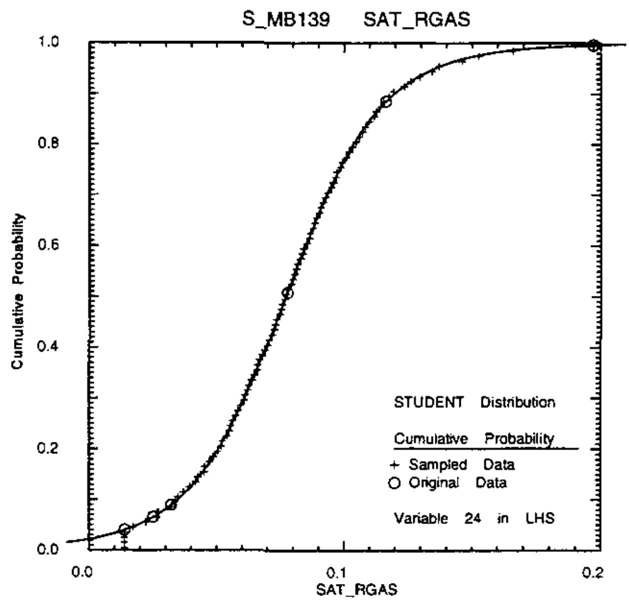
mean	median	minimum	maximum	std. deviation
0.07711	0.07711	0.01398	0.19719	0.06

Units: None

Distribution: Student's-t

Parameter 24: Residual Gas Saturation - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

CDF/PDF Graph



Data: Site-Specific Experimental Data

Residual gas saturation parameter values for the marker beds are based on curve-fitted laboratory measurements of capillary pressure. The parameter records package is retained in SWCF: SWCF-A 1.2.07.1:PDD:QA:SALADO: PKG 10:Salado Anhydrite Two-Phase Parameters (WPO 30643).

Discussion:

The two-phase flow program reports the results of curve-fitted measurements of capillary pressure on six marker bed samples tested using mercury injection (Howarth and Christian-Frear 1996). The samples were taken from intact MB139 core samples collected from the northern experimental area of the repository. The measurements were conducted at ambient conditions (no stress) and were assumed to be 100 percent saturated at the initiation of capillary pressure tests.

WIPP Data Entry Form #464 WPO#: 34508

Parameter 24: Residual Gas Saturation - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

References:

Howarth S.M., and Christian-Frear, T. 1996. (SWCF WPO 38019). *Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant.*

Parameter 25: Pore Distribution - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139

Parameter(s) Description:

The Brooks-Corey pore size distribution parameter (λ) is used to calculate capillary pressure and relative permeabilities for gas and brine flow in the two-phase flow model. It is a sampled parameter for MB139 and the values are then applied to MB138 and Anhydrite Layers a & b.

Material and Parameter Name(s):

S_MB139 PORE_DIS (#587)
S_MB138 PORE_DIS (#566)
S_ANH_AB PORE_DIS (#527)

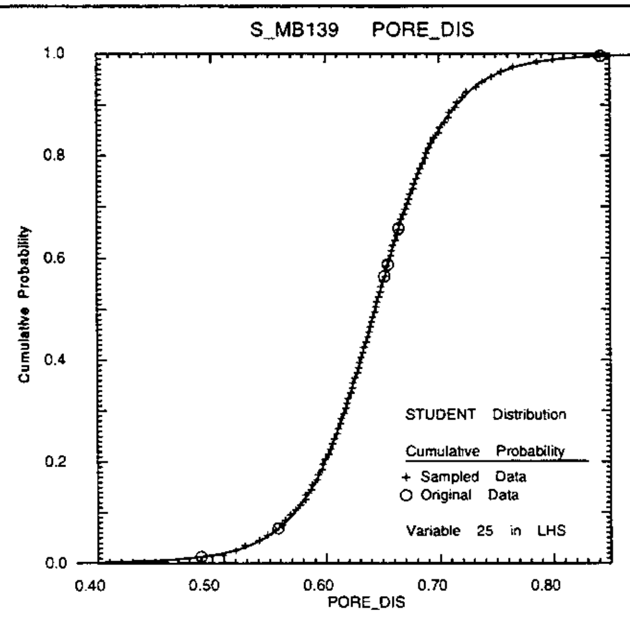
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
0.6436	0.6436	0.49053	0.84178	0.11

Units: None

Distribution Type: Student's-t

CDF/PDF Graph



Parameter 25: Pore Distribution - Marker Bed 138, Anhydrite Layers a & b, and Marker Bed 139 (Continued)

Data: Site-Specific Experimental Data

Pore size distribution parameter values for all anhydrite units are based on curve fit values predicted from laboratory measurements of capillary pressure. The parameter records package associated with this parameter is retained in SWCF: SWCF-A 1.2.07.1:PDD:QA:SALADO: PKG 10:Salado Anhydrite Two-Phase Parameters (WPO 30643).

Discussion:

Curve fit parameter values are derived from six specimens cut from intact MB139 core samples collected from the northern experimental area of the repository. Reported data and parameters are based on mercury injection capillary pressure tests (Howarth and Christian-Frear 1996). As with other two-phase flow parameters, the median value assigned to MB138 and anhydrite a and b is supported by and based on MB139 data.

WIPP Data Entry Form #464 WPO#: 34859

References:

Howarth S.M., and Christian-Frear, T. 1996. (WIPP Central Files WPO 38019). *Porosity, Single-Phase Permeability, and Capillary Pressure Data from Preliminary Laboratory Experiments on Selected Samples from Marker Bed 139 at the Waste Isolation Pilot Plant.*

Parameter 26: Initial Pressure - Salado Halite

Parameter Description:

The initial brine far-field (undisturbed) pore pressure in the Salado halite is applied at an elevation consistent with the intersection of MB139 and the waste-handling shaft.

Material and Parameter Name(s):

S_HALITE PRESSURE (#546)

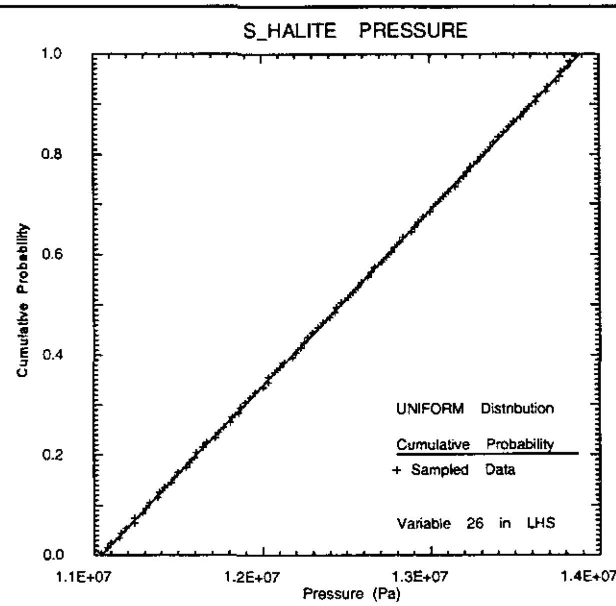
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
1.247×10^7	1.247×10^7	1.104×10^7	1.389×10^7	8.23×10^5

Units: pascals

Distribution Type: Uniform

CDF/PDF Graph



Parameter 26: Initial Pressure - Salado Halite (Continued)

Data: Site-Specific Experimental Data

Two hydraulic tests were performed in boreholes in undisturbed halite in the underground WIPP repository. Both tests were performed in the area where Room Q would later be mined. The tests were undertaken in April-July, 1989. Pressure, fluid volume, temperature, axial test-tool movement, and radial borehole closure were measured during the hydraulic tests in undisturbed rock. The following parameter records package is associated with the tests: SWCF-A:WBS 1.2.07.1:PDD:QA:SALADO:PKG4:Halite Pressure (WPO 31221).

Discussion:

It was assumed that Darcy flow and borehole closure were the only forms of pressure/flow transmission during the hydraulic tests in undisturbed halite. The uncertainty associated with the estimated parameter values is high. The distribution is based on the two data points provided in the data package and the calculated median is 1.247×10^7 pascals.

WIPP Data Entry Form #464 WPO#: 34394

References:

Beauheim, R.L., Saulnier, G.J., Jr., and Avis, J.D. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant Site: First Interim Report.* SAND90-0083. Albuquerque, NM: Sandia National Laboratories. WPO 26003.

Beauheim, R.L., Roberts, R.M., Dale, T.F., Fort, M.D., and Stensrud, W.A. 1993. *Hydraulic Testing of Salado Formation Evaporities at the Waste Isolation Pilot Plant Site: Second Interpretive Report.* SAND92-0533. Albuquerque, NM: Sandia National Laboratories. WPO 23378.

Jensen, A.L., Howard, C.L., Jones, R.L., and Peterson, T.P. 1993. *Room Q Data Report: Test Borehole Data from April 1989 through November 1991.* SAND92-1172. Albuquerque, NM: Sandia National Laboratories. WPO 23548.

Saulnier, G.J., Jr., Domski, P.S., Palmer, J.B., Roberts, R.M., Strensrud, W.A., and Jensen, A.L. 1991. *WIPP Salado Hydrology Program Data Report #1.* SAND90-7000. Albuquerque, NM: Sandia National Laboratories. WPO 25746.

Stensrud, W.A., Dale, T.F., Domski, P.S., Palmer, J.B., Roberts, R.M., Fort, M.D., and Saulnier, G.J., Jr. 1992. *Waste Isolation Pilot Plant Salado Hydrology Program Data Report #2.* SAND92-7072. Albuquerque, NM: Sandia National Laboratories. WPO 26432.

Parameter 27: Initial Pressure - Castile Brine Reservoir

Parameter Description:

Initial brine pore pressure in the Castile brine reservoir.

Material and Parameter Name(s):

CASTILER PRESSURE (#66)

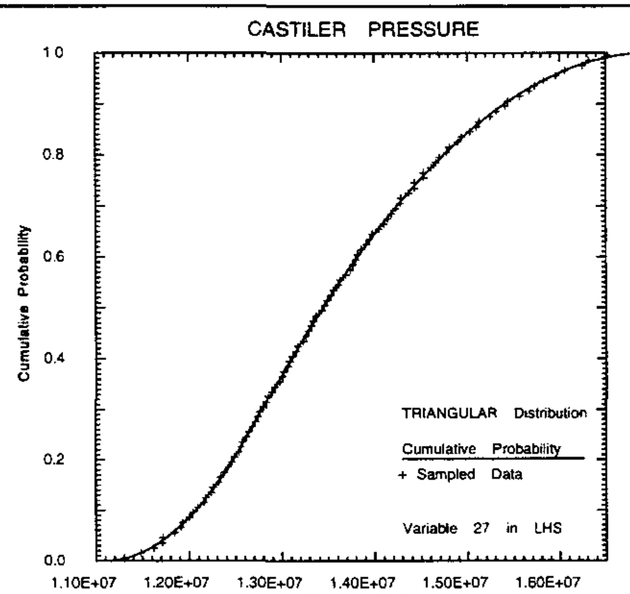
Computational Code: BRAGFLO

mean	mode	minimum	maximum	std. deviation
1.36×10^7	1.27×10^7	1.11×10^7	1.70×10^7	1.2457×10^6

Units: pascals

Distribution Type: Triangular

CDF/PDF Graph



Parameter 27: Initial Pressure - Castile Brine Reservoir (Continued)

Data: Site-Specific Experimental Data and Professional Judgment

The parameter records package associated with this parameter is as follows: SWCF:A: WBS1.2.07.1:PDD:QA:NONSALADO:PKG#19B: Castile Brine Reservoir Pressure (WPO 31072).

Discussion:

All pressure measurements were adjusted to reflect formation pressure of the WIPP-12 reservoir. Pressure adjustments were made as follows:

$$P_a = P + \rho \, g \, (h - 140) \, 1 \times 10^{-6}$$

where:
- P_a = adjusted pressure (megapascals)
- P = measured/estimated pressure (megapascals)
- ρ = assumed density (kilograms per cubic meter)
- g = gravitational constant (9.8 Newtons per kilogram)
- h = brine reservoir elevation (meters above sea level)

Observed (measured and interpreted) Castile brine reservoir fluid pressures were compared with their corresponding lithostatic pressures; four locations (shown in Table PAR-9) were found to best represent the formation pressure. The measured values in Table PAR-9 are adjusted to reflect formation pressure at the depth of WIPP-12 which is representative of the depth of the BRAGFLO Castile Brine Reservoir. The pressure adjustment requires an assumption about pressure variation with depth in the Castile. Two bounding cases were used, hydrostatic and 85 percent of lithostatic; the adjusted pressure was calculated using the equation provided above. A brine density of 1,240 kilograms per cubic meter (Reeves et al. 1989) was assumed for the hydrostatic variation; an average formation density of 2,040 kilograms per cubic meter (Sandia WIPP Project 1992) was assumed for the lithostatic variation. The best measured value (that is, the mode) is the brine reservoir pressure reported for WIPP-12 (12.7 megapascals). The maximum brine reservoir pressure is 85 percent of lithostatic at WIPP-12 depth (17 megapascals). The minimum value is the lowest measured hydrostatic pressure (11.1 megapascals). Freeze and Larson (1996), attached to Appendix MASS Section 18, provide more detail.

WIPP Data Entry Form #464 WPO#: 31612

Parameter 27: Initial Pressure - Castile Brine Reservoir (Continued)

References:

Freeze, Geoff, and Larson, K. 1996. Memorandum to Martin Tierney Re: Initial Pressure in the Castile Brine Reservoir, March 20, 1996. WPO 37148.

Lappin, A.R., Hunter, R.L., Garber, D.P., and Davies, P.B., eds. 1989. *Systems Analysis, Long-Term Radionuclide Transport, and Dose Assessments, Waste Isolation Pilot Plant (WIPP), Southeastern New Mexico, March, 1989*. SAND89-0462. Albuquerque, NM: Sandia National Laboratories. WPO 24125.

Popielak, R.S., Beauheim, R.L., Black, S.R., Coons, W.E., Ellingson, C.T., and Olsen, R.L. 1983. *Brine Reservoirs in the Castile Formation, Waste Isolation Pilot Plant (WIPP) Project, Southeastern New Mexico,* DOE Report TME-3153.

Reeves, M., Freeze, G.A., Kelley, V.A., Pickens, J.F., Upton, D.T., and Davies, P.B. 1989. *Regional Double-Porosity Solute Transport in the Culebra Dolomite under Brine-Reservoir-Breach Release Conditions: An Analysis of Parameter Sensitivity and Importance*. SAND89-7069. Albuquerque, NM: Sandia National Laboratories. WPO 24048.

Sandia WIPP Project. 1992. *Preliminary Performance Assessment for the Waste Isolation Pilot Plant, December, 1992: Volume 3, Model Parameters*. SAND92-0700/3. Albuquerque, NM: Sandia National Laboratories. WPO 23529.

Table PAR-9. Measured Castile Brine Reservoir Formation Pressures

Location	Pressure at Reservoir Depth (megapascals)	Pressure at WIPP-12 Depth with Hydrostatic Adjustment (megapascals)	Pressure at WIPP-12 Depth with 85 percent Lithostatic Adjustment (megapascals)
WIPP-12	12.7[b]	12.7	12.7
ERDA-6	14.1[a]	15.5	16.4
Belco	14.3[a]	14.5	14.5
Gulf Covington	13.6[a]	12.1	11.1

[a] from Popielak et al. 1983, Table H.1
[b] from Reeves et al. 1989, Appendix A

Parameter 28: Log of Intrinsic Permeability - Castile Brine Reservoir

Parameter Description:

The log of the intrinsic permeability of the Castile Brine Reservoir. It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Parameter Name(s):

CASTILER PRMX_LOG (#67)
CASTILER PRMY_LOG (#68)
CASTILER PRMZ_LOG (#69)

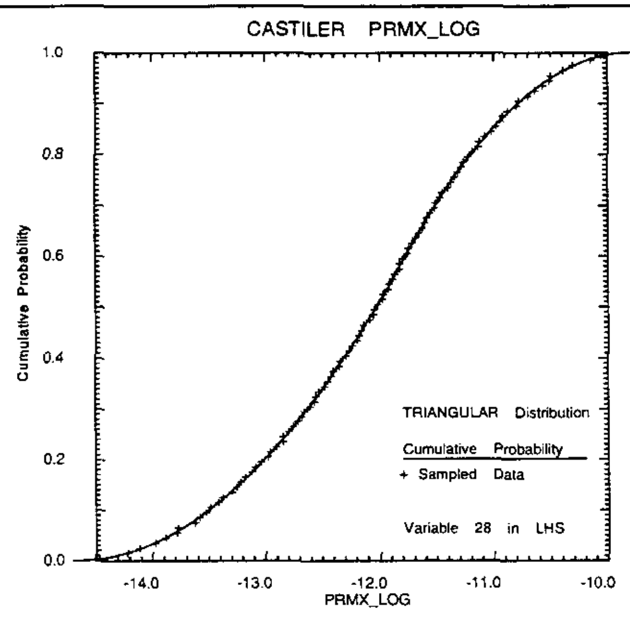
Computational Code: BRAGFLO

mean	mode	minimum	maximum	std. deviation
-12.10	-11.80	-14.70	-9.80	1.01

Units: log(square meters)

Distribution Type: Triangular

CDF/PDF Graph



Parameter 28: Log of Intrinsic Permeability - Castile Brine Reservoir (Continued)

Data: Site-Specific Experimental Data and Professional Judgment

Although several shorter flow tests were conducted to measure permeability of Castile brine reservoirs, only one test is considered representative of the long-term behavior of the brine reservoir behavior: the WIPP-12 Flow Test 3 (24,800 bbl produced, 9 months recovery). The Graph Theoretic Field Model (GTFM) analysis of WIPP-12 Flow Test 3 (Reeves et al. 1989) is considered better than the Horner analysis because it considers the effects of pre-test borehole pumping history. The GTFM interpreted hydraulic conductivity from WIPP-12 Flow Test 3 therefore provides the basis for the mean permeability for the Castile brine reservoir. The other values from WIPP-12 and ERDA-6 were used to establish the permeability distribution.

Professional judgment was used to better define the data mean and range because of the shortage of directly relevant data points. The parameter records package associated with this parameter is as follows: SWCF-A:1.2.07.1:PDD:QA:NONSALADO:PKG#19A: Castile Brine Reservoir Permeability (WPO 31070).

Discussion:

The GTFM analysis from WIPP-12 Flow Test 3 consists of a match to pressure response data and a match to flow rate data. The late-time match to the pressure data are controlled primarily by the formation pressure and is not very sensitive to the hydraulic conductivity or the specific storage. To match the flow rate data, the GTFM interpreted hydraulic conductivity (K) is strongly correlated with the specified specific storage (S_s), where:

$$S_s = \rho g \, (C_R + \Phi\beta)$$

For Castile brine reservoir properties, specific storage is proportional to the bulk rock compressibility (C_R). The correlation between K and S_s is such that their product is approximately a constant. For example, if the assumed specific storage (or rock compressibility) in GTFM is reduced by an order of magnitude, the interpreted hydraulic conductivity must increase by an order of magnitude to produce the same flow rate. The new combination of K and S_s will produce a different early-time pressure response, but will not impact the late-time match. For the GTFM analyses of the WIPP-12 Flow Tests, a rock compressibility of 1×10^{-9} pascals^{-1} was assumed. Because the mean rock compressibility for the Castile brine reservoir is 1×10^{-10} pascals^{-1}, the hydraulic conductivity required to reproduce the WIPP-12 flow is approximately 1×10^{-5} meters per second (permeability of -11.81 log (square meters)). For all triangular distributions, the mode is the best estimate.

Parameter 28: Log of Intrinsic Permeability - Castile Brine Reservoir (Continued)

Discussion (continued):

GTFM analysis determines a hydraulic conductivity (with units of meters per second) based on pressure change, flow rate, and assumptions about fluid and formation properties. Conversions from meters per second to square meters were based on a conversion factor of 1.7 $\times 10^{-7}$ square meters per (meters per second). The conversion factor is based on the assumed GTFM fluid properties.

WIPP Data Entry Form #464 WPO#: 31613

References:

Popielak, R.S., Beauheim, R.L., Black, S.R., Coons, W.E., Ellingson, C.T., and Olsen, R.L. 1983. *Brine Reservoirs in the Castile Formation, Waste Isolation Pilot Plant (WIPP) Project, Southeastern New Mexico.* DOE Report TME-3153.

Reeves, M., Freeze, G.A., Kelley, V.A., Pickens, J.F., Upton, D.T., and Davies, P.B. 1989. *Regional Double-Porosity Solute Transport in the Culebra Dolomite under Brine-Reservoir-Breach Release Conditions: An Analysis of Parameter Sensitivity and Importance.* SAND89-7069. Albuquerque, NM: Sandia National Laboratories. WPO 24048.

Parameter 29: Rock Compressibility - Castile Brine Reservoir

Parameter Description:

The rock (or bulk) compressibility of the Castile Brine Reservoir is used to calculate the pore compressibility which is used in BRAGFLO. Pore compressibility is used to predict the effect of material compressibility on porosity and mass storage in the equation of state for flow through porous media as follows:

$$\phi = \phi_o \exp\left(c_p\left(p - p_o\right)\right)$$

where,

ϕ = porosity of solid matrix (cubic meters per cubic meters)
ϕ_o = porosity at reference pressure p_o
c_p = pore compressibility (pascals^{-1})
p = pore pressure (pascals)
p_o = reference pore pressure (pascals)

The rock compressibility is divided by effective porosity to calculate pore compressibility.

Material and Parameter Name(s):

CASTILER COMP_RCK (#61)

Computational Code: BRAGFLO

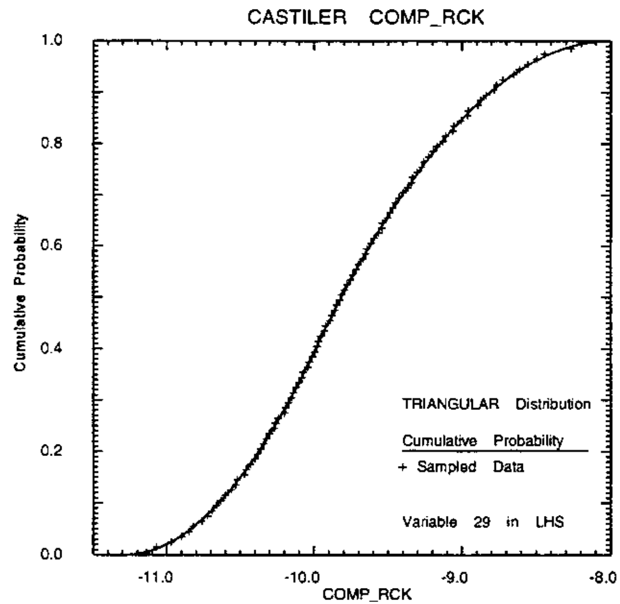
mean	mode	minimum	maximum	std. deviation
-9.8	-10.0	-11.3	-8.0	0.68

Units: log pascals^{-1}

Distribution Type: Triangular

Parameter 29: Rock Compressibility - Castile Brine Reservoir (Continued)

CDF/PDF Graph



Data: Site-Specific Experimental Data and Professional Judgment

Rock compressibility is interpreted from the bulk modulus from the acoustic log of the Castile Anhydrite III unit in WIPP-12 and other sources cited in the discussion section. The acoustic log measures compressional wave travel time through the rock, then uses a correlation between wave velocity and elastic rock properties to estimate bulk modulus.

The acoustic log covered the entire thickness of the Anhydrite III unit in WIPP-12. The laboratory compression tests on anhydrite from other WIPP locations give similar results for bulk modulus (Popielak et al. 1983).

The parameter records package associated with this parameter is as follows: SWCF-A:WBS1.2.07.1:PDD:NON-SALADO:PKG #19E:Castile Brine Reservoir Rock Compressibility (WPO 31084).

Discussion:

Acoustic logging measures velocities a relatively short distance, with few if any fractures included, and is therefore representative of undisturbed (intact) rock.

Parameter 29: Rock Compressibility - Castile Brine Reservoir (Continued)

Discussion (Continued):

The estimated bulk modulus, K, for the intact Anhydrite III at WIPP-12 was 6.9×10^{10} pascals (10×10^6 pounds per square inch). Assuming uniaxial strain, the rock compressibility (C_R) can be estimated from the bulk modulus (K) and the shear modulus (G) of the rock:

$$C_R = \frac{1}{K + 4\ G/3}$$

No estimates for shear modulus for Anhydrite III were available. Beauheim et al. (1991) reported a value for G that was approximately 1/3 of K for Salado anhydrite. Using this estimate for G, the calculated intact rock compressibility is 1×10^{-11} pascals^{-1}.

The bulk modulus may be 2 to 10 times smaller for fractured rock (Popielak et al. 1983), corresponding to a 2 to 10 times increase in compressibility (assuming G changes accordingly). Beauheim et al. (1991) suggest that fracturing might result in a fourfold increase in rock compressibility. Using these adjustments for fractured rock, the calculated rock compressibility ranges from 2×10^{-11} pascals^{-1} to 1×10^{-10} pascals^{-1}, with an average value of 5×10^{-11} pascals^{-1}.

Hydraulic testing was performed in transition-zone (disturbed) Salado anhydrite and halite. Interpreted rock compressibilities for transition zone anhydrite ranged from 5×10^{-12} pascals^{-1} to 3×10^{-9} pascals^{-1}. Freeze and Cherry (1979) report a range for rock compressibility for fractured or jointed rock of 1×10^{-8} to 1×10^{-10} pascals^{-1}.

WIPP Data Entry Form #464 WPO#: 31561

References:

Beauheim, R.L., Saulnier, G.J., Jr., and Avis, J.D. 1991. *Interpretation of Brine-Permeability Tests of the Salado Formation at the Waste Isolation Pilot Plant: First Interim Report.* SAND90-0083. Albuquerque, NM: Sandia National Laboratories. WPO 26003.

Freeze, R.A., and Cherry, J.A. 1979. *Groundwater.* Prentice-Hall, Inc., Englewood Cliffs, NJ.

Parameter 29: Rock Compressibility - Castile Brine Reservoir (Continued)

References (Continued):

Popielak, R.S., Beauheim, R.L., Black, S.R., Coons, W.E., Ellingson, C.T., and Olsen, R.L. 1983. *Brine Reservoirs in the Castile Formation, Waste Isolation Pilot Plant (WIPP) Project, Southeastern New Mexico.* DOE Report TME-3153.

Reeves, M., Freeze, G.A., Kelley, V.A., Pickens, J.F., Upton, D.T., and Davies, P.B. 1989. *Regional Double-Porosity Solute Transport in the Culebra Dolomite Under Brine-Reservoir-Breach Release Conditions: An Analysis of Parameter Sensitivity and Importance.* SAND89-7069. Albuquerque, NM: Sandia National Laboratories. WPO 24048.

Parameter 30: Log of Intrinsic Permeability - Intrusion Borehole Filled With Silty Sand

Parameter Description:

This parameter represents the log of the intrinsic permeability of the silty-sand-filled borehole in the human-intrusion scenario. This permeability is representative of degraded concrete or material which may sluff into the borehole or spall from the sides. It is a sampled parameter for the x-direction and the values are then applied to the y- and z-directions.

Material and Parameter Name(s):

BH_SAND PRMX_LOG (#3184)
BH_SAND PRMY_LOG (#3190)
BH_SAND PRMZ_LOG (#3191)

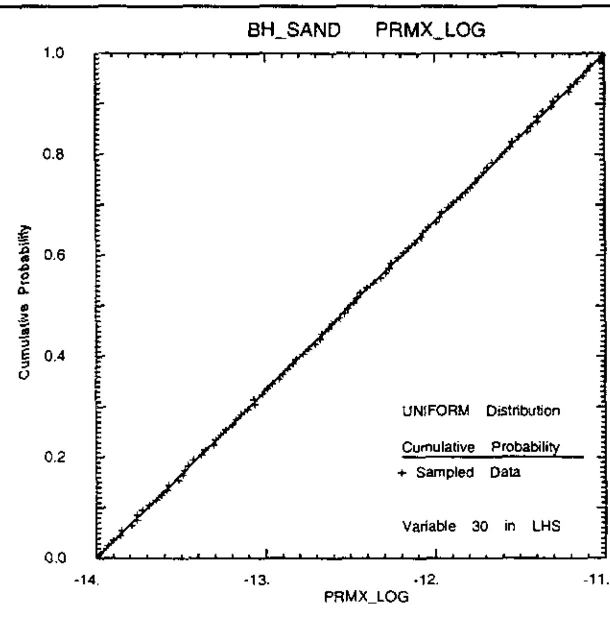
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
-12.50	-12.50	-14.00	-11.00	0.87

Units: log(square meters)

Distribution Type: Uniform

CDF/PDF Graph



Parameter 30: Log of Intrinsic Permeability - Intrusion Borehole Filled With Silty Sand (Continued)

Data: Site-Specific Experimental Data

Permeability predictions for the intrusion borehole are based on models and data for steel corrosion and concrete alteration found in the literature; wherever possible, the predictions have been calibrated by comparing predicted behavior to field data (Thompson et al. 1996). This parameter varies uniformly from 10^{-14} to 10^{-11} square meters which is the permeability of a silty sand.

Discussion:

This parameter represents the permeability of the silty-sand-filled borehole in the human-intrusion scenario. The permeability is representative of degraded concrete or material which may sluff into the borehole or spall from the sides. There are three plug configurations and different permeabilities associated with each configuration. Borehole materials and plug configurations are based on a review of current regulations and practices, and the permeability predictions are based on models and data for steel corrosion and concrete alteration found in the literature (Thompson et al. 1996). Wherever possible, the predictions have been calibrated by comparing predicted behavior to field data (Thompson et al. 1996).

The three plug configurations consist of: a continuous concrete plug through the Salado and Castile which is assigned a probability of 0.02 (see section 6.4.7.2.1), a two-plug configuration (a lower plug located between the Castile brine reservoir and underlying formations and an upper plug located in the Rustler immediately above the Salado), which is assigned a probability of 0.68 (see section 6.4.7.2.2), and a three-plug configuration (two plugs same as two-plug configuration and third plug located in the Castile above the brine reservoir and below the waste-disposal panel) which is assigned a probability of 0.30 (see: section 6.4.7.2.3).

The plugs are initially expected to have a tight permeability of 5×10^{-17} square meters (Thompson et al. 1996). The continuous concrete plug is assumed not to degrade and has a permeability of 5×10^{-17} square meters for the entire regulatory period. For the two-plug configuration, the permeability between the repository and the surface is 5×10^{-17} square meters for the first 200 years and 10^{-14} to 10^{-11} square meters after that; the permeability between the Castile and the repository is 10^{-14} to 10^{-11} square meters up to 1,200 years and 10^{-15} to 10^{-12} square meters after that. The three-plug configuration has the same material properties as the corresponding regions in the two-plug configuration and the third plug is assumed to behave as the lower plug in the two-plug configuration.

WIPP Data Entry Form #464 WPO#: 36641

References:

Thompson, T.W., Coons, W.E., Krumhansl, J.L., and Hansen, F.D. 1996. *Inadvertent Intrusion Borehole Permeability, Final Draft,* July 8, 1996. (see MASS Attachment 16-3)

Parameter 31: Index for Selecting Brine Pocket Volumes

Parameter Description:

The index for selecting brine pocket fields is actually an identifier for brine pocket volumes that is used in BRAGFLO.

Material and Parameter Name(s):

CASTILER GRIDFLO (#3194)

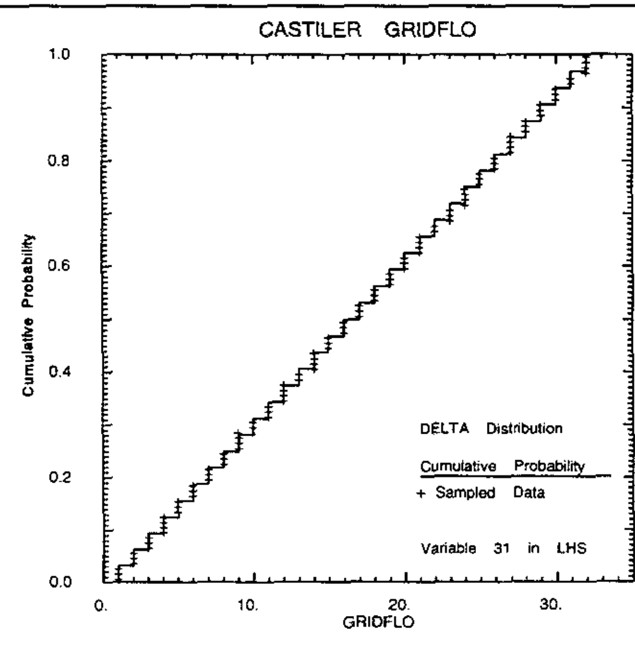
Computational Code: BRAGFLO

mean	median	minimum	maximum	std. deviation
n.a.	n.a.	1	32	n.a.

Units: None

Distribution Type: Delta

CDF/PDF Graph



Parameter 31: Index for Selecting Brine Pocket Volumes (Continued)

Data: Professional Judgment

No experimental data are associated with the index for selecting brine pocket volumes.

Discussion:

This index identifies which Castile reservoir brine volume to use for determining the consequence of first penetration of a brine reservoir. There are five possible brine pocket volumes: 32,000, 64,000, 96,000, 128,000, and 160,000 cubic meters. Each parameter value (1 through 32) corresponds to one of these five volumes as shown below:

1 = 32,000 cubic meters	17 = 32,000 cubic meters
2 = 32,000 cubic meters	18 = 64,000 cubic meters
3 = 32,000 cubic meters [3]	19 = 64,000 cubic meters
4 = 64,000 cubic meters	20 = 96,000 cubic meters
5 = 32,000 cubic meters	21 = 64,000 cubic meters
6 = 64,000 cubic meters	22 = 96,000 cubic meters
7 = 64,000 cubic meters	23 = 96,000 cubic meters
8 = 96,000 cubic meters	24 = 128,000 cubic meters
9 = 32,000 cubic meters	25 = 64,000 cubic meters
10 = 64,000 cubic meters	26 = 96,000 cubic meters
11 = 64,000 cubic meters	27 = 96,000 cubic meters
12 = 96,000 cubic meters	28 = 128,000 cubic meters
13 = 64,000 cubic meters	29 = 96,000 cubic meters
14 = 96,000 cubic meters	30 = 128,000 cubic meters
15 = 96,000 cubic meters	31 = 128,000 cubic meters
16 = 128,000 cubic meters	32 = 160,000 cubic meters

Each of the 32 possibilities has an equal probability of occurring. The minimum volume (32,000 cubic meters) is the minimum value from the WIPP-12 analysis. The DOE also considers larger reservoir volumes because reservoirs larger than the WIPP-12 volume could reasonably exist under the waste panels.

WIPP Data Entry Form #464 WPO#: 36658

References:

Helton, Jon. 1996. Memorandum to Martin Tierney, Re: Addition of Discrete Parameter, March 21, 1996. WPO 37147.

Parameter 31: Waste Particle Diameter in CUTTINGS Model

Parameter Description:

This parameter describes the particle diameter of the waste material. It is used in the CUTTINGS_S code for the blowout-induced spall model.

Material and Parameter Name(s):

BLOWOUT PARTDIA (#3246)

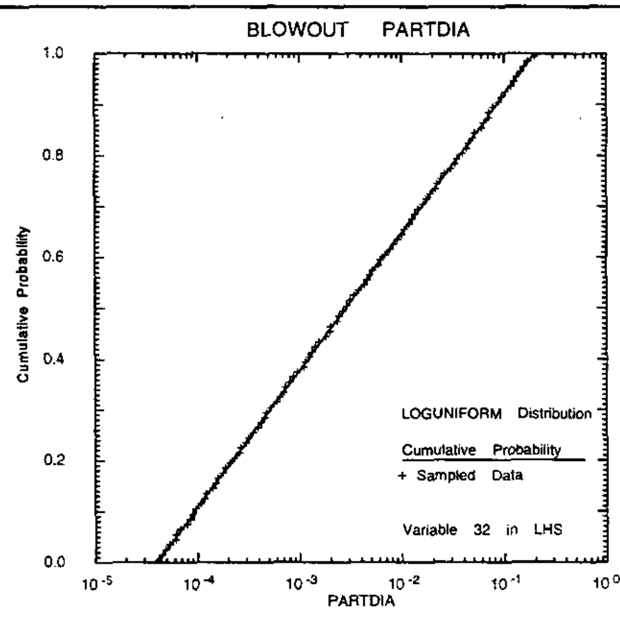
Computational Code: CUTTINGS_S

mean	median	minimum	maximum	std. deviation
0.0235	0.0028	0.000040	0.20	0.04

Units: meters

Distribution Type: Loguniform

CDF/PDF Graph



Parameter 32: Waste Particle Diameter in CUTTINGS Model (Continued)

Data: Professional Judgment

WIPP specific experimental data do not exist for the waste particle diameter. The minimum value is derived from the waste permeability value (as described below) and the maximum value is equal to 1/3 of a drum diameter. The parameter records packages associated with this parameter is located at: SWCF-A:WBS1.1.01.1.5:PDD/1.2.07.1/CUTTTINGS/QA:Release of Solids Caused by Blowout (WPO 35695).

Discussion:

The minimum particle diameter was derived from the BRAGFLO waste permeability value (1.7×10^{-13} square meters) and the Kozeny-Carmen equation:

$$K = \left(\frac{\ell q}{\mu}\right)\left[\frac{n^3}{(1-n)^2}\right]\left(\frac{d_m^2}{180}\right)$$

(Freeze and Cherry 1979).

The upper limit for the particle diameter is set to 1/3 of a drum diameter.

This parameter distribution is conservative since it shifts the waste particle diameter toward the lower bound and hence, to greater release estimates (Berglund 1996).

WIPP Data Entry Form #464 WPO#: 37088

References:

Berglund, J.W. 1996. Memo to M.S. Tierney, "Parameters required for the CUTTINGS_S code for use in WIPP Performance Assessment." April 1, 1996. WPO 36766.

Freeze, R.A., and Cherry, J.A. 1979. *Groundwater.* Englewood Cliffs, NJ: Prentice Hall, p. 351.

Parameter 33: Effective Shear Resistance to Erosion

Parameter Description:

This parameter describes the intrusion borehole's effective shear strength for erosion. It is used in the CUTTINGS_S code for the cavings model.

Material and Parameter Name(s):

BOREHOLE TAUFAIL (#2254)

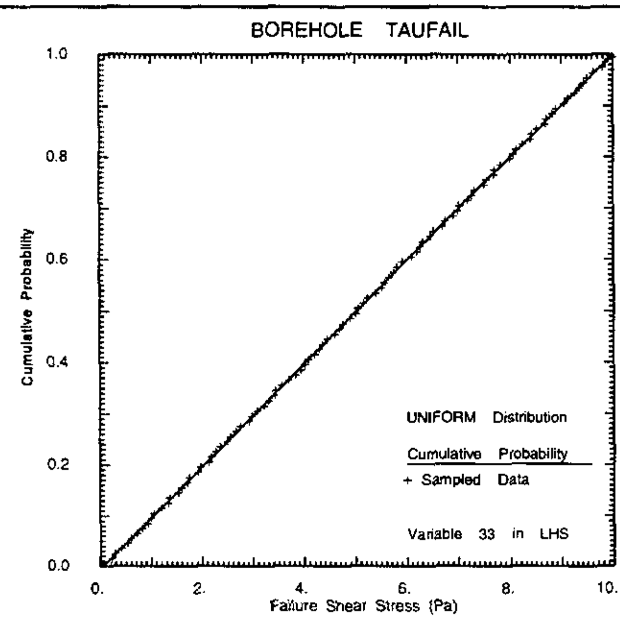
Computational Code: CUTTINGS_S

mean	median	minimum	maximum	std. deviation
5.03	5.03	0.05	10.0	2.9

Units: pascals

Distribution Type: Uniform

CDF/PDF Graph



Parameter 33: Effective Shear Resistance to Erosion (Continued)

Data: Professional Judgment

WIPP specific experimental data do not exist for the effective shear resistance to erosion. Therefore, it is conservatively assumed to be similar to that of an ocean bay mud (Parthenaides and Passwell 1970), or a montmorillonite clay (Sargunam et al. 1973).

Discussion:

The cavings component of direct surface release consists of that quantity of waste material that is eroded from the borehole wall by the action of the flowing drilling fluid after a waste disposal room is penetrated. The erosion process is assumed to be driven solely by the shearing action of the drilling fluid (mud) on the waste as it moves up the borehole annulus.

The nature of the state of the waste material present at the time of intrusion by a drill bit is a major factor in the shear resistance to erosion. The future states of decomposed waste is both time dependent and unknowable, and consequently a decomposed state consisting of graded granular materials is assumed. This is consistent with the granular nature of decomposed geologic materials and corresponds to an end state of the decomposition process.

The final eroded diameter is determined through an iterative process that equates the fluid shear stress adjacent to the waste to a measure of the erosion resistance of the waste. The effective shear resistance for erosion equals the threshold value of fluid shear stress required to sustain general erosion at the borehole wall adjacent to the waste.

In the absence of experimental data, the effective shear resistance to erosion of the repository material is assumed to be similar to that of an ocean bay mud (Parthenaides and Paaswell 1970), or a montmorillonite clay (Sargunam et al. 1973). These values are on an order of a fraction to several pascals and for the cavings release model are considered to be conservative.

WIPP Data Entry Form #464 WPO#: 31536

References:

Partheniades, E. and Paaswell, R.E. 1970. "Erodibility of Channels with Cohesive Boundary." *Proceedings of the American Society of Civil Engineers, Journal of the Hydraulics Division*. Vol. 96, No. HY3, 755 – 771. WPO 31536.

Sargunam, A., Riley, P., Arulanandan, K., and Krone, R.B. 1973. "Physico-Chemical Factors in Erosion of Cohesive Soils." *Proceedings of the American Society of Civil Engineers, Journal of the Hydraulics Division*. Vol. 99. No. HY3: 555-558. March 1973.

Parameter 34: Mining Transmissivity Multiplier

Parameter Description:

This parameter is a multiplier which applies to the transmissivity in areas of the Culebra which are located above areas of present and future potash mining.

Material and Parameter Name(s):

CULEBRA MINP_FAC (#3419)

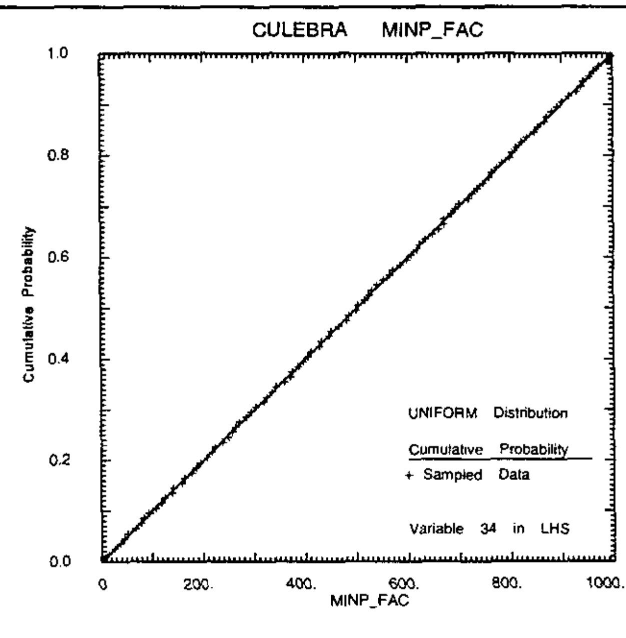
Computational Code: SECOFL2D

mean	median	minimum	maximum	std. deviation
500.5	500.5	1.0	1000.0	288.4

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 34: Mining Transmissivity Multiplier (Continued)

Data: Regulatory Basis

Data for the Mining Transmissivity Multiplier comes directly from the Preamble published in 40 CFR Part 194 (61 FR 5229). Based on its review of the literature, the EPA determined that mining can increase the conductivity of overlying formations by a factor of much as 1,000 (see Section 6.4.6.2.3). Since the EPA does not specify a distribution for the multiplier, the DOE has assigned it a uniform distribution from 1 to 1,000 with a median value of 500.5. A discussion of the data associated with this parameter may be found in the following parameter records package: SWCF-A:WBS1.2.07.1:PDD:QA:NON-SALADO:Mining Transmissivity Multiplier (WPO 36489).

Discussion:

EPA's 40 CFR Part 194 requires that the DOE evaluate the consequences of mining in the McNutt on the performance of the WIPP (Larson 1996). The impacts of mining are taken into account by using a multiplier which varies from 1 to 1,000 with a uniform distribution. The multiplier applies only to the transmissivity in the Culebra and it applies to areas that qualify under a range of criteria, including both mined areas and areas to be mined (Howard, B. A. 1996).

In the performance assessment, two cases are considered: 1) the partial mining case which includes all mining outside of the controlled area and 2) the full mining case which includes mining outside and inside of the controlled area. Everywhere that the Culebra is underlain by economical quantities of potash (see Section 2.3.1.1), the transmissivity is multiplied by the multiplier. The multiplier is applied uniformly over the entire mined area for a particular T-field; however, the value of the multiplier changes for different T-fields. The partial mining case applies to all transmissivity vectors in the performance assessment analysis. Starting from that initial condition, the full mining case has a 1 in 100 probability of occurring in any century over the 10,000 year regulatory time frame (for any given T-field).

WIPP Data Entry Form #464 WPO#: 37666

References:

Howard, B. A. 1996. Memo from B. A. Howard to Mel Marietta, April 3, 1996, RE: Future Mining Events in the Performance Assessment. Attachment: Extent of Mining Position Paper, Revision 1. WPO 38571.

Parameter 34: Mining Transmissivity Multiplier (Continued)

References (Continued):

Larson, Kurt. 1996. Memo to Mike Wallace, "Mining Transmissivity Multiplier—Area to be mined." April 25, 1996. WPO 37455.

Wallace, M. 1996. Memo to M. Tierney, "Distribution for Non-Salado Parameter for SECOFL2D: Mining Transmissivity Multiplier," April 18, 1996. WPO 39355.

Parameter 35: Culebra Transmissivity Field Index

Parameter Description:

This parameter is intended to incorporate uncertainty in the transmissivity field within the Culebra Dolomite Member of the Rustler Formation.

Material and Parameter Name(s):

GLOBAL TRANSIDX (#225)

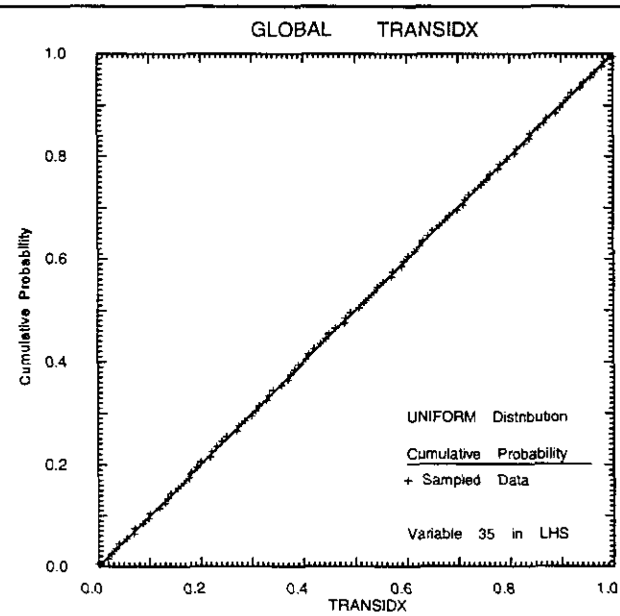
Computational Code(s): SECOFL2D

mean	median	minimum	maximum	std. deviation
0.5	0.5	0.0	1.0	0.29

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 35: Culebra Transmissivity Field Index (Continued)

Data: Professional Judgment - General Engineering Knowledge

No experimental data are associated with the transmissivity field index. The parameter is an index for selecting one of 100 transmissivity fields produced by GRASP_INV. It varies uniformly from 0 to 1.

Discussion:

Using an approach known as conditioning, or making realizations of random fields coherent with measured information such as hydraulic head values, 100 equally likely Culebra transmissivity fields were generated (employing GRASP-INV). After incorporating changes (requested by U.S. Environmental Protection Agency [EPA]) to account for future potash mining, the fields were ranked by travel time to the accessible environment (3.5 kilometers from the center of the repository area). Each realization was then converted to a flow field, assuming uniform Culebra thickness of 8 meters and 16 percent effective porosity. TRANSDIX was used to sample on the interval (0,1); the result was mapped onto the integers 1-100 (the number of transmissivity fields), and the resulting integer was used to select a transmissivity field (Ruskauff 1996; Sandia WIPP Project 1992).

WIPP Data Entry Form #464 WPO#: 33055

References:

Ruskauff, Greg. 1996. Memorandum to Martin Tierney, Re: Culebra Transmissivity Field Index, March 13, 1996. WPO 35193

Sandia WIPP Project. 1992. *Preliminary Performance Assessment for the Waste Isolation Pilot Plant, December 1992, Vol.3: Model Parameters.* SAND92-0700/3. Albuquerque, NM: Sandia National Laboratories. WPO 23529.

Parameter 36: Log of the Distribution of Solubility of Am(III) in Salado Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for americium in the +III oxidation state in Salado brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLAM3 SOLSIM (#3262)

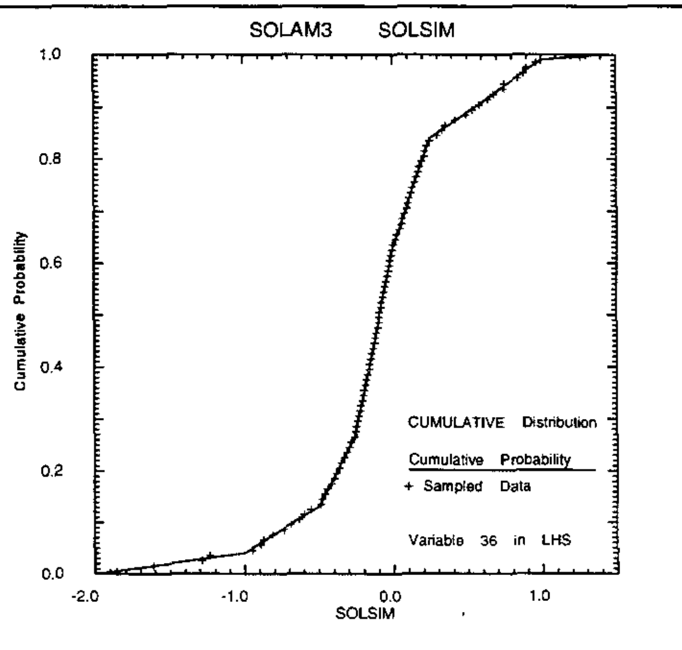
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 36: Log of the Distribution of Solubility of Am(III) in Salado Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the Fracture Matrix Transport (FMT) code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of Am (+III) in Salado brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 5.82×10^{-7} moles/liter (see SOLMOD3, SOLSIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37105

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791

Novak, C.F. 1996.Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 37: Log of the Distribution of Solubility of Am(III) in Castile Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for americium in the +III oxidation state in Castile brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLAM3 SOLCIM (#3263)

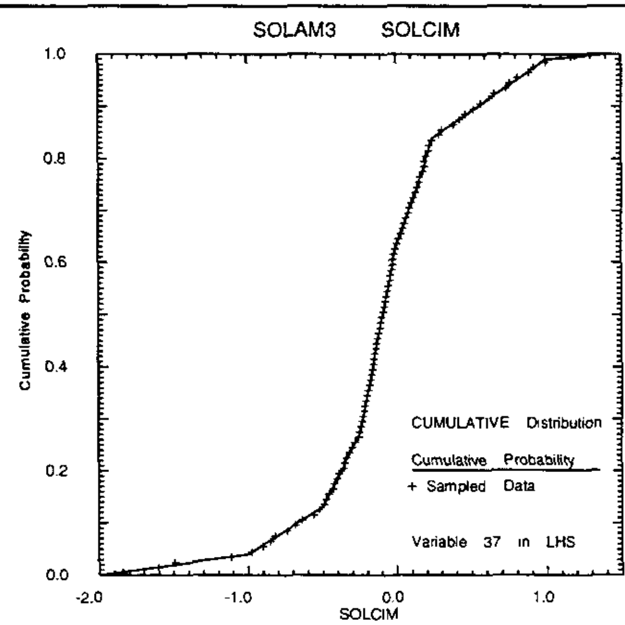
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 37: Log of the Distribution of Solubility of Am(III) in Castile Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the FMT code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of Am (+III) in Castile brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 6.52×10^{-8} moles/liter (see SOLMOD3, SOLCIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37106

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791.

Novak, C.F. 1996.Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 38: Log of the Distribution of Solubility of Pu(III) in Salado Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for plutonium in the +III oxidation state in Salado brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLPU3 SOLSIM (#3265)

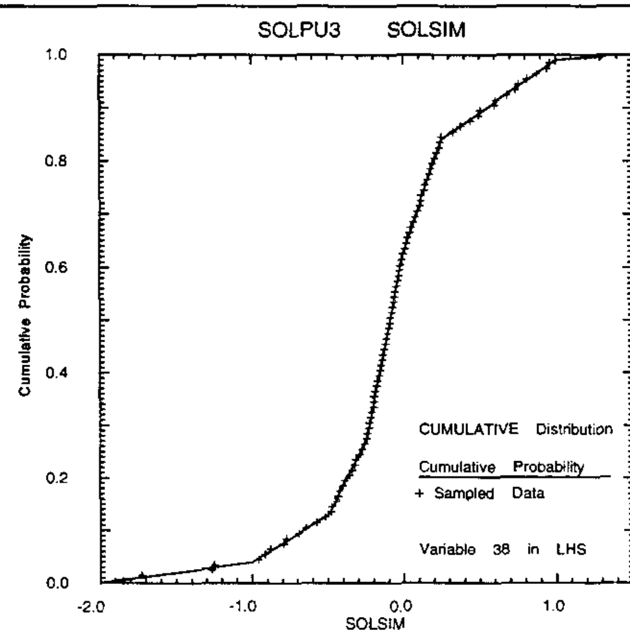
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 38: Log of the Distribution of Solubility of Pu(III) in Salado Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the FMT code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of Pu (+III) in Salado brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 5.82×10^{-7} moles/liter (see SOLMOD3, SOLSIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37109

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791

Novak, C.F. 1996.Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 39: Log of the Distribution of Solubility of Pu(III) in Castile Brine

Parameter Description:

This parameter represents the distribution (log_{10}) of the uncertainty about the modeled solubility value for plutonium in the +III oxidation state in Castile brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLPU3 SOLCIM (#3264)

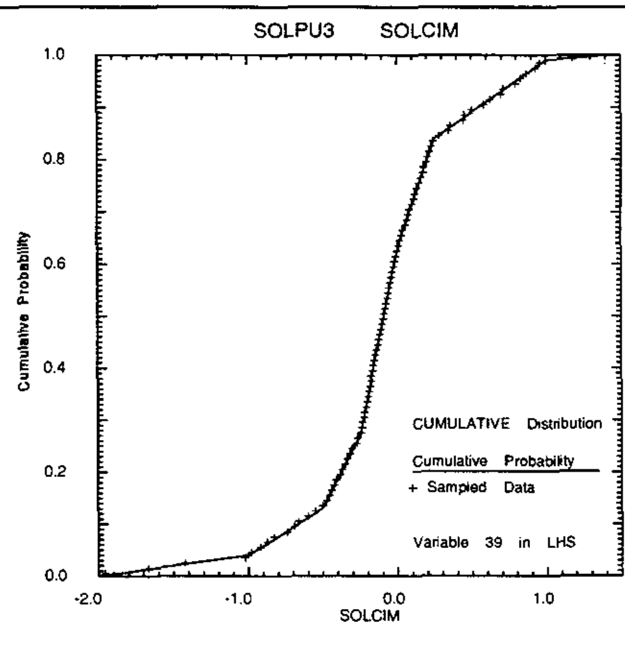
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 39: Log of the Distribution of Solubility of Pu(III) in Castile Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the FMT code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of Pu (+III) in Castile brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 6.52×10^{-8} moles/liter (see SOLMOD3, SOLCIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37108

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791.

Novak, C.F. 1996.Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 40: Log of the Distribution of Solubility of Pu(IV) in Salado Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for plutonium in the +IV oxidation state in Salado brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLPU4 SOLSIM (#3266)

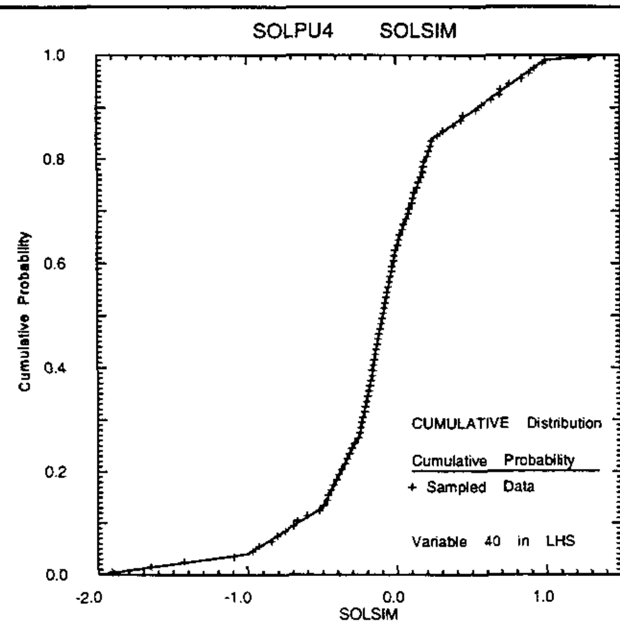
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 40: Log of the Distribution of Solubility of Pu(IV) in Salado Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the FMT code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of Pu(+IV) in Salado brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 4.4×10^{-6} moles/liter (see SOLMOD4, SOLSIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37110

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791.

Novak, C.F. 1996.Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 41: Log of the Distribution of Solubility of Pu(IV) in Castile Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for plutonium in the +IV oxidation state in Castile brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLPU4 SOLCIM (#3389)

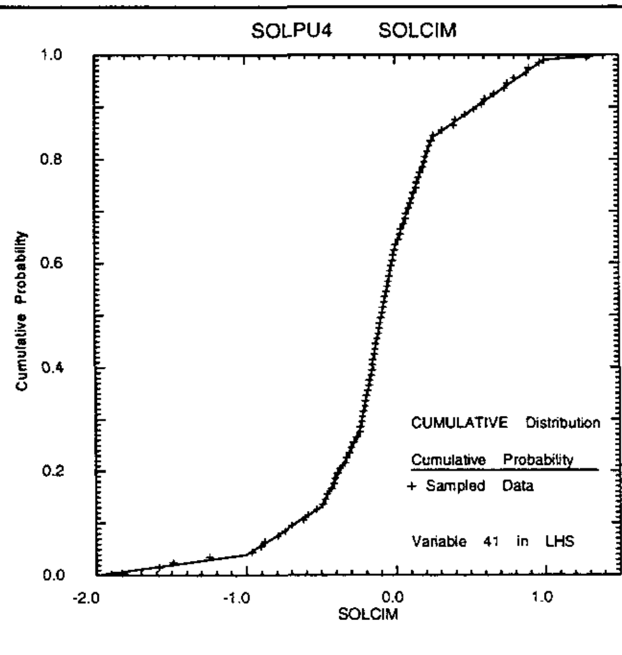
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 41: Log of the Distribution of Solubility of Pu(IV) in Castile Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the FMT code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of Pu(+IV) in Castile brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 6.0×10^{-9} moles/liter (see SOLMOD4, SOLCIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37111

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791.

Novak, C.F. 1996.Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 42: Log of the Distribution of Solubility of U(IV) in Salado Brine

Parameter Description:

This parameter represents the distribution (log_{10}) of the uncertainty about the modeled solubility value for uranium in the +IV oxidation state in Salado brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLU4 SOLSIM (#3390)

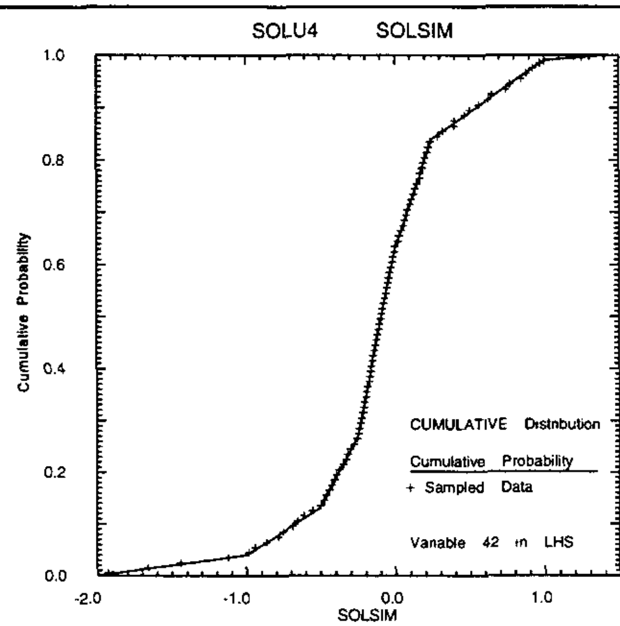
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 42: Log of the Distribution of Solubility of U(IV) in Salado Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the FMT code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of U(+IV) in Salado brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 4.4×10^{-6} moles/liter (see SOLMOD4, SOLSIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37112

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791.

Novak, C.F. 1996. Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 43: Log of the Distribution of Solubility of U(VI) in Salado Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for uranium in the +VI oxidation state in Salado brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLU6 SOLSIM (#3391)

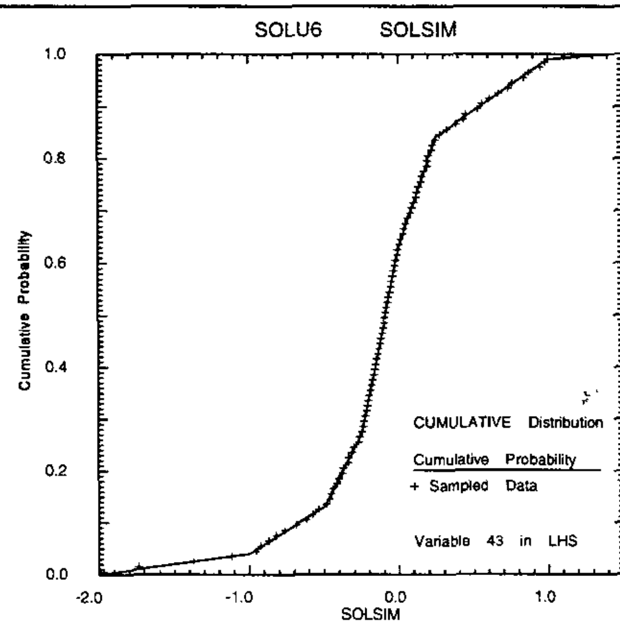
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 43: Log of the Distribution of Solubility of U(VI) in Salado Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Data on U(+VI) solubility in Salado brine was compiled by Hobart and Moore (1996), both from ongoing WIPP-directed research and from published literature. Project experimental data was from Reed et al. (1996) (see SOTERM, Section 3.0). Published data was from Yamazaki, et al (1992) and Pashalidas et al (1993). Based on these data, Hobart and Moore recommend a value for U(+VI) for use in performance assessment. The uncertainty in this value was bounded by the distribution prepared by Bynum (1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of U(+VI) in Salado brine is a function of pH, CO_2 fugacity, and other brine components. The solubility provided by Hobart and Moore (1996) is 8.7×10^{-6} moles/liter (see SOLMOD6, SOLSIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37113

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791

Hobart, D.E., and Moore, R. 1996. *Draft Analysis of Uranium (VI) Solubility Data for WIPP Performance Assessment*, Sandia National Laboratories, March 28, 1996. WPO 33703.

Parameter 43: Log of the Distribution of Solubility of U(VI) in Salado Brine (Continued)

References (Continued):

Pashalidis, I., Runde, W., Kim, J.I. 1993. "A Study of Solid-Liquid Phase Equilibria of Pu(VI) and U(VI) in Aqueous Carbonate Systems," *Radiochim. Acta*, 63, 141-146. Contained in WPO 36488.

Reed, D.T., Wygmans, D.G., and Richmann, M.K. 1996. *Stability of Pu(VI), Np(VI), and U(VI) in Simulated WIPP Brine*, Argonne National Laboratory Interim Report (personal communication). Contained in WPO 35197 3/13/96 Interim Report – WPO 35197.

Yamazaki, H., Lagerman, B., Symeopoulos, V., and Choppin, G. 1992. *Solubility of Uranyl in Brine*, Proceedings of the Third International High Level Radioactive Waste Management Conference, Las Vegas, NV, April 12-16, 1992, American Nuclear Society, La Grange Park, IL, and American Society of Engineers, New York. Located in: Vol. 2, p. 1607-1611. SAND92-7069C-WPO 39678

Parameter 44: Log of the Distribution of Solubility of U(VI) in Castile Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for uranium in the +VI oxidation state in Castile brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLU6 SOLCIM (#3392)

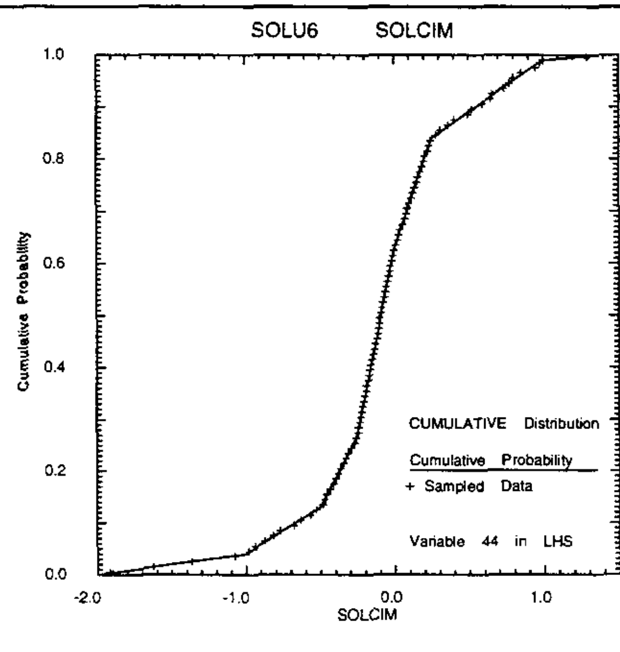
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 44: Log of the Distribution of Solubility of U(VI) in Castile Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Data on U(+VI) solubility in Castile brine was compiled by Hobart and Moore (1996), both from ongoing WIPP-directed research and from published literature. Project experimental data was from Reed et al. (1996) (see SOTERM, Section 3.0). Published data was from Yamazaki, et al (1992) and Pashalidas et al (1993). Based on these data, Hobart and Moore recommend a value for U(+VI) for use in performance assessment. The uncertainty in this value was bounded by the distribution prepared by Bynum (1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of U(+VI) in Castile brine is a function of pH, CO_2 fugacity, and other brine components. The solubility provided by Hobart and Moore (1996) is 8.8×10^{-6} moles/liter (see SOLMOD6, SOLCIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37114

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791.

Hobart, D.E., and Moore, R. 1996. *Draft Analysis of Uranium (VI) Solubility Data for WIPP Performance Assessment*, Sandia National Laboratories, March 28, 1996. WPO 33703.

Parameter 44: Log of the Distribution of Solubility of U(VI) in Castile Brine (Continued)

References (Continued):

Reed, D.T., Wygmans, D.G., and Richmann, M.K. 1996. *Stability of Pu(VI), Np(VI), and U(VI) in Simulated WIPP Brine*, Argonne National Laboratory Interim Report (personal communication). 3/13/96 Interim Report contained in WPO 35197.

Yamazaki, H., Lagerman, B., Symeopoulos, V., and Choppin, G. 1992. *Solubility of Uranyl in Brine*, Proceedings of the Third International High Level Radioactive Waste Management Conference, Las Vegas, NV, April 12-26, 1992, American Nuclear Society, La Grange Park and American Society of Engineers, New York. SAND92-7069C – WPO 39678.

M

Parameter 45: Log of the Distribution of Solubility of Th(IV) in Salado Brine

Parameter Description:

This parameter represents the distribution ($\log_{10}$) of the uncertainty about the modeled solubility value for thorium in the +IV oxidation state in Salado brine. The disposal room chemical environment is controlled by the $Mg(OH)_2$-$MgCO_3$ buffer system.

Material and Parameter Name(s):

SOLTH4 SOLSIM (#3393)

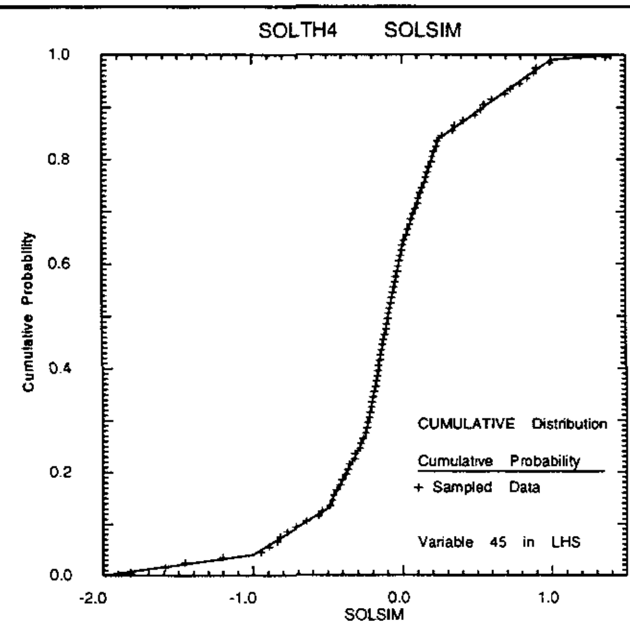
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.18	-0.09	-2.0	1.40	0.37

Units: None

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 45: Log of the Distribution of Solubility of Th(IV) in Salado Brine (Continued)

Data: Site-Specific Experimental Data and Thermodynamic Calculations

Solubilities were calculated using the FMT code (Novak 1996). Bynum (1996) compared 150 modeled and experimentally determined solubilities and provided a distribution of the differences between them. The parameter records package associated with this parameter is located at: SWCF-A:WBS 1.2.0.7.1; WBS 1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Actinides Solubility Source Term Look-up Tables (WPO 35835).

Discussion:

The solubility of Th(+IV) in Salado brine is a function of pH, CO_2 fugacity, and other brine components as modeled by FMT, a computer code for calculating equilibrium concentrations that is based on experimentally determined thermodynamic parameters (Novak 1996; Novak and Moore 1996; Siegel 1996). The FMT-calculated solubility is 4.4×10^{-6} moles/liter (see SOLMOD4, SOLSIM in Table PAR-39). The distribution of solubilities was determined by Bynum (1996) by comparing modeled solubilities for all oxidation states with the experimentally determined solubilities. The parameter is the $\log_{10}$ of the distribution about this value, which is plotted in log space as shown in the CDF/PDF graph. The log of the solubility is obtained by adding this parameter to the log of the FMT model value.

Further information on this parameter is provided in Appendix SOTERM and Appendix IRES.

WIPP Data Entry Form #464 WPO#: 37115

References:

Bynum, R.V. 1996. Memorandum to Martin Tierney and Christine Stockman, Re: Revised Update of Uncertainty Range and Distribution for Actinide Solubility to be used in CCA NUTS Calculations, May 23, 1996. WPO 37791.

Novak, C.F. 1996.Memorandum to J.T. Holmes Re: Release of FMT Data Base Files HMW_3456_960318.CHEMDAT and HMW_345_960325.CHEMDAT, March 27, 1996. WPO 35923.

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Siegel, M. 1996. SNL Technical Memorandum to Martin Tierney Re: Solubility Parameters for Use in the CCA NUTS and GRIDFLOW Calculations, March 29, 1996. WPO 37314.

Parameter 46: Humic Proportionality Constant

Parameter Description:

The humic proportionality constant is used to calculate concentrations of actinides associated with mobile humic substances for actinide elements with oxidation state of +III, in the Castile brine.

Material and Parameter Name(s):

PHUMOX3 PHUMCIM (#3429)

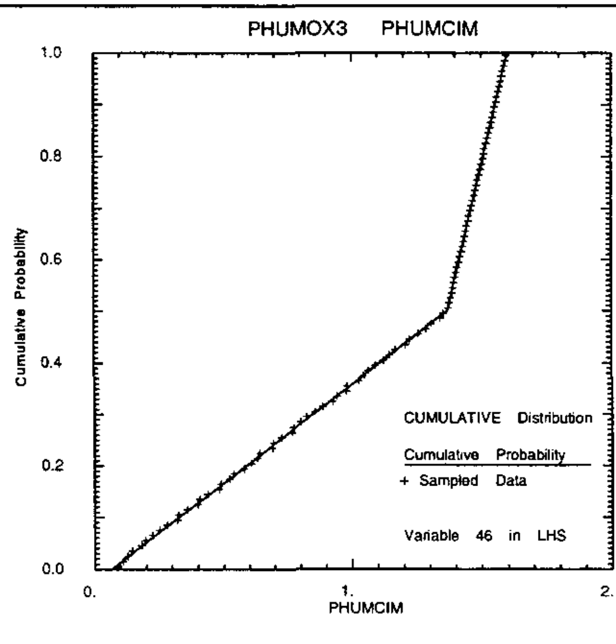
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
1.0	1.37	0.065	1.6	0.47

Units: moles/moles

Distribution Type: Log cumulative

CDF/PDF Graph



Parameter 46: Humic Proportionality Constant (Continued)

Data: Site-Specific Experimental Data

Experiments were conducted at Florida State University (Greg R. Choppin) and at SNL (Hans W. Papenguth and co-workers). These results, combined with WIPP-specific data on calcium and magnesium concentrations, formed the basis for this parameter distribution. The parameter records package associated with this parameter is located at: SWCF-A:WBS1.1.10.2.1.PDD:QA:Mobile Colloidal Actinide Source Term 3: Humic Substances (WPO 35855).

Discussion:

Humic substances encompass a broad variety of high-molecular-weight organic compounds that can mobilize actinides. To determine the concentration of actinides associated with humic substances, four pieces of information are required: 1) the concentration of reactive humic substance in the aqueous phase (that is, humic solubility); 2) the binding capacity of the humic substance; 3) actinide uptake (that is, actinide complexation constants); and 4) concentration of actinide ions in the aqueous phase (that is, actinide solubility). Quantification of actinide solubilities is described in Novak and Moore (1996). Collection of the other data, interpretation of that information, and development of parameter values for performance assessment calculations is described in detail in Papenguth and Moore (1996). The humic proportionality constant is a combination of information from 1) and 3) above. This constant is multiplied by 4), the actinide concentration, to obtain the concentrations of actinides mobilized on humic colloids.

Further information on this parameter is found in Appendix SOTERM.

WIPP Data Entry Form #464 WPO#: 37683

M

References:

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Papenguth, Hans W. 1996. Memo to Christine T. Stockman. RE: Colloidal Actinide Source Term Parameters, Revision 2, April 22, 1996. WPO 37522.

Papenguth, Hans W., and Moore, R.C. 1996. *Mobile - Colloidal- Actinide Source Term, 3. Humic Substances*, Sandia National Laboratories (WPO 35855 Attachment A).

Parameter 47: Oxidation State Distribution Parameter

Parameter Description:

This parameter determines whether the repository environment is more reducing or less reducing for a particular realization.

Material and Parameter Name(s):

GLOBAL OXSTAT (#3417)

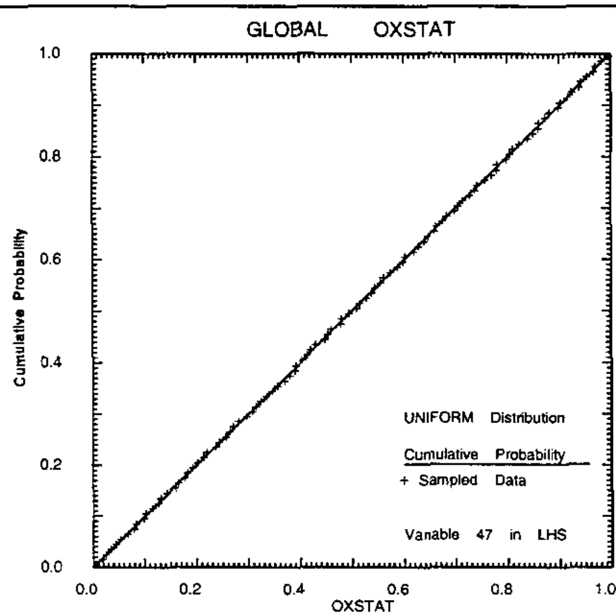
Computational Code(s): NUTS

mean	median	minimum	maximum	std. deviation
0.5	0.5	0	1.0	0.29

Units: None

Distribution Type: Uniform

CDF/PDF Graph



Parameter 47: Oxidation State Distribution Parameter (Continued)

Data: Site-Specific Experimental Data and Literature Research

Experimental results from LANL, PNL, and Argonne National Laboratories-East were used, as well as data from an extensive literature search. The parameter records package associated with this parameter is located at: SWCF-A:WBS1.1.10.1.1:PDD:QA:DISSOLVED SPECIES:Oxidation State Distribution: Actinides:OX3:OX4:OX5:OX6 (WPO 35194).

Discussion:

The oxidation state distribution parameter is used to designate which oxidation states dominate the solubility. Actinides addressed are thorium, uranium, neptunium, plutonium, americium, and curium. Analysis of literature data demonstrated that certain actinides (that is, Am, Th, Cm) will exist only in one oxidation state given the expected WIPP repository conditions. Therefore, this distribution is not used with the performance assessment for these actinides. Experimental evidence indicated that two oxidation states were possible for Pu, U, and Np under the expected WIPP repository conditions. For these actinides, it is assumed that their solubilities and k_ds will be dominated by only one oxidation state, but it is uncertain which of two possible states will dominate. Therefore, in half of the realizations employing this parameter (if >0.5), the higher oxidation state solubilities and k_ds will be used, and in the other half of the realizations (if <0.5), the lower oxidation state solubilities and k_ds will be used (Weiner et al. 1996). Further information on this parameter is found in Appendix SOTERM.

WIPP Data Entry Form #464 WPO#: 37663

References:

Novak, C.F., and Moore, R.C. 1996. Technical Memorandum to Malcolm Siegel, Re: Estimates of Dissolved Concentrations for +III, +IV, +V, and +VI Actinides in a Salado and a Castile Brine under Anticipated Repository Conditions, March 28, 1996. WPO 36207.

Stockman, Christine. 1996. Memo to Martin Tierney. RE: Implementation of Chemistry Parameters in PA. April 16, 1996. WPO 37536.

Weiner, Ruth F., Hobart, D.E., Tait, C.D., and Clark, D.L. 1996. *Analysis of Actinide Oxidation States in the WIPP*, WBS 1.1.10.1.1. WPO 35194.

Parameter 48: Climate Index

Parameter Description:

A change in climate over the next 10,000 years could alter flow rates in the Culebra, thereby impacting radionuclide transport. The Climate Index is a multiplication factor to enhance the magnitude of flow in each realization of the Culebra flow field caused by changes in future climate.

Material and Parameter Name(s):

GLOBAL CLIMTIDX (#233)

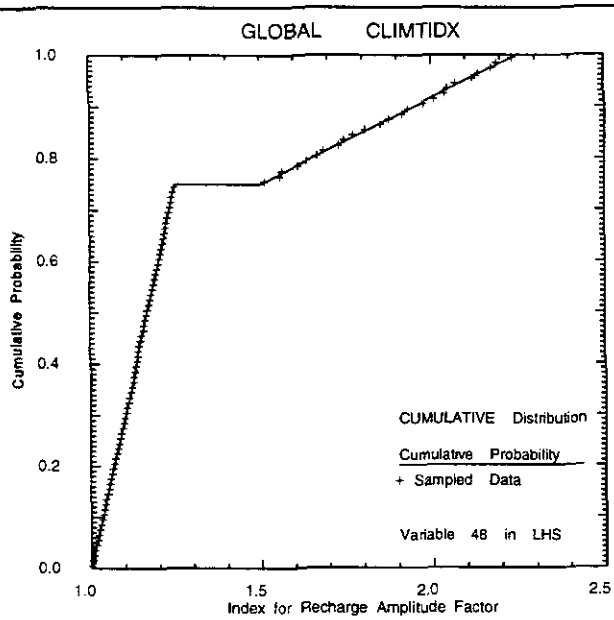
Computational Code(s): SECOTP2D

mean	median	minimum	maximum	std. deviation
1.31	1.17	1.0	2.25	0.35

Units: None

Distribution Type: Cumulative

CDF/PDF Graph



Parameter 48: Climate Index (Continued)

Data: General Literature and Professional Judgment

The parameter distribution was obtained by first surveying the available literature to obtain information that can be used to infer the annual precipitation rate since the end of the Pleistocene and for the next 10,000 years. Next, numerical simulations were performed to see how various assumed rates and temporal patterns of recharge would impact groundwater flow velocities in the Culebra within the WIPP site. The parameter records package associated with this parameter is located at: SWCF-A:WBS1.2.07.1:PDD:QA:NON-SALADO:Culebra Transmissivity Zone:CLIMTIDX/GLOBAL (WPO 36425).

Discussion:

The following main assumptions were used in the numerical simulations:

1) the groundwater basin conceptual model is applicable,
2) the lateral boundaries are flow divides (that is, no-flow boundaries) during the period simulated,
3) flow in the unsaturated zone can be neglected, and
4) the flow system was equilibrated to a recharge rate sufficient to maintain the water table near the land surface at the start of the simulations.

As described in the Climate Index Record Package (Corbet and Swift 1996), a step recharge function, which represents a radical disruption of the climate pattern of the Holocene, is unlikely and is assigned a 0.25 probability of occurrence and the Holocene recharge pattern is assigned a 0.75 probability of occurrence.

First, simulations were performed using a step recharge function for the pattern of future recharge. The results specify a uniform distribution between 1.5 and 2.25.

Next, six transient simulations using the Holocene pattern of future recharge were performed. The results specify a uniform distribution between 1.0 and 1.25.

WIPP Data Entry Form #464 WPO#: 33031

References:

Corbet, T. and Swift, P. 1996. Memo to M. Tierney. Re: Distribution for Non-Salado Parameter for SECOFL2D: Climate Index, April 12, 1996. WPO 37465.

Parameter 49: Culebra Half Matrix Block Length

Parameter Description:

This parameter is used to describe the half matrix block length (defined as one-half the thickness of a matrix slab between two parallel plates of fractures) for the Culebra dolomite. It is one of the parameters required in the SECOTP2D code for the double-porosity conceptualization of the Culebra (see also: Appendix SECOTP2D).

Material and Parameter Name(s):

CULEBRA HMBLKLT (#3485)

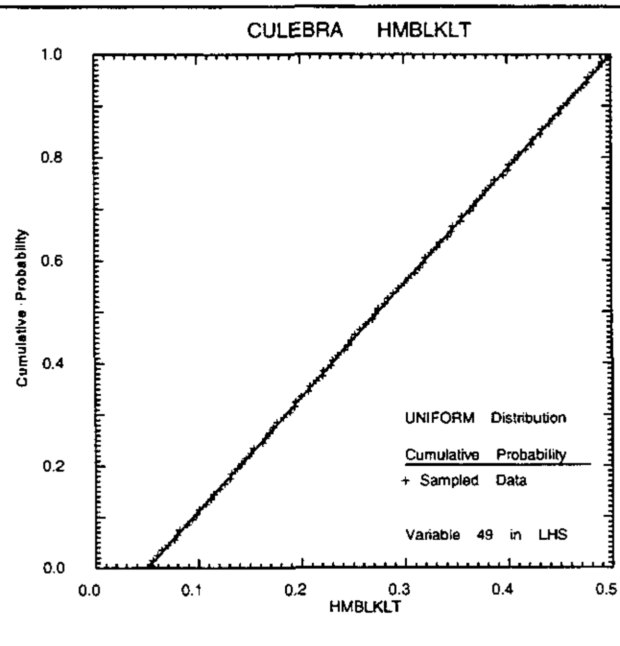
Computational Code(s): SECOTP2D

mean	median	minimum	maximum	std. deviation
0.275	0.275	0.05	0.5	0.13

Units: meters

Distribution Type: Uniform

CDF/PDF Graph



Parameter 49: Culebra Half Matrix Block Length (Continued)

Data: Professional Judgment - General Engineering Knowledge

The half matrix block length distribution is derived from numerical simulations of tracer test data. The data associated with this parameter are located in the following parameter records packages: SWCF-A:WBS1.2.07.1:PDD:QA:NON-SALADO:Culebra Half Matrix Block Length (Culebra Transport Parameter) (WPO 37225). Supporting data records packages for this parameter include: SWCF-A:1.1.5.2.3:TD:QA:Tracer Test Interpretations, Interim Simulations (WPO 37450); SWCF-A:1.1.5.3.4:TD:QA:Tracer Test Sample Analyses, H-11 Tracer Tests Conducted June 1995 through July 1995 (WPO 37468); SWCF-A:1.1.5.3.4:TD: QA:Tracer Test Sample Analyses, H-19 Tracer Tests Conducted December 1995 through April 1996 (WPO 37452); and SWCF-A:1.1.5.3.4:TD:QA:Tracer Test Sample Analyses, H-11 Tracer Tests Conducted February 1996 through March 1996 (WPO 37467).

Discussion:

The half matrix block length is defined as one-half the thickness of a matrix slab between two parallel plates of fractures. Diffusive processes at the WIPP will cause some fraction of actinides, which are released from the repository, to diffuse from the advective porosity into the diffusive porosity (or matrix), thereby delaying and attenuating discharges at the site boundary. The larger the half matrix block length (smaller surface area for diffusion), the larger the release because there will be less diffusion and in turn less access to surface area for sorption (Meigs and McCord 1996; see Appendix MASS Attachment 15-6).

The distribution of values for the half matrix block length is uniform, with values ranging from 0.05 to 0.5 meters (that is, full matrix block length values from 0.1 to 1.0 meters). This distribution is based on numerical simulations of tracer test data from the H-3, H-11, and H-19 hydropads (Meigs and McCord 1996). Multiwell convergent flow tracer tests have been performed previously at H-3 and H-11 (Stensrud et al. 1989; Hydro Geo Chem, Inc. 1985). More recently, additional tracer tests have been performed at H-11 and new tests have been performed at H-19 (Beauheim et al. 1995). The 1995-96 tests at H-11 and H-19 consisted of single-well injection-withdrawal tests and multiwell convergent flow tests.

The matrix block length and the advective porosity are essentially fitting parameters inferred from comparing the results of numerical simulations of the tracer tests to the field data. Numerical simulations were performed with double-porosity models with both homogeneous and heterogeneous hydraulic conductivity fields. For the homogeneous approach, the field data was analyzed using the SWIFT-II transport code, and for the heterogeneous approach, the field data was analyzed using the THEMM code. Both modeling approaches yielded consistent results for each well-to-well path with regard to matrix block length (Meigs and McCord,

Parameter 49: Culebra Half Matrix Block Length (Continued)

Discussion (Continued):

1996). Additional details on the numerical simulations are contained in a records package entitled "Tracer Test Interpretations, Interim Simulations" (WPO 37450).

WIPP Data Entry Form #464 WPO#: 38356

References:

Beauheim, R. L., Meigs, L.C., Saulnier, G.J., and Stensrud, W.A. 1995. Culebra Transport Program Test Plan: Tracer Testing of the Culebra Dolomite Member of the Rustler Formation at the H-19 and H-11 Hydropads on the WIPP Site. WPO 30156.

Hydro Geo Chem, Inc. 1985. WIPP Hydrology Program Waste Isolation Pilot Plant, SENM Hydrologic Data Report #1. SAND85-7206. Albuquerque, NM: Sandia National Laboratories. WPO 28430.

Meigs, Lucy, and McCord, Jim. 1996. Memo to file. RE: Physical Transport in the Culebra Dolomite, July 11, 1996 (contained in SWCF-A:1.1.5.2.3:TD:QA:Tracer Test Interpretations, Interim Simulations, WPO 37450).

Stensrud, W.A., Bame, M.A., Lantz, K.D., Palmer, J.B., and Saulnier, G.J., Jr. 1989. WIPP Hydrology Program Waste Isolation Pilot Plant Southeastern New Mexico Hydrologic Report #8. SAND89-7056. Albuquerque, NM: Sandia National Laboratories. WPO 28582.

Parameter 50: Culebra Advective Porosity

Parameter Description:

This parameter is used to describe the advective porosity (typically referred to as the fracture porosity) for the Culebra dolomite. It is one of the parameters required in the SECOTP2D code for the double-porosity conceptualization of the Culebra (see also Appendix SECOTP2D).

Material and Parameter Name(s):

CULEBRA APOROS (#3487)

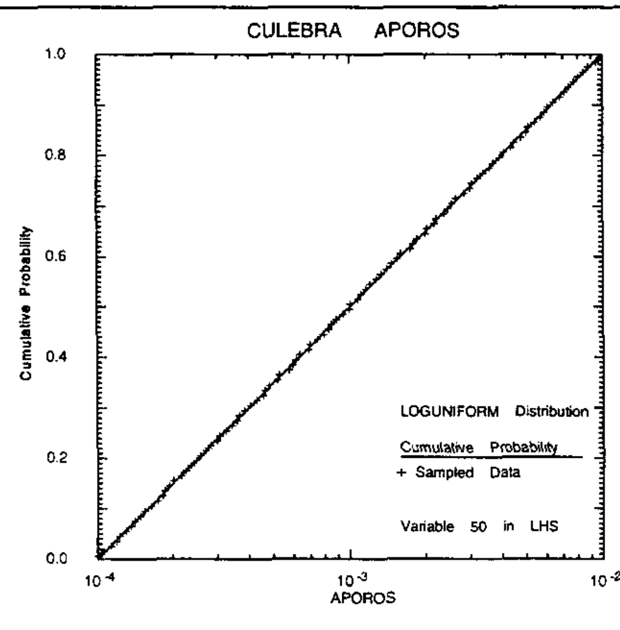
Computational Code(s): SECOTP2D

mean	median	minimum	maximum	std. deviation
2.1×10^{-3}	1.0×10^{-3}	1.0×10^{-4}	1.0×10^{-2}	0

Units: None

Distribution Type: Loguniform

CDF/PDF Graph



Parameter 50: Culebra Advective Porosity (Continued)

Data: Professional Judgment - General Engineering Knowledge

This porosity distribution is derived from numerical simulations of tracer test data. The data associated with this parameter are located in the following parameter records packages: SWCF-A:WBS1.2.07.1:PDD:QA:NON-SALADO:Culebra Advective Porosity (Culebra Transport Parameter) (WPO 37227). Supporting data records packages for this parameter include: SWCF-A:1.1.5.2.3:TD:QA: Tracer Test Interpretations, Interim Simulations (WPO 37450); SWCF-A:1.1.5.3.4:TD:QA: Tracer Test Sample Analyses, H-19 Tracer Tests Conducted December 1995 through April 1996 (WPO 37452); and SWCF-A:1.1.5.3.4:TD:QA:Tracer Test Sample Analyses, H-11 Tracer Tests Conducted February 1996 through March 1996 (WPO 37467).

Discussion:

The Culebra is a fractured dolomite with nonuniform properties and multiple scales of porosity, including fractures ranging from microscale to large, vuggy zones, inter-particle and inter-crystalline porosity. When the permeability contrast is significant between different scales of connected porosity, the total porosity of the system can be modeled by dividing it into the advective (for example, fractures, and to some extent vugs connected by fractures, and interparticle porosity) porosity and the diffusive (or matrix) porosity. The advective porosity refers to porosity through which most of the flow occurs (for example, fractures), while the diffusive porosity includes features such as intercrystalline porosity, and to some extent microfractures, vugs, and interparticle porosity, accessible to solutes only through diffusion. The advective porosity used for the performance assessment simulations has been determined from evaluation of tracer test data (Meigs and McCord 1996). The diffusive porosity has been determined from laboratory measurements of core plugs, which do not contain large fractures (Meigs and McCord 1996; see Appendix MASS Attachment 15-6).

The distribution for the advective porosity is based on numerical simulations of tracer test data from the H-3, H-11, and H-19 hydropads (Meigs and McCord 1996). Multiwell convergent flow tests have been performed previously at H-3 and H-11 (Stensrud et al. 1989; Hydro Geo Chem, Inc. 1985). More recently, additional tracer tests have been performed at H-11 and new tests have been performed at H-19 (Beauheim et al. 1995). The recent tests at H-11 and H-19 consisted of single-well injection-withdrawal tests and multiwell convergent flow tests.

The advective porosity and the matrix block length are essentially fitting parameters inferred from comparing the results of numerical simulations of the tracer tests to the field data. Numerical simulations were performed with double-porosity models with both homogeneous

Parameter 50: Culebra Advective Porosity (Continued)

Discussion (Continued):

and heterogeneous hydraulic conductivity fields. For the homogeneous approach, the field data was analyzed using the SWIFT-II transport code, and for the heterogeneous approach, the field data was analyzed using the THEMM code. Both modeling approaches yielded consistent results for each well-to-well path with regard to advective porosity (Meigs and McCord 1996). Additional details on the numerical simulations are contained in a records package entitled "Tracer Test Interpretations, Interim Simulations" (WPO 37450).

WIPP Data Entry Form #464 WPO#: 38358

References:

Beauheim, R. L., Meigs, L.C., Saulnier, G.J., and Stensrud, W.A. 1995. Culebra Transport Program Test Plan: Tracer Testing of the Culebra Dolomite Member of the Rustler Formation at the H-19 and H-11 Hydropads on the WIPP Site. WPO 30156.

Hydro Geo Chem, Inc. 1985. WIPP Hydrology Program Waste Isolation Pilot Plant, SENM Hydrologic Data Report #1. SAND85-7206. Albuquerque, NM: Sandia National Laboratories. WPO 28430.

Meigs, Lucy, and McCord, Jim. 1996. Memo to file. RE: Physical Transport in the Culebra Dolomite, July 11, 1996 (contained in SWCF-A:1.1.5.2.3:TD:QA:Tracer Test Interpretations, Interim Simulations, WPO 37450).

Stensrud, W.A., Bame, M.A., Lantz, K.D., Palmer, J.B., and Saulnier, G.J., Jr. 1989. WIPP Hydrology Program Waste Isolation Pilot Plant Southeastern New Mexico Hydrologic Data Report #8. SAND89-7056. Albuquerque, NM: Sandia National Laboratories. WPO 28582.

Parameter 51: Culebra Diffusive Porosity

Parameter Description:

This parameter is used to describe the diffusive porosity (typically referred to as the matrix porosity) for the Culebra dolomite. It is one of the parameters required in the SECOTP2D code for the double-porosity conceptualization of the Culebra (see also Appendix SECOTP2D).

Material and Parameter Name(s):

CULEBRA DPOROS (#3486)

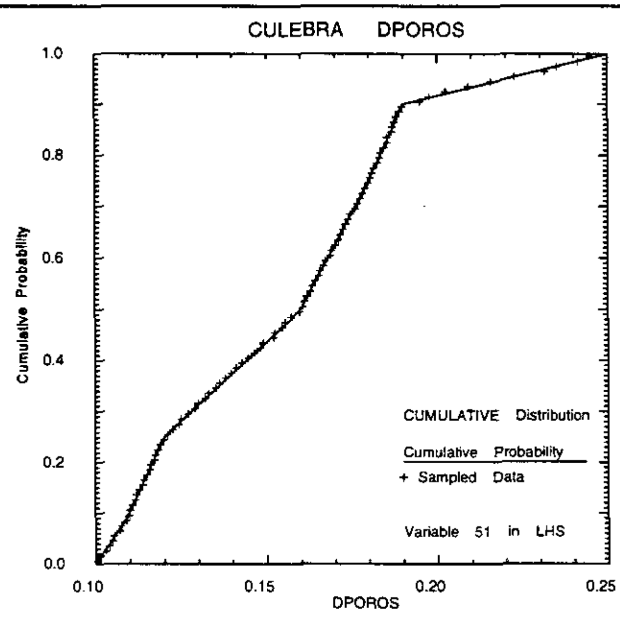
Computational Code(s): SECOTP2D

mean	median	minimum	maximum	std. deviation
0.16	0.16	0.10	0.25	0.4

Units: None

Distribution Type: Cumulative

CDF/PDF Graph



Parameter 51: Culebra Diffusive Porosity (Continued)

Data: Site-Specific Experimental Data and Professional Judgment - General Engineering Knowledge

This porosity distribution is derived from laboratory measurements. The data associated with this parameter are located in the following parameter records packages: SWCF-A:WBS1.2.07.1:PDD:QA:NON-SALADO:Culebra Diffusive Porosity (Culebra Transport Parameter) (WPO 37228). Supporting data records packages for this parameter include: SWCF-A:1.1.5.3.4:TD:QA:Non-Salado Core Analyses Performed by Terra Tek (AA-2896) (WPO 38234).

Discussion:

The Culebra is a fractured dolomite with nonuniform properties and multiple scales of porosity, including fractures ranging from microscale to large, vuggy zones and inter-particle and inter-crystalline porosity. When the permeability contrast is significant between different scales of connected porosity, the total porosity of the system can be modeled by dividing it into the advective (for example, fractures and, to some extent, vugs connected by fractures, and interparticle porosity) porosity and the diffusive (or matrix) porosity. The advective porosity refers to porosity through which most of the flow occurs, while the diffusive porosity includes features such as intercrystalline porosity and, to some extent, microfractures, vugs, and interparticle porosity accessible to solutes only through diffusion. The advective porosity to be used for the performance assessment simulations has been determined from evaluation of tracer test data. The diffusive porosity has been determined from laboratory measurement of core plugs, which do not contain large fractures (Meigs and McCord 1996; see Appendix MASS Attachment 15-6).

This diffusive porosity distribution is derived from laboratory measurements. Boyle's Law helium porosity measurements have been made from 103 Culebra core plugs from 17 locations as reported in Kelley and Saulnier (1990) as well as additional porosity measurements recently completed by Terra Tek (WPO 38234). The methodology used for porosity measurements are described in Kelley and Saulnier (1990). To account for areal averaging, individual porosity measurements from a borehole and/or hydropad were averaged to yield a borehole/hydropad average porosity. The averaged values were used to construct the distribution (Meigs and McCord 1996).

WIPP Data Entry Form #464 WPO#: 38357

Parameter 51: Culebra Diffusive Porosity (Continued)

References:

Kelley, V. A., and Saulnier, G. 1990. *Core Analyses for Selected Samples from the Culebra Dolomite at the Waste Isolation Pilot Plant Site*. SAND90-7011. Albuquerque, NM: Sandia National Laboratories. WPO 28629.

Meigs, Lucy, and McCord, Jim. 1996. Memo to file. RE: Physical Transport in the Culebra Dolomite, July 11, 1996 (contained in SWCF-A:1.1.5.2.3:TD:QA:Tracer Test Interpretations, Interim Simulations, WPO 37450).

Parameter 52: Matrix Distribution Coefficient for U(VI)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for uranium in the +VI oxidation state. K_d is the equilibrium ratio of the mass of U adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Parameter Name(s):

U+6 MKD_U (#3475)

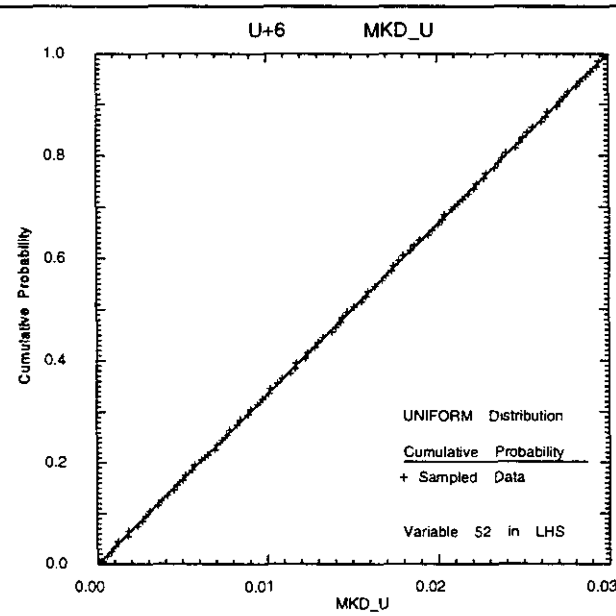
Computational Code(s): SECOTP2D, NUTS

mean	median	minimum	maximum	std. deviation
1.5×10^{-2}	1.5×10^{-2}	3.0×10^{-5}	3.0×10^{-2}	0.01

Units: cubic meters per kilogram

Distribution Type: Uniform

CDF/PDF Graph



Parameter 52: Matrix Distribution Coefficient for U(VI) (Continued)

Data: Site-Specific Experimental Data

The data associated with this parameter are located in the following parameter records package: SWCF-A:WBS1.1.10.3.1:PDD:QA:Culebra Dissolved Actinide Distribution Coefficients (K_ds) (WPO 38231).

Discussion:

Brush (1996) describes the laboratory sorption studies used to determine matrix K_ds for dissolved U. The experimental data do not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believes that this is a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for U in the Culebra is set to zero, which is also conservative. The laboratory sorption studies are summarized below.

Triay at Los Alamos National Laboratory (LANL) studied the sorption of Pu(V), Am(III), U(VI), Th(IV), and Np(V) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples which Triay used contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

P. V. Brady at SNL studied the sorption of Pu(V), Am(III), Np(III) (a nonradioactive analog of Am(III) and Pu(III)), U(VI), Th(IV), and Np(V) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock or Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D. A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP Air Intake Shaft (AIS). This study did not yield K_ds directly; U was moderately retarded by sorption and discrete values for the retardation factor were obtained which were then used, along with the porosity determined from the nonsorbing tracer test, to calculate K_ds (Brush 1996).

H. W. Stockman at SNL performed a modeling study of the oxidation states of Pu and U in the Culebra. This study showed that Culebra fluids have limited capacity to either oxidize or reduce actinide elements. Therefore, it is reasonable to use the oxidation-state distributions of Pu and U predicted for WIPP disposal rooms to specify the oxidation states in the Culebra and

Parameter 52: Matrix Distribution Coefficient for U(VI) (Continued)

Discussion (Continued):

to assume that these oxidation states will be maintained along the entire off-site transport pathway (Brush 1996).

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties about the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

WIPP Data Entry Form #464 WPO#: 38346

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. WPO 38801.

Parameter 53: Matrix Distribution Coefficient for U(IV)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for uranium in the +IV oxidation state. K_d is the equilibrium ratio of the mass of U adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Parameter Name(s):

U+4 MKD_U (#3479)

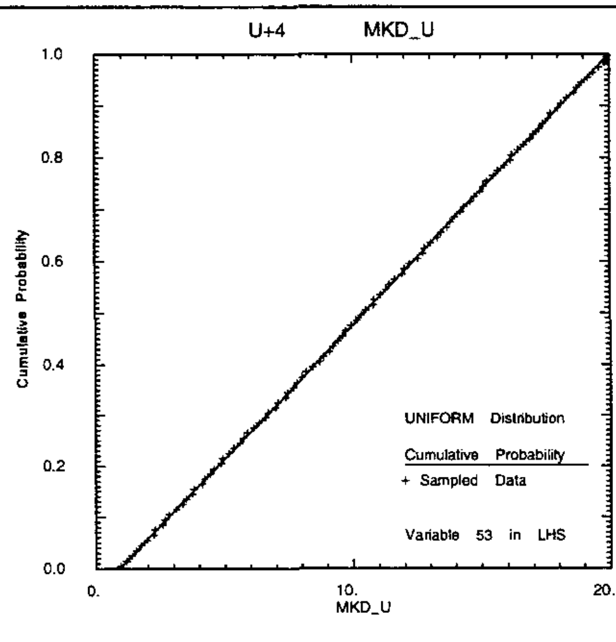
Computational Code(s): SECOTP2D, NUTS

mean	median	minimum	maximum	std. deviation
10.0	10.0	0.90	20.0	5.5

Units: cubic meters per kilogram

Distribution Type: Uniform

CDF/PDF Graph



Parameter 53: Matrix Distribution Coefficient for U(IV) (Continued)

Data: Site-Specific Experimental Data

The data associated with this parameter are located in the following parameter records package: SWCF-A:WBS1.1.10.3.1:PDD:QA:Culebra Dissolved Actinide Distribution Coefficients (K_ds) (WPO 38231).

M

Discussion:

Brush (1996) describes the laboratory sorption studies used to determine matrix K_ds for dissolved U. The experimental data do not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believes that this is a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for U in the Culebra is set to zero, which is also conservative. The laboratory sorption studies are summarized below.

Triay at LANL studied the sorption of Pu(V), Am(III), U(VI), Th(IV), and Np(V) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples which Triay used contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

P. V. Brady at SNL studied the sorption of Pu(V), Am(III), Np(III) (a nonradioactive analog of Am(III) and Pu(III)), U(VI), Th(IV), and Np(V) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock/Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D. A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly; U was moderately retarded by sorption and discrete values for the retardation factor were obtained which were then used, along with the porosity determined from the nonsorbing tracer test, to calculate K_ds (Brush 1996).

H. W. Stockman at SNL performed a modeling study of the oxidation states of Pu and U in the Culebra. This study showed that Culebra fluids have limited capacity to either oxidize or reduce actinide elements. Therefore, it is reasonable to use the oxidation-state distributions of Pu and U predicted for WIPP disposal rooms to specify the oxidation states in the Culebra and

Parameter 53: Matrix Distribution Coefficient for U(IV) (Continued)

Discussion (Continued):

to assume that these oxidation states will be maintained along the entire off-site transport pathway (Brush 1996).

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties about the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

WIPP Data Entry Form #464 WPO#: 38350

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. WPO 38801.

Parameter 54: Matrix Distribution Coefficient for Pu(III)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for plutonium in the +III oxidation state. K_d is the equilibrium ratio of the mass of Pu adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Parameter Name(s):

PU+3 MKD_PU (#3480)

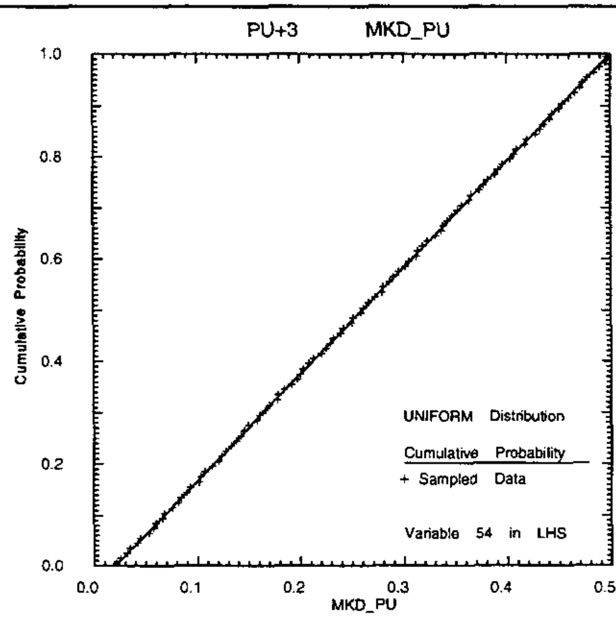
Computational Code(s): SECOTP2D, NUTS

mean	median	minimum	maximum	std. deviation
0.26	0.26	0.02	0.50	0.14

Units: cubic meters per kilogram

Distribution Type: Uniform

CDF/PDF Graph



Parameter 54: Matrix Distribution Coefficient for Pu(III) (Continued)

Data: Site-Specific Experimental Data

The data associated with this parameter are located in the following parameter records package: SWCF-A:WBS1.1.10.3.1:PDD:QA:Culebra Dissolved Actinide Distribution Coefficients (K_ds) (WPO 38231).

Discussion:

Brush (1996) describes the laboratory sorption studies used to determine matrix K_ds for dissolved Pu. The experimental data do not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believes that this is a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for Pu in the Culebra is set to zero, which is also conservative. The laboratory sorption studies are summarized below.

Triay at LANL studied the sorption of Pu(V), Am(III), U(VI), Th(IV), and Np(V) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples which Triay used contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

P. V. Brady at SNL studied the sorption of Pu(V), Am(III), Np(III) (a nonradioactive analog of Am(III) and Pu(III)), U(VI), Th(IV), and Np(V) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock/Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D. A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly because the experiments never reached breakthrough; Lucero was only able to calculate minimum values of retardation (R) and K_d. These minimum values depend on factors such as the initial concentration of each radionuclide, the volume of brine pumped through the core, and the analytical detection limit for the radionuclide (Brush 1996).

H. W. Stockman at SNL performed a modeling study of the oxidation states of Pu and U in the Culebra. This study showed that Culebra fluids have limited capacity to either oxidize or reduce actinide elements. Therefore, it is reasonable to use the oxidation-state distributions of

Parameter 54: Matrix Distribution Coefficient for Pu(III) (Continued)

Discussion (Continued):

Pu and U predicted for WIPP disposal rooms to specify the oxidation states in the Culebra and to assume that these oxidation states will be maintained along the entire off-site transport pathway (Brush 1996).

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties about the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

WIPP Data Entry Form #464 WPO#: 38351

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. WPO 38801.

Parameter 55: Matrix Distribution Coefficient for Pu(IV)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for plutonium in the +IV oxidation state. K_d is the equilibrium ratio of the mass of Pu adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Parameter Name(s):

PU+4 MKD_PU (#3481)

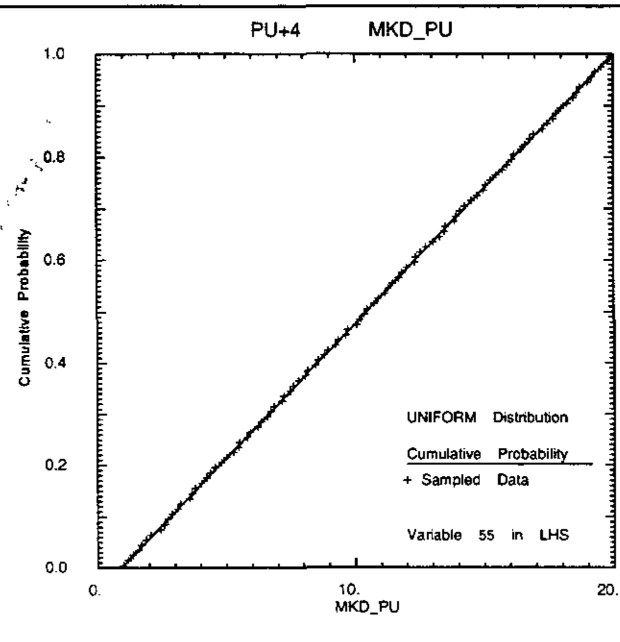
Computational Code(s): SECOTP2D, NUTS

mean	median	minimum	maximum	std. deviation
10.0	10.0	0.90	20.0	5.5

Units: cubic meters per kilogram

Distribution Type: Uniform

CDF/PDF Graph



Parameter 55: Matrix Distribution Coefficient for Pu(IV) (Continued)

Data: Site-Specific Experimental Data

The data associated with this parameter are located in the following parameter records package: SWCF-A:WBS1.1.10.3.1:PDD:QA:Culebra Dissolved Actinide Distribution Coefficients (K_ds) (WPO 38231).

Discussion:

Brush (1996) describes the laboratory sorption studies used to determine matrix K_ds for dissolved Pu. The experimental data do not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believes that this is a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for Pu in the Culebra is set to zero, which is also conservative. The laboratory sorption studies are summarized below.

Triay at LANL studied the sorption of Pu(V), Am(III), U(VI), Th(IV), and Np(V) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples which Triay used contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

P. V. Brady at SNL studied the sorption of Pu(V), Am(III), Np(III) (a nonradioactive analog of Am(III) and Pu(III)), U(VI), Th(IV), and Np(V) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock/Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D. A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly because the experiments never reached breakthrough; Lucero was only able to calculate minimum values of retardation (R) and K_d. These minimum values depend on factors such as the initial concentration of each radionuclide, the volume of brine pumped through the core, and the analytical detection limit for the radionuclide (Brush 1996).

H. W. Stockman at SNL performed a modeling study of the oxidation states of Pu and U in the Culebra. This study showed that Culebra fluids have limited capacity to either oxidize or reduce actinide elements. Therefore, it is reasonable to use the oxidation-state distributions of

Parameter 55: Matrix Distribution Coefficient for Pu(IV) (Continued)

Discussion (Continued):

Pu and U predicted for WIPP disposal rooms to specify the oxidation states in the Culebra and to assume that these oxidation states will be maintained along the entire off-site transport pathway (Brush 1996).

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties about the extent to which deep (Castile and Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

WIPP Data Entry Form #464 WPO#: 38352

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. WPO 38801.

Parameter 56: Matrix Distribution Coefficient for Th(IV)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for thorium in the +IV oxidation state. K_d is the equilibrium ratio of the mass of Th adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Parameter Name(s):

TH+4 MKD_TH (#3478)

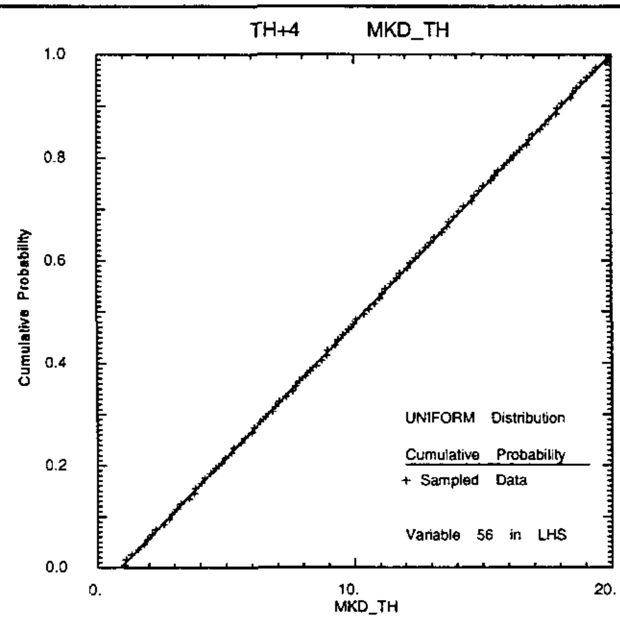
Computational Code(s): SECOTP2D, NUTS

mean	median	minimum	maximum	std. deviation
10.0	10.0	0.90	20.0	5.5

Units: cubic meters per kilogram

Distribution Type: Uniform

CDF/PDF Graph



Parameter 56: Matrix Distribution Coefficient for Th(IV) (Continued)

Data: Site-Specific Experimental Data

The data associated with this parameter are located in the following parameter records package: SWCF-A:WBS1.1.10.3.1:PDD:QA:Culebra Dissolved Actinide Distribution Coefficients (K_ds) (WPO 38231).

Discussion:

Brush (1996) describes the laboratory sorption studies used to determine matrix K_ds for dissolved Th. The experimental data do not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believes that this is a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for Th in the Culebra is set to zero, which is also conservative. The laboratory sorption studies are summarized below.

Triay at LANL studied the sorption of Pu(V), Am(III), U(VI), Th(IV), and Np(V) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples which Triay used contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

P. V. Brady at SNL studied the sorption of Pu(V), Am(III), Np(III) (a nonradioactive analog of Am(III) and Pu(III)), U(VI), Th(IV), and Np(V) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock/Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D. A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly because the experiments never reached breakthrough; Lucero was only able to calculate minimum values of retardation (R) and K_d. These minimum values depend on factors such as the initial concentration of each radionuclide, the volume of brine pumped through the core, and the analytical detection limit for the radionuclide (Brush 1996).

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties about the extent to which deep (Castile and

Parameter 56: Matrix Distribution Coefficient for Th(IV) (Continued)

Discussion (Continued):

Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

WIPP Data Entry Form #464 WPO#: 38349

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. WPO 38801

Parameter 57: Matrix Distribution Coefficient for Am(III)

Parameter Description:

This parameter describes the matrix distribution coefficient (K_d) for americium in the +III oxidation state. K_d is the equilibrium ratio of the mass of Am adsorbed on the solid phase(s) per unit mass of solid divided by the concentration of that element in the aqueous phase.

Material and Parameter Name(s):

AM+3 MKD_AM (#3482)

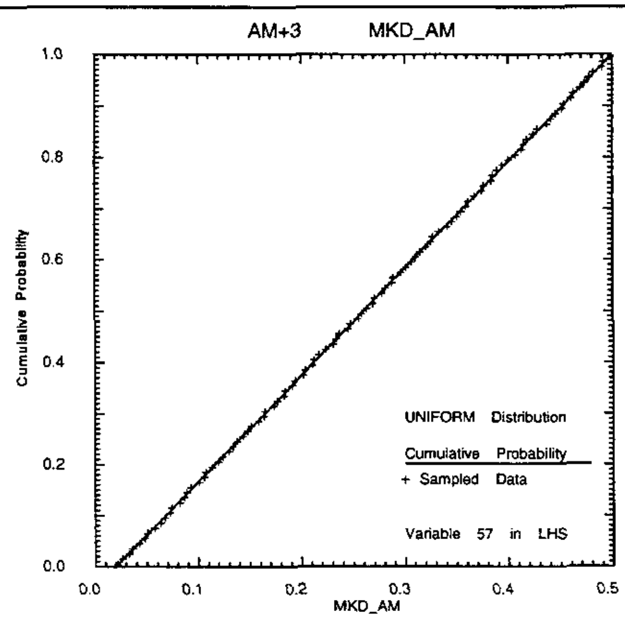
Computational Code(s): SECOTP2D, NUTS

mean	median	minimum	maximum	std. deviation
0.26	0.26	0.02	0.50	0.14

Units: cubic meters per kilogram

Distribution Type: Uniform

CDF/PDF Graph



Parameter 57: Matrix Distribution Coefficient for Am(III) (Continued)

Data: Site-Specific Experimental Data

The data associated with this parameter are located in the following parameter records package: SWCF-A:WBS1.1.10.3.1:PDD:QA:Culebra Dissolved Actinide Distribution Coefficients (K_ds) (WPO 38231).

Discussion:

Brush (1996) describes the laboratory sorption studies used to determine matrix K_ds for dissolved Am. The experimental data do not include K_ds for the clay-rich rock associated with fracture surfaces and dispersed in the matrix of the Culebra. Brush (1996) believes that this is a more conservative approach. Further, the fracture-surface K_d (actually, K_a) for Am in the Culebra is set to zero, which is also conservative. The laboratory sorption studies are summarized below.

Triay at LANL studied the sorption of Pu(V), Am(III), U(VI), Th(IV), and Np(V) by dolomite-rich Culebra rock. These experiments yielded sorption isotherms, plots of the quantity of radionuclide sorbed by the solid phase(s) versus the final dissolved radionuclide concentration, or plots of K_ds versus the final dissolved radionuclide concentration. The samples which Triay used contained a lower concentration of clay minerals than the Culebra as a whole and therefore, Triay's K_ds are conservative (Brush 1996).

P. V. Brady at SNL studied the sorption of Pu(V), Am(III), Np(III) (a nonradioactive analog of Am(III) and Pu(III)), U(VI), Th(IV), and Np(V) from synthetic NaCl solutions by samples of pure dolomite from Norway. Although this study did not yield K_ds for actual samples of Culebra rock/Culebra fluids, it did yield results useful for interpreting the results of Triay's study and for extending Triay's data to the pH conditions (about 9 to 10) expected from an MgO backfill in WIPP disposal rooms (Brush 1996).

D. A. Lucero at SNL studied actinide transport through intact core samples from the Culebra in the WIPP AIS. This study did not yield K_ds directly because the experiments never reached breakthrough; Lucero was only able to calculate minimum values of retardation (R) and K_d. These minimum values depend on factors such as the initial concentration of each radionuclide, the volume of brine pumped through the core, and the analytical detection limit for the radionuclide (Brush 1996).

The range and probability distribution of matrix K_ds for deep (Castile and Salado) or Culebra brines that resulted in less retardation for each element or elemental oxidation state was used in the calculations. Since there are uncertainties about the extent to which deep (Castile and

Parameter 57: Matrix Distribution Coefficient for Am(III) (Continued)

Discussion (Continued):

Salado) and Culebra brines will mix, there are uncertainties as to the probability distributions of these factors (especially brine type, the partial pressure of CO_2, and the resulting pH) in the Culebra. Therefore, the matrix K_ds were specified as a uniform distribution rather than a Student's-t distribution.

WIPP Data Entry Form #464 WPO#: 38353

References:

Brush, L. H. 1996. Memo to M. S. Tierney, RE: Ranges and Probability Distributions of K_ds for Dissolved Pu, Am, U, Th, and Np in the Culebra for the PA Calculations to Support the WIPP CCA, June 10, 1996. WPO 38801.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median[1]	Low	High	Standard Deviation	WPO #
1	2907	STEEL	Generic steel in waste	CORRMCO2	Inundated corrosion rate for steel without CO2 present	UNIFORM	m/s	7.9370E-15	7.9370E-15	0	1.5870E-14	0	34357
2	2823	WAS_AREA	Waste emplacement area and waste	PROBDEG	Prob. of plastics&rubber biodegradation in event of significant microbial gas generation	DELTA	NONE	n.a.	n.a.	0	2	n.a.	34881
(2)	2824	REPOSIT	Repository regions outside of Panel region	PROBDEG	Prob. of plastics&rubber biodegradation in event of microbial gas generation	DELTA	NONE	n.a.	n.a.	0	2	n.a.	33264
3	657	WAS_AREA	Waste emplacement area and waste	GRATMICI	Biodegradation rate, inundated conditions	UNIFORM	mol/kg*s	4.9150E-09	4.9150E-09	3.1710E-10	9.5129E-09	0	34928
(3)	2128	REPOSIT	Repository regions outside of Panel region	GRATMICI	Gas production rate, microbial, inundated conditions	UNIFORM	mol/kg*s	4.9150E-09	4.9150E-09	3.1710E-10	9.5129E-09	0	33235
4	656	WAS_AREA	Waste emplacement area and waste	GRATMICH	Biodegradation rate, humid conditions relative to inundated rate	UNIFORM	mol/kg*s	6.3420E-10	6.3420E-10	0	1.2684E-09	0	34923
(4)	2127	REPOSIT	Repository regions outside of Panel region	GRATMICH	Gas production rate, microbial, humid conditions relative to inundated rate	UNIFORM	mol/kg*s	6.3420E-10	6.3420E-10	0	1.2684E-09	0	33234
5	2994	CELLULS	Cellulose	FBETA	Factor beta for microbial reaction rates	UNIFORM	NONE	5.0000E-01	5.0000E-01	0	1.0000E+00	0.29	31826
6	671	WAS_AREA	Waste emplacement area and waste	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	7.5000E-02	7.5000E-02	0	1.5000E-01	0.04	34905
(6)	2137	REPOSIT	Repository regions outside of Panel region	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	7.5000E-02	7.5000E-02	0	1.5000E-01	0.04	33286
7	670	WAS_AREA	Waste emplacement area and waste	SAT_RBRN	Residual Brine Saturation	UNIFORM	NONE	2.7600E-01	2.7600E-01	0	5.5200E-01	0.16	34902
(7)	2741	REPOSIT	Repository regions outside of Panel region	SAT_RBRN	Residual Brine Saturation	UNIFORM	NONE	2.7600E-01	2.7600E-01	0	5.5200E-01	0.16	33283
8	2231	WAS_AREA	Waste emplacement area and waste	SAT_WICK	Index for computing wicking	UNIFORM	NONE	5.0000E-01	5.0000E-01	0	1.0000E+00	0.29	34908
(8)	2138	REPOSIT	Repository regions outside of Panel region	SAT_WICK	Index for computing wicking	UNIFORM	NONE	5.0000E-01	5.0000E-01	0	1.0000E+00	0.29	33289
9	2334	CL_L_T1	Lower Salado clay: 0 to 10 years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31908
(9)	2335	CL_L_T1	Lower Salado clay: 0 to 10 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31909

[1] For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median[1]	Low	High	Standard Deviation	WPO #
(9)	2336	CL_L_T1	Lower Salado clay: 0 to 10 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31910
(9)	3009	CLAY_RUS	Clay seals in Rustler formation	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31886
(9)	3010	CLAY_RUS	Clay seals in Rustler formation	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31887
(9)	3011	CLAY_RUS	Clay seals in Rustler formation	PRMZLOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31888
(9)	2351	CL_L_T2	Lower Salado clay: 10 to 25 years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31935
(9)	2352	CL_L_T2	Lower Salado clay: 10 to 25 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31936
(9)	2353	CL_L_T2	Lower Salado clay: 10 to 25 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31937
(9)	2368	CL_L_T3	Lower Salado clay: 25 to 50 years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31990
(9)	2369	CL_L_T3	Lower Salado clay: 25 to 50 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31992
(9)	2370	CL_L_T3	Lower Salado clay: 25 to 50 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31993
(9)	3078	CL_L_T4	Lower Salado clay: 50 to 10K years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32016
(9)	3079	CL_L_T4	Lower Salado clay: 50 to 10K years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32017
(9)	3080	CL_L_T4	Lower Salado clay: 50 to 10K years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32018
(9)	2385	CL_M_T1	Upper Salado clay: 0 to 10 years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32048
(9)	2386	CL_M_T1	Upper Salado clay: 0 to 10 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32049
(9)	2387	CL_M_T1	Upper Salado clay: 0 to 10 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32050
(9)	2402	CL_M_T2	Upper Salado clay: 10 to 25 years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32123
(9)	2403	CL_M_T2	Upper Salado clay: 10 to 25 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32124
(9)	2404	CL_M_T2	Upper Salado clay: 10 to 25 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32125
(9)	2419	CL_M_T3	Upper Salado clay: 25 to 50 years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32155

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
(9)	2420	CL_M_T3	Upper Salado clay: 25 to 50 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32156
(9)	2421	CL_M_T3	Upper Salado clay: 25 to 50 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32157
(9)	2436	CL_M_T4	Upper Salado clay: 50 to 100 years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32202
(9)	2437	CL_M_T4	Upper Salado clay: 50 to 100 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32203
(9)	2438	CL_M_T4	Upper Salado clay: 50 to 100 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32204
(9)	2453	CL_M_T5	Upper Salado clay: 100 to 10K years	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32239
(9)	2454	CL_M_T5	Upper Salado clay: 100 to 10K years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32240
(9)	2455	CL_M_T5	Upper Salado clay: 100 to 10K years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	32241
(9)	2317	CLAY_BOT	Shaft Bottom Clay	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31866
(9)	2318	CLAY_BOT	Shaft Bottom Clay	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31867
(9)	2319	CLAY_BOT	Shaft Bottom Clay Upper Salado clay: 0 to 10 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8867E+01	-1.8301E+01	-2.1000E+01	-1.7301E+01	0.78	31868
10	**2470**	**CONC_T1**	**Concrete column: 0 to 400 years**	**PRMX_LOG**	**Log of intrinsic permeability, X-direction**	**TRIANGULAR**	**log(m^2)**	**-1.8816E+01**	**-1.8750E+01**	**-2.0699E+01**	**-1.7000E+01**	**0.76**	**32583**
(10)	2471	CONC_T1	Concrete column: 0 to 400 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.8816E+01	-1.8750E+01	-2.0699E+01	-1.7000E+01	0.76	32585
(10)	2472	CONC_T1	Concrete column: 0 to 400 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.8816E+01	-1.8750E+01	-2.0699E+01	-1.7000E+01	0.76	32587
11	**2283**	**ASPHALT**	**Asphalt column**	**PRMX_LOG**	**Log of intrinsic permeability, X-direction**	**TRIANGULAR**	**log(m^2)**	**-1.9667E+01**	**-2.0000E+01**	**-2.1000E+01**	**-1.8000E+01**	**0.62**	**31390**
(11)	2284	ASPHALT	Asphalt column	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.9667E+01	-2.0000E+01	-2.1000E+01	-1.8000E+01	0.62	31391
(11)	2285	ASPHALT	Asphalt column	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.9667E+01	-2.0000E+01	-2.1000E+01	-1.8000E+01	0.62	31392
12	**3133**	**SHFT_DRZ**	**Shaft disturbed Rock Zone**	**PRMX_LOG**	**Log of intrinsic permeability, X-direction**	**TRIANGULAR**	**log(m^2)**	**-1.5333E+01**	**-1.5000E+01**	**-1.7000E+01**	**-1.4000E+01**	**0.62**	**36563**
13	**2939**	**SALT_T1**	**Shaft salt column compacted: time 0 to 10 years**	**CUMPROB**	**Cumulative Probability**	**UNIFORM**	**NONE**	**5.0000E-01**	**5.0000E-01**	**0**	**1.0000E+00**	**0.29**	**33361**

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
14	**2529**	**SALT_T1**	**Shaft salt column compacted: time 0 to 10 years**	**SAT_RGAS**	**Residual Gas Saturation**	**UNIFORM**	**NONE**	**2.0000E-01**	**2.0000E-01**	**0**	**4.0000E-01**	**0.12**	**33420**
(14)	2546	SALT_T2	Shaft salt column compacted: time 10 to 25 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	33393
(14)	2563	SALT_T3	Shaft salt column compacted: time 25 to 50 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	33447
(14)	2580	SALT_T4	Shaft salt column compacted: time 50 to 100 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	33565
(14)	2597	SALT_T5	Shaft salt column compacted: time 100 to 200 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	33628
(14)	2993	SALT_T6	Shaft salt column compacted: time 200 to 10K years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	33484
(14)	2512	EARTH	Earthen Fill	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32964
(14)	3015	CLAY_RUS	Clay seals in Rustler formation	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	31896
(14)	2343	CL_L_T1	Lower Salado clay: 0 to 10 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	31922
(14)	2360	CL_L_T2	Lower Salado clay: 10 to 25 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	31971
(14)	2377	CL_L_T3	Lower Salado clay: 25 to 50 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32005
(14)	3083	CL_L_T4	Lower Salado clay: 50 to 10K years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32027
(14)	2394	CL_M_T1	Upper Salado clay: 0 to 10 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32062
(14)	2411	CL_M_T2	Upper Salado clay: 10 to 25 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32137
(14)	2428	CL_M_T3	Upper Salado clay: 25 to 50 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32169
(14)	2445	CL_M_T4	Upper Salado clay: 50 to 100 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32226
(14)	2462	CL_M_T5	Upper Salado clay: 100 to 10K years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32255
(14)	2326	CLAY_BOT	Shaft Bottom Clay	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	31875

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
(14)	2479	CONC_T1	Concrete column: 0 to 400 years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32625
(14)	2495	CONC_T2	Concrete column: 400 to 10K years	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32678
(14)	3064	CONC_MON	Degraded concrete monolith at shaft base	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	32546
(14)	2292	ASPHALT	Asphalt column	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	2.0000E-01	0	4.0000E-01	0.12	31407
15	**2528**	**SALT_T1**	**Shaft salt column compacted: time 0 to 10 years**	**SAT_RBRN**	**Residual Brine Saturation**	**CUMULATIVE**	**NONE**	**2.5000E-01**	**2.0000E-01**	**0**	**6.0000E-01**	**0.18**	**33418**
(15)	2545	SALT_T2	Shaft salt column compacted: time 10 to 25 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	33391
(15)	2562	SALT_T3	Shaft salt column compacted: time 25 to 50 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	33446
(15)	2579	SALT_T4	Shaft salt column compacted: time 50 to 100 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	33564
(15)	2596	SALT_T5	Shaft salt column compacted: time 100 to 200 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	33626
(15)	2992	SALT_T6	Shaft salt column compacted: time 200 to 10K years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	33483
(15)	2511	EARTH	Earthen Fill	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32963
(15)	3014	CLAY_RUS	Clay seals in Rustler formation	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	31895
(15)	2342	CL_L_T1	Lower Salado clay: 0 to 10 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	31921
(15)	2359	CL_L_T2	Lower Salado clay: 10 to 25 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	31969
(15)	2376	CL_L_T3	Lower Salado clay: 25 to 50 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32004
(15)	3082	CL_L_T4	Lower Salado clay: 50 to 10K years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32025
(15)	2393	CL_M_T1	Upper Salado clay: 0 to 10 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32061

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
(15)	2410	CL_M_T2	Upper Salado clay: 10 to 25 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32136
(15)	2427	CL_M_T3	Upper Salado clay: 25 to 50 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32168
(15)	2444	CL_M_T4	Upper Salado clay: 50 to 100 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32225
(15)	2461	CL_M_T5	Upper Salado clay: 100 to 10K years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32254
(15)	2325	CLAY_BOT	Shaft Bottom Clay	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	31874A
(15)	2478	CONC_T1	Concrete column: 0 to 400 years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32623
(15)	2494	CONC_T2	Concrete column: 400 to 10K years	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32676
(15)	3063	CONC_MON	Degraded concrete monolith at shaft base	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	32542
(15)	2291	ASPHALT	Asphalt column	SAT_RBRN	Residual Brine Saturation	CUMULATIVE	NONE	2.5000E-01	2.0000E-01	0	6.0000E-01	0.18	31405
16	**2516**	**SALT_T1**	**Shaft salt column compacted: time 0 to 10 years**	**PORE_DIS**	**Brooks-Corey pore distribution parameter**	**CUMULATIVE**	**NONE**	**2.5200E+00**	**9.4000E-01**	**1.1000E-01**	**8.1000E+00**	**2.48**	**33380**
(16)	2550	SALT_T3	Shaft salt column compacted: time 25 to 50 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	33415
(16)	2567	SALT_T4	Shaft salt column compacted: time 50 to 100 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	33465
(16)	2533	SALT_T2	Shaft salt column compacted: time 10 to 25 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	33355
(16)	2809	SALT_T5	Shaft salt column compacted: time 100 to 200 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	33588
(16)	2989	SALT_T6	Shaft salt column compacted: time 200 to 10K years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	33655
(16)	2499	EARTH	Earthen Fill	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32923
(16)	3006	CLAY_RUS	Clay seals in Rustler formation	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	31883
(16)	2330	CL_L_T1	Lower Salado clay: 0 to 10 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	31904

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
(16)	2347	CL_L_T2	Lower Salado clay: 10 to 25 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	31931
(16)	2364	CL_L_T3	Lower Salado clay: 25 to 50 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	31982
(16)	3076	CL_L_T4	Lower Salado clay: 50 to 100 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32013
(16)	2381	CL_M_T1	Upper Salado clay: 0 to 10 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32044
(16)	2398	CL_M_T2	Upper Salado clay: 10 to 25 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32119
(16)	2415	CL_M_T3	Upper Salado clay: 25 to 50 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32146
(16)	2432	CL_M_T4	Upper Salado clay: 50 to 100 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32198
(16)	2449	CL_M_T5	Upper Salado clay: 100 to 10K years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32235
(16)	2313	CLAY_BOT	Shaft Bottom Clay	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	31862
(16)	2466	CONC_T1	Concrete column: 0 to 400 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32570
(16)	2466	CONC_T1	Concrete column: 0 to 400 years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32570
(16)	2483	CONC_T2	Concrete column: 400 to 10K years	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32658
(16)	3057	CONC_MON	Degraded concrete monolith at shaft base	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	32514
(16)	2279	ASPHALT	Asphalt column	POR_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.5200E+00	9.4000E-01	1.1000E-01	8.1000E+00	2.48	31386
17	**544**	**S_HALITE**	**Salado halite, intact**	**POROSITY**	**Effective porosity**	**CUMULATIVE**	**NONE**	**1.2800E-02**	**1.0000E-02**	**1.0000E-03**	**3.0000E-02**	**0.01**	**34387**
18	**547**	**S_HALITE**	**Salado halite, intact**	**PRMX_LOG**	**Log of intrinsic permeability, X-direction**	***UNIFORM***	***log(m^2)***	***-2.2500E+01***	***-2.2500E+01***	***-2.4000E+01***	***-2.1000E+01***	***0.87***	***34397A***
(18)	548	S_HALITE	Salado halite, intact	PRMY_LOG	Log of intrinsic permeability, Y-direction	UNIFORM	log(m^2)	-2.2500E+01	-2.2500E+01	-2.4000E+01	-2.1000E+01	0.87	34399A
(18)	549	S_HALITE	Salado halite, intact	PRMZ_LOG	Log of intrinsic permeability, Z-direction	UNIFORM	log(m^2)	-2.2500E+01	-2.2500E+01	-2.4000E+01	-2.1000E+01	0.87	34401A
19	**541**	**S_HALITE**	**Salado halite, intact**	**COMP_RCK**	**Bulk Compressibility**	**UNIFORM**	**Pa^-1**	**9.7500E-11**	**9.7500E-11**	**2.9400E-12**	**1.9200E-10**	**0**	**34210**
20	**591**	**S_MB139**	**Salado MB139, intact and fractured**	**PRMX_LOG**	**Log of intrinsic permeability, X-direction**	**STUDENT'S-T**	log(m^2)	**-1.8890E+01**	**-1.8890E+01**	**-2.1000E+01**	**-1.7100E+01**	**1.20**	**34865**

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
(20)	592	S_MB139	Salado MB139, intact and fractured	PRMY_LOG	Log of intrinsic permeability, Y-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34866
(20)	593	S_MB139	Salado MB139, intact and fractured	PRMZ_LOG	Log of intrinsic permeability, Z-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34868
(20)	531	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PRMX_LOG	Log of intrinsic permeability, X-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34196
(20)	532	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PRMY_LOG	Log of intrinsic permeability, Y-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34197
(20)	533	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PRMZ_LOG	Log of intrinsic permeability, Z-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34198
(20)	570	S_MB138	Salado MB138, intact and fractured	PRMX_LOG	Log of intrinsic permeability, X-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34536
(20)	571	S_MB138	Salado MB138, intact and fractured	PRMY_LOG	Log of intrinsic permeability, Y-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34537
(20)	572	S_MB138	Salado MB138, intact and fractured	PRMZ_LOG	Log of intrinsic permeability, Z-direction	STUDENT'S-T	log(m^2)	-1.8890E+01	-1.8890E+01	-2.1000E+01	-1.7100E+01	1.20	34538
21	**580**	**S_MB139**	**Salado MB139, intact and fractured**	**COMP_RCK**	**Bulk Compressibility**	**STUDENT'S-T**	**Pa^-1**	**8.2630E-11**	**8.2630E-11**	**1.0900E-11**	**2.7500E-10**	**0**	**34574**
(21)	521	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	COMP_RCK	Bulk Compressibility	STUDENT'S-T	Pa^-1	8.2630E-11	8.2630E-11	1.0900E-11	2.7500E-10	0	34135
(21)	560	S_MB138	Salado MB138, intact and fractured	COMP_RCK	Bulk Compressibility	STUDENT'S-T	Pa^-1	8.2630E-11	8.2630E-11	1.0900E-11	2.7500E-10	0	34439
22	**596**	**S_MB139**	**Salado MB139, intact and fractured**	**RELP_MOD**	**Model number, relative permeability model**	**DELTA**	**NONE**	**n.a.**	**n.a.**	**1**	**4**	**n.a.**	**34500**
(22)	536	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	RELP_MOD	Model number, relative permeability model	DELTA	NONE	n.a.	n.a.	1	4	n.a.	34201
(22)	575	S_MB138	Salado MB138, intact and fractured	RELP_MOD	Model number, relative permeability model	DELTA	NONE	n.a.	n.a.	1	4	n.a.	34542
23	**598**	**S_MB139**	**Salado MB139, intact and fractured**	**SAT_RBRN**	**Residual Brine Saturation**	**STUDENT'S-T**	**NONE**	**8.3630E-02**	**8.3630E-02**	**7.8460E-03**	**1.7400E-01**	**0.05**	**34506**
(23)	538	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	SAT_RBRN	Residual Brine Saturation	STUDENT'S-T	NONE	8.3630E-02	8.3630E-02	7.8460E-03	1.7400E-01	0.05	34203

[1] For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
(23)	577	S_MB138	Salado MB138, intact and fractured	SAT_RBRN	Residual Brine Saturation	STUDENT'S-T	NONE	8.3630E-02	8.3630E-02	7.8460E-03	1.7400E-01	0.05	34545
24	**599**	**S_MB139**	**Salado MB139, intact and fractured**	**SAT_RGAS**	**Residual Gas Saturation**	**STUDENT'S-T**	**NONE**	**7.7110E-02**	**7.7110E-02**	**1.3980E-02**	**1.9719E-01**	**0.06**	**34508**
(24)	539	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	SAT_RGAS	Residual Gas Saturation	STUDENT'S-T	NONE	7.7110E-02	7.7110E-02	1.3980E-02	1.9719E-01	0.06	34204
(24)	578	S_MB138	Salado MB138, intact and fractured	SAT_RGAS	Residual Gas Saturation	STUDENT'S-T	NONE	7.7110E-02	7.7110E-02	1.3980E-02	1.9719E-01	0.06	34546
25	**587**	**S_MB139**	**Salado MB139, intact and fractured**	***PORE_DIS***	**Brooks-Corey pore distribution parameter**	***STUDENT'S-T***	***NONE***	***6.4360E-01***	***6.4360E-01***	***4.9053E-01***	***8.4178E-01***	***0.11***	***34859***
(25)	527	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	POR_DIS	Brooks-Corey pore distribution parameter	STUDENT'S-T	NONE	6.4360E-01	6.4360E-01	4.9053E-01	8.4178E-01	0.11	34192
(25)	566	S_MB138	Salado MB138, intact and fractured	POR_DIS	Brooks-Corey pore distribution parameter	STUDENT'S-T	NONE	6.4360E-01	6.4360E-01	4.9053E-01	8.4178E-01	0.11	34527
26	**546**	**S_HALITE**	**Salado halite, intact**	**PRESSURE**	**Brine far-field pore pressure**	**UNIFORM**	**Pa**	**1.2470E+07**	**1.2470E+07**	**1.1040E+07**	**1.3890E+07**	**823000.00**	**34394**
27	**66**	**CASTILER**	**Castile Brine Reservoir**	**PRESSURE**	**Brine far-field pore pressure**	**TRIANGULAR**	**Pa**	**1.3600E+07**	**1.2700E+07**	**1.1100E+07**	**1.7000E+07**	**1245700.00**	**31612A**
28	**67**	**CASTILER**	**Castile Brine Reservoir**	**PRMX_LOG**	**Log of intrinsic permeability, X-direction**	**TRIANGULAR**	**log(m^2)**	**-1.2100E+01**	**-1.1800E+01**	**-1.4700E+01**	**-9.8000E+00**	**1.01**	**31613**
(28)	68	CASTILER	Castile Brine Reservoir	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.2100E+01	-1.1800E+01	-1.4700E+01	-9.8000E+00	1.01	31614
(28)	69	CASTILER	Castile Brine Reservoir	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.2100E+01	-1.1800E+01	-1.4700E+01	-9.8000E+00	1.01	31615
29	**61**	**CASTILER**	**Castile Brine Reservoir**	**COMP_RCK**	**Bulk Compressibility**	**TRIANGULAR**	**log(Pa^-1)**	**-9.8000E+00**	**-1.0000E+01**	**-1.1300E+01**	**-8.0000E+00**	**0.68**	**31561**
30	**3184**	**BH_SAND**	**Borehole filled with silty sand**	**PRMX_LOG**	**Log of intrinsic permeability, X-direction**	**UNIFORM**	**log(m^2)**	**-1.2500E+01**	**-1.2500E+01**	**-1.4000E+01**	**-1.1000E+01**	**0.87**	**36641**
(30)	3190	BH_SAND	Borehole filled with silty sand	PRMY_LOG	Log of intrinsic permeability, Y-direction	UNIFORM	log(m^2)	-1.2500E+01	-1.2500E+01	-1.4000E+01	-1.1000E+01	0.87	36654
(30)	3191	BH_SAND	Borehole filled with silty sand	PRMZ_LOG	Log of intrinsic permeability, Z-direction	UNIFORM	log(m^2)	-1.2500E+01	-1.2500E+01	-1.4000E+01	-1.1000E+01	0.87	36655
31	**3194**	**CASTILER**	**Castile Brine Reservoir**	**GRIDFLO**	**Index for selecting a Brine Pocket**	**DELTA**	**NONE**	**n.a.**	**n.a.**	**1**	**32**	**n.a.**	**36658A**
32	**3246**	**BLOWOUT**	**BRAGFLO Direct Brine Releases**	**PARTDIA**	**Logarithm of waste particle diameter in CUTTINGS model**	**LOGUNIFORM**	**m**	**2.3500E-02**	**2.8000E-03**	**4.0000E-05**	**2.0000E-01**	**0.04**	**37088**

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median	Low	High	Standard Deviation	WPO #
33	2254	BOREHOLE	Borehole and Fill	TAUFAIL	Effective shear strength for erosion (rfail)	UNIFORM	Pa	5.0300E+00	5.0300E+00	5.0000E-02	1.0000E+01	2.90	31536
34	3419	CULEBRA	Culebra member of the Rustler formation	MINP_FAC	Mining Transmissivity Multiplier	UNIFORM	NONE	5.0050E+02	5.0050E+02	1.0000E+00	1.0000E+03	288.40	37666
35	225	GLOBAL	Information that applies globally	TRANSIDX	Index for selecting realizations of the Transmissivity Field	UNIFORM	NONE	5.0000E-01	5.0000E-01	0.0000E+00	1.0000E+00	0.29	33055
36	3262	SOLAM3	Solubility of Americium in oxidation state III	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37105A
37	3263	SOLAM3	Solubility of Americium in oxidation state III	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37106A
38	3265	SOLPU3	Solubility of Plutonium in oxidation state III	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37109A
39	3264	SOLPU3	Solubility of Plutonium in oxidation state III	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37108A
40	3266	SOLPU4	Solubility of Plutonium in oxidation state IV	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37110A
41	3389	SOLPU4	Solubility of Plutonium in oxidation state IV	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37111A
42	3390	SOLU4	Solubility of Uranium in oxidation state IV	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37112A
43	3391	SOLU6	Solubility of Uranium in oxidation state VI	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37113A

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-10. Parameters Sampled in LHS Code (and parameters to which sampled values were applied) (Continued)

LHS #	Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Mean	Median[1]	Low	High	Standard Deviation	WPO #
44	3392	SOLU6	Solubility of Uranium in oxidation state VI	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37114A
45	3393	SOLTH4	Solubility of Thorium in oxidation state IV	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	1.8000E-01	-9.0000E-02	-2.0000E+00	1.4000E+00	0.37	37115A
46	3429	PHUMOX3	Proportionality constant with humic colloids for actinide in oxidation state III	PHUMCIM	Proportionality constant of actinides incastile brine w/ humic colloids, inorgan	CUMULATIVE	moles/liter	1.1000E+00	1.3700E+00	6.5000E-02	1.6000E+00	0.47	37683
47	3417	GLOBAL	Information that applies globally	OXSTAT	Index for Oxidation Solubilities	UNIFORM	NONE	5.0000E-01	5.0000E-01	0.0000E+00	1.0000E+00	0.29	37663
48	223	GLOBAL	Information that applies globally	CLIMTIDX	Climate Index	CUMULATIVE	NONE	1.3100E+00	1.1700E+00	1.0000E+00	2.2500E+00	0.35	33031
49	3485	CULEBRA	Culebra member of the Rustler formation	HMBLKLT	Culebra Half Matrix-Block Length	UNIFORM	m	2.7500E-01	2.7500E-01	5.0000E-02	5.0000E-01	0.13	38356
50	3487	CULEBRA	Culebra member of the Rustler formation	APOROS	Culebra Advective Porosity	LOGUNIFORM	NONE	2.1000E-03	1.0000E-03	1.0000E-04	1.0000E-02	0	38358
51	3486	CULEBRA	Culebra member of the Rustler formation	DPOROS	Diffusive Porosity for Culebra Dolomite	CUMULATIVE	NONE	1.6000E-01	1.6000E-01	1.0000E-01	2.5000E-01	0.04	38357
52	3475	U+6	Uranium VI	MKD_U	Matrix Distribution Coefficient for Uranium	UNIFORM	m^3/kg	1.5000E-02	1.5000E-02	3.0000E-05	3.0000E-02	0.01	38346
53	3479	U+4	Uranium IV	MKD_U	Matrix Distribution Coefficient for Uranium	UNIFORM	m^3/kg	1.0000E+01	1.0000E+01	9.0000E-01	2.0000E+01	5.50	38350
54	3480	PU+3	Plutonium III	MKD_PU	Matrix Distribution Coefficient for Plutonium	UNIFORM	m^3/kg	2.6000E-01	2.6000E-01	2.0000E-02	5.0000E-01	0.14	38351
55	3481	PU+4	Plutonium IV	MKD_PU	Matrix Distribution Coefficient for Plutonium	UNIFORM	m^3/kg	1.0000E+01	1.0000E+01	9.0000E-01	2.0000E+01	5.50	38352
56	3478	TH+4	Thorium IV	MKD_TH	Matrix Distribution Coefficient for Thorium	UNIFORM	m^3/kg	1.0000E+01	1.0000E+01	9.0000E-01	2.0000E+01	5.50	38349
57	3482	AM+3	Americium III	MKD_AM	Matrix Distribution Coefficient for Americium	UNIFORM	m^3/kg	2.6000E-01	2.6000E-01	2.0000E-02	5.0000E-01	0.14	38353

[1]For parameters with a triangular distribution, the value provided for the median is actually the mode.

Table PAR-11. Borehole, Blowout, and Drill Mud Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
23	BOREHOLE	Borehole and Fill	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	31486
3242	BOREHOLE	Borehole and Fill	COLDIA	Drill collar diameter in CUTTINGS model	CONSTANT	m	2.0320E-01	37084
25	BOREHOLE	Borehole and Fill	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	2.6400E-09	31510
26	BOREHOLE	Borehole and Fill	DIAMMOD	Modern or current diameter	CONSTANT	m	3.1115E-01	31511
27	BOREHOLE	Borehole and Fill	DOMEGA	Drill string angular velocity (O)	CUMULATIVE	rad/s	7.8000E+00	31512
3239	BOREHOLE	Borehole and Fill	INV_AR	The area of the repository in the CUTTINGS model	CONSTANT	m^2	1.1152E+05	37081
3122	BOREHOLE	Borehole and Fill	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	36361
3244	BOREHOLE	Borehole and Fill	L1	Drill collar length in CUTTINGS model	CONSTANT	m	1.8288E+02	37086
3243	BOREHOLE	Borehole and Fill	L2	Drill pipe length when repository penetrated, CUTTINGS model	CONSTANT	m	4.7212E+02	37085
29	BOREHOLE	Borehole and Fill	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31514
3120	BOREHOLE	Borehole and Fill	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	5.6000E-01	36362
3121	BOREHOLE	Borehole and Fill	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4600E-01	36363
3241	BOREHOLE	Borehole and Fill	PIPED	Drill pipe diameter in CUTTINGS model	CONSTANT	m	1.1430E-01	37083
32	BOREHOLE	Borehole and Fill	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31523
30	BOREHOLE	Borehole and Fill	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	9.4000E-01	31521
31	BOREHOLE	Borehole and Fill	POROSITY	Effective porosity	CONSTANT	NONE	5.0000E-02	31522
33	BOREHOLE	Borehole and Fill	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	0.0000E+00	31524
34	BOREHOLE	Borehole and Fill	PRMX_LOG	Log of intrinsic permeability, X-direction	NORMAL	log(m^2)	-1.2500E+01	31525
35	BOREHOLE	Borehole and Fill	PRMY_LOG	Log of intrinsic permeability, Y-direction	NORMAL	log (m^2)	-1.2500E+01	31527
36	BOREHOLE	Borehole and Fill	PRMZ_LOG	Log of intrinsic permeability, Z-direction	NORMAL	log(m^2)	-1.2500E+01	31528
38	BOREHOLE	Borehole and Fill	PTINDEX	Index for computing uncertainty in threshold displacement pressure	UNIFORM	NONE	5.0000E-01	31530
40	BOREHOLE	Borehole and Fill	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31532
3261	BOREHOLE	Borehole and Fill	RHW_AR	The total area of the remote-handled waste in the CUTTINGS model	CONSTANT	m^2	1.5760E+04	37104
3240	BOREHOLE	Borehole and Fill	ROUGHP	Friction factor for very rough pipe in CUTTINGS model	CONSTANT	NONE	8.0000E-02	37082
41	BOREHOLE	Borehole and Fill	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	2.0000E-01	31533
42	BOREHOLE	Borehole and Fill	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	2.0000E-01	31535
3414	BOREHOLE	Borehole and Fill	WUF	Unit of Waste	CONSTANT	Curies	4.0700E+00	37137
3259	BLOWOUT	BRAGFLO Direct Brine Releases	APORO	Waste permeability in CUTTINGS model	CONSTANT	m^2	1.7E-13	37102
3245	BLOWOUT	BRAGFLO Direct Brine Releases	CEMENT	Waste Cementation Strength	CONSTANT	Pa	6895	37087
3420	BLOWOUT	BRAGFLO Direct Brine Releases	FCE	Cementation Scaling Factor	CONSTANT	NONE	1	37668

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-11. Borehole, Blowout, and Drill Mud Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3256	BLOWOUT	BRAGFLO Direct Brine Releases	FGE	Gravity effectiveness factor in CUTTINGS model	CONSTANT	NONE	18.1	37098
3255	BLOWOUT	BRAGFLO Direct Brine Releases	FSE	Stress effectiveness factor in CUTTINGS model	CONSTANT	NONE	0	37097
3470	BLOWOUT	BRAGFLO Direct Brine Releases	GAS_MIN	Gas rate cut-off	CONSTANT	mscf/day	100	38209
3250	BLOWOUT	BRAGFLO Direct Brine Releases	HREPO	Height of repository at burial time in CUTTINGS model	CONSTANT	m	3.96	37092
3260	BLOWOUT	BRAGFLO Direct Brine Releases	INPORO	Default value for initial repository porosity in CUTTINGS model	CONSTANT	NONE	0.849	37103
3254	BLOWOUT	BRAGFLO Direct Brine Releases	KGAS	Ratio of specific heats for Hydrogen in CUTTINGS model	CONSTANT	NONE	1.41	37096
3471	BLOWOUT	BRAGFLO Direct Brine Releases	MAXFLOW	Maximum blowout flow	CONSTANT	s	950400	38210
3472	BLOWOUT	BRAGFLO Direct Brine Releases	MINFLOW	Minimum blowout flow	CONSTANT	s	259200	38211
3246	BLOWOUT	BRAGFLO Direct Brine Releases	PARTDIA	Logarithm of waste particle diameter in CUTTINGS model	LOGUNIFORM	m	0.0028	37088
3251	BLOWOUT	BRAGFLO Direct Brine Releases	PSUF	Surface atmospheric pressure at elevation 1,039 meters in CUTTINGS model	CONSTANT	Pa	89465	37093
3456	BLOWOUT	BRAGFLO Direct Brine Releases	RE_CAST	External drainage radius for the Castile formation	CONSTANT	m	114	38208
3253	BLOWOUT	BRAGFLO Direct Brine Releases	RGAS	Gas Constant for Hydrogen	CONSTANT	N*m/kg/degK	4116	37095
3247	BLOWOUT	BRAGFLO Direct Brine Releases	RHOS	Waste Particle Density in CUTTING_S Model	CONSTANT	kg/m^3	2650	37089
3248	BLOWOUT	BRAGFLO Direct Brine Releases	ROOM	Equivalent radius of one room in CUTTINGS model	CONSTANT	m	17.1	37090
3249	BLOWOUT	BRAGFLO Direct Brine Releases	RPANEL	Equivalent radius of one panel in CUTTINGS model	CONSTANT	m	60.87	37091
3257	BLOWOUT	BRAGFLO Direct Brine Releases	SUFTEN	Surface tension of brine in CUTTINGS model	CONSTANT	N/m	0.08	37100
3473	BLOWOUT	BRAGFLO Direct Brine Releases	THCK_CAS	Thickness of the Castile formation	CONSTANT	m	12.34	38213
3258	BLOWOUT	BRAGFLO Direct Brine Releases	TREPO	Temperature of repository in CUTTINGS model	CONSTANT	K	300	37101
3252	BLOWOUT	BRAGFLO Direct Brine Releases	VISC	Hydrogen viscosity in CUTTINGS model	CONSTANT	Pa*s	0.0000092	37[illegible]

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-12. Borehole (Concrete Plug) Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3150	CONC_PLG	Concrete Plug, surface and Rustler	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	36593
3148	CONC_PLG	Concrete Plug, surface and Rustler	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^1	1.2000E-09	36591
3156	CONC_PLG	Concrete Plug, surface and Rustler	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	36600
3151	CONC_PLG	Concrete Plug, surface and Rustler	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	36595
3157	CONC_PLG	Concrete Plug, surface and Rustler	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	36601
3158	CONC_PLG	Concrete Plug, surface and Rustler	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	36603
3155	CONC_PLG	Concrete Plug, surface and Rustler	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36599
3154	CONC_PLG	Concrete Plug, surface and Rustler	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	9.4000E-01	36598
3147	CONC_PLG	Concrete Plug, surface and Rustler	POROSITY	Effective porosity	CONSTANT	NONE	3.2000E-01	36589
3185	CONC_PLG	Concrete Plug, surface and Rustler	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.6301E+01	36642
3192	CONC_PLG	Concrete Plug, surface and Rustler	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.6301E+01	36656
3193	CONC_PLG	Concrete Plug, surface and Rustler	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.6301E+01	36657
3149	CONC_PLG	Concrete Plug, surface and Rustler	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	36592
3152	CONC_PLG	Concrete Plug, surface and Rustler	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	36596
3153	CONC_PLG	Concrete Plug, surface and Rustler	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	36597

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-13. Borehole (Open) Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3138	BH_OPEN	Borehole Unrestricted	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	36568
3136	BH_OPEN	Borehole Unrestricted	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	0.0000E+00	36566
3144	BH_OPEN	Borehole Unrestricted	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	36585
3139	BH_OPEN	Borehole Unrestricted	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	36569
3145	BH_OPEN	Borehole Unrestricted	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	36586
3146	BH_OPEN	Borehole Unrestricted	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	36588
3143	BH_OPEN	Borehole Unrestricted	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36584
3142	BH_OPEN	Borehole Unrestricted	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	36572
3135	BH_OPEN	Borehole Unrestricted	POROSITY	Effective porosity	CONSTANT	NONE	3.2000E-01	36565
3134	BH_OPEN	Borehole Unrestricted	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-9.0000E+00	36564
3186	BH_OPEN	Borehole Unrestricted	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-9.0000E+00	36649
3187	BH_OPEN	Borehole Unrestricted	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-9.0000E+00	36650
3137	BH_OPEN	Borehole Unrestricted	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	5.0000E+00	36567
3140	BH_OPEN	Borehole Unrestricted	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	36570
3141	BH_OPEN	Borehole Unrestricted	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	36571

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-14. Borehole (Silty Sand) Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3162	BH_SAND	Borehole filled with silty sand	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	36612
3160	BH_SAND	Borehole filled with silty sand	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	0.0000E+00	36610
3424	BH_SAND	Borehole filled with silty sand	CUMPROB1	Distributed Sampling Parameter 1	UNIFORM	NONE	5.0000E-01	37677
3425	BH_SAND	Borehole filled with silty sand	CUMPROB2	Distributed Sampling Parameter 2	UNIFORM	NONE	5.0000E-01	37678
3426	BH_SAND	Borehole filled with silty sand	CUMPROB3	Distributed Sampling Parameter 3	UNIFORM	NONE	5.0000E-01	37679
3427	BH_SAND	Borehole filled with silty sand	CUMPROB4	Distributed Sampling Parameter 4	UNIFORM	NONE	5.0000E-01	37680
3428	BH_SAND	Borehole filled with silty sand	CUMPROB5	Distributed Sampling Parameter 5	UNIFORM	NONE	5.0000E-01	38781
3168	BH_SAND	Borehole filled with silty sand	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	36619
3163	BH_SAND	Borehole filled with silty sand	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	36613
3169	BH_SAND	Borehole filled with silty sand	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	36620
3170	BH_SAND	Borehole filled with silty sand	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	36621
3423	BH_SAND	Borehole filled with silty sand	PMLOG_HI	Permeability Distribution - High	CONSTANT	Log(m^2)	-1.1000E+01	37675
3422	BH_SAND	Borehole filled with silty sand	PMLOG_LO	Permeability Distribution - Low	CONSTANT	Log(m^2)	-1.4000E+01	37672
3167	BH_SAND	Borehole filled with silty sand	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36617
3166	BH_SAND	Borehole filled with silty sand	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	9.4000E-01	36616
3159	BH_SAND	Borehole filled with silty sand	POROSITY	Effective porosity	CONSTANT	NONE	3.2000E-01	36605
3161	BH_SAND	Borehole filled with silty sand	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	36611
3164	BH_SAND	Borehole filled with silty sand	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	36614
3165	BH_SAND	Borehole filled with silty sand	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	36615

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-15. Borehole (Creep) Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3174	BH_CREEP	Creep Borehole Fill	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	36627
3172	BH_CREEP	Creep Borehole Fill	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	0.0000E+00	36625
3180	BH_CREEP	Creep Borehole Fill	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	36636
3175	BH_CREEP	Creep Borehole Fill	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	36628
3181	BH_CREEP	Creep Borehole Fill	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	36637
3182	BH_CREEP	Creep Borehole Fill	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	36639
3179	BH_CREEP	Creep Borehole Fill	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36634
3178	BH_CREEP	Creep Borehole Fill	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	9.4000E-01	36633
3171	BH_CREEP	Creep Borehole Fill	POROSITY	Effective porosity	CONSTANT	NONE	3.2000E-01	36624
3173	BH_CREEP	Creep Borehole Fill	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	36626
3176	BH_CREEP	Creep Borehole Fill	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	36630
3177	BH_CREEP	Creep Borehole Fill	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	36631

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-16. Earthen Fill Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2497	EARTH	Earthen Fill	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	3.1000E-08	32918
2706	EARTH	Earthen Fill	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32919
2498	EARTH	Earthen Fill	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32922
2501	EARTH	Earthen Fill	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32925
2500	EARTH	Earthen Fill	POROSITY	Effective porosity	CONSTANT	m^3/m^3	3.2000E-01	32924
2502	EARTH	Earthen Fill	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32926
2503	EARTH	Earthen Fill	PRMX_LOG	Log of intrinsic permeability, X-direction	TRIANGULAR	log(m^2)	-1.4000E+01	32927
2504	EARTH	Earthen Fill	PRMY_LOG	Log of intrinsic permeability, Y-direction	TRIANGULAR	log(m^2)	-1.4000E+01	32928
2505	EARTH	Earthen Fill	PRMZ_LOG	Log of intrinsic permeability, Z-direction	TRIANGULAR	log(m^2)	-1.4000E+01	32944
2509	EARTH	Earthen Fill	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32952
3032	EARTH	Earthen Fill	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32954
3035	EARTH	Earthen Fill	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32956
3033	EARTH	Earthen Fill	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32957
3034	EARTH	Earthen Fill	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32959

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-17. Rustler Compacted Clay Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3001	CLAY_RUS	Clay seals in Rustler formation	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.9600E-09	31878
3002	CLAY_RUS	Clay seals in Rustler formation	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31879
3003	CLAY_RUS	Clay seals in Rustler formation	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31882
3131	CLAY_RUS	Clay seals in Rustler formation	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36561
3007	CLAY_RUS	Clay seals in Rustler formation	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	31884
3008	CLAY_RUS	Clay seals in Rustler formation	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31885
3012	CLAY_RUS	Clay seals in Rustler formation	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31889
2996	CLAY_RUS	Clay seals in Rustler formation	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	31890
2999	CLAY_RUS	Clay seals in Rustler formation	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	31891
2997	CLAY_RUS	Clay seals in Rustler formation	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	31892
2998	CLAY_RUS	Clay seals in Rustler formation	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	31893

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-18. Asphalt Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2277	ASPHALT	Asphalt column	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	2.9700E-08	31380
3238	ASPHALT	Asphalt column	DNSGRAIN	Material Grain Density	CONSTANT	kg/m^3	2.0222E+03	36760
2599	ASPHALT	Asphalt column	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31381
2278	ASPHALT	Asphalt column	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31385
2281	ASPHALT	Asphalt column	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31388
2280	ASPHALT	Asphalt column	POROSITY	Effective porosity	CONSTANT	m^3/m^3	1.0000E-02	31387
2282	ASPHALT	Asphalt column	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31389
2933	ASPHALT	Asphalt column	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.6290E+00	31395
2289	ASPHALT	Asphalt column	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31397
2929	ASPHALT	Asphalt column	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	31399
2932	ASPHALT	Asphalt column	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	31400
2930	ASPHALT	Asphalt column	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	31401
2931	ASPHALT	Asphalt column	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	31402
2290	ASPHALT	Asphalt column	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	0.0000E+00	31403

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-19. Concrete Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2464	CONC_T1	Concrete column: 0 to 400 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^1	1.2000E-09	32556
2681	CONC_T1	Concrete column: 0 to 400 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32559
2465	CONC_T1	Concrete column: 0 to 400 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32567
2468	CONC_T1	Concrete column: 0 to 400 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32576
2467	CONC_T1	Concrete column: 0 to 400 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	32572
2469	CONC_T1	Concrete column: 0 to 400 years	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32580
3040	CONC_T1	Concrete column: 0 to 400 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	32600
2476	CONC_T1	Concrete column: 0 to 400 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32605
3036	CONC_T1	Concrete column: 0 to 400 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32607
3039	CONC_T1	Concrete column: 0 to 400 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32608
3037	CONC_T1	Concrete column: 0 to 400 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32609
3038	CONC_T1	Concrete column: 0 to 400 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32617
2481	CONC_T2	Concrete column: 400 to 10K years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^1	1.2000E-09	32638
2686	CONC_T2	Concrete column: 400 to 10K years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32640
2482	CONC_T2	Concrete column: 400 to 10K years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32657
2808	CONC_T2	Concrete column: 400 to 10K years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32660
2484	CONC_T2	Concrete column: 400 to 10K years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	32659
2485	CONC_T2	Concrete column: 400 to 10K years	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32661
2486	CONC_T2	Concrete column: 400 to 10K years	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.4000E+01	32662
2487	CONC_T2	Concrete column: 400 to 10K years	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.4000E+01	32663
3045	CONC_T2	Concrete column: 400 to 10K years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	32667
2492	CONC_T2	Concrete column: 400 to 10K years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32669
3041	CONC_T2	Concrete column: 400 to 10K years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32670
3044	CONC_T2	Concrete column: 400 to 10K years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32671
3042	CONC_T2	Concrete column: 400 to 10K years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32672
3043	CONC_T2	Concrete column: 400 to 10K years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32673

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-20. Compacted Salt Shaft Material Parameter

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2514	SALT_T1	Shaft salt column compacted: time 0 to 10 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.6000E-09	33359
2744	SALT_T1	Shaft salt column compacted: time 0 to 10 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33364
2515	SALT_T1	Shaft salt column compacted: time 0 to 10 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33373
2942	SALT_T1	Shaft salt column compacted: time 0 to 10 years	PMLT_HI	Log triangular distribution high value for permeability	CONSTANT	log(m^2)	-1.2265E+01	33375
2941	SALT_T1	Shaft salt column compacted: time 0 to 10 years	PMLT_LO	Log triangular distribution low value for permeability	CONSTANT	log(m^2)	-1.7301E+01	33377
2940	SALT_T1	Shaft salt column compacted: time 0 to 10 years	PMLT_MD	Log triangular distribution mode for permeability	CONSTANT	log(m^2)	-1.4783E+01	33378
2518	SALT_T1	Shaft salt column compacted: time 0 to 10 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33382
2517	SALT_T1	Shaft salt column compacted: time 0 to 10 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	33381
2519	SALT_T1	Shaft salt column compacted: time 0 to 10 years	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	33386
2938	SALT_T1	Shaft salt column compacted: time 0 to 10 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.8140E+00	33401
2526	SALT_T1	Shaft salt column compacted: time 0 to 10 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33405
2934	SALT_T1	Shaft salt column compacted: time 0 to 10 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	33407
2937	SALT_T1	Shaft salt column compacted: time 0 to 10 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	33410
2935	SALT_T1	Shaft salt column compacted: time 0 to 10 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	33411
2936	SALT_T1	Shaft salt column compacted: time 0 to 10 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	33413
2531	SALT_T2	Shaft salt column compacted: time 10 to 25 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.6000E-09	33429
2749	SALT_T2	Shaft salt column compacted: time 10 to 25 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33431
2532	SALT_T2	Shaft salt column compacted: time 10 to 25 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33438
2950	SALT_T2	Shaft salt column compacted: time 10 to 25 years	PMLT_HI	Log triangular distribution high value for permeability	CONSTANT	log(m^2)	-1.2265E+01	33440
2949	SALT_T2	Shaft salt column compacted: time 10 to 25 years	PMLT_LO	Log triangular distribution low value for permeability	CONSTANT	log(m^2)	-1.7301E+01	33442
2948	SALT_T2	Shaft salt column compacted: time 10 to 25 years	PMLT_MD	Log triangular distribution mode for permeability	CONSTANT	log(m^2)	-1.4783E+01	33445
2535	SALT_T2	Shaft salt column compacted: time 10 to 25 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33362
2534	SALT_T2	Shaft salt column compacted: time 10 to 25 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	33357
2947	SALT_T2	Shaft salt column compacted: time 10 to 25 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.1100E+00	33374
2543	SALT_T2	Shaft salt column compacted: time 10 to 25 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33379
2943	SALT_T2	Shaft salt column compacted: time 10 to 25 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	33383
2946	SALT_T2	Shaft salt column compacted: time 10 to 25 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	33384
2944	SALT_T2	Shaft salt column compacted: time 10 to 25 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	33385
2945	SALT_T2	Shaft salt column compacted: time 10 to 25 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	33387
2548	SALT_T3	Shaft salt column compacted: time 25 to 50 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.6000E-09	33400
2754	SALT_T3	Shaft salt column compacted: time 25 to 50 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33402
2549	SALT_T3	Shaft salt column compacted: time 25 to 50 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33408
2958	SALT_T3	Shaft salt column compacted: time 25 to 50 years	PMLT_HI	Log triangular distribution high value for permeability	CONSTANT	log(m^2)	-1.2265E+01	33409
2957	SALT_T3	Shaft salt column compacted: time 25 to 50 years	PMLT_LO	Log triangular distribution low value for permeability	CONSTANT	log(m^2)	-1.7301E+01	33412

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-20. Compacted Salt Shaft Material Parameter (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2956	SALT_T3	Shaft salt column compacted: time 25 to 50 years	PMLT_MD	Log triangular distribution mode for permeability	CONSTANT	log(m^2)	-1.4783E+01	33414
2552	SALT_T3	Shaft salt column compacted: time 25 to 50 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33419
2551	SALT_T3	Shaft salt column compacted: time 25 to 50 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	33417
2955	SALT_T3	Shaft salt column compacted: time 25 to 50 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	33432
2560	SALT_T3	Shaft salt column compacted: time 25 to 50 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33436
2951	SALT_T3	Shaft salt column compacted: time 25 to 50 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	33437
2954	SALT_T3	Shaft salt column compacted: time 25 to 50 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	33439
2952	SALT_T3	Shaft salt column compacted: time 25 to 50 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	33441
2953	SALT_T3	Shaft salt column compacted: time 25 to 50 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	33443
2565	SALT_T4	Shaft salt column compacted: time 50 to 100 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.6000E-09	33453
2759	SALT_T4	Shaft salt column compacted: time 50 to 100 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33454
2566	SALT_T4	Shaft salt column compacted: time 50 to 100 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33459
2966	SALT_T4	Shaft salt column compacted: time 50 to 100 years	PMLT_HI	Log triangular distribution high value for permeability	CONSTANT	log(m^2)	-1.3951E+01	33460
2965	SALT_T4	Shaft salt column compacted: time 50 to 100 years	PMLT_LO	Log triangular distribution low value for permeability	CONSTANT	log(m^2)	-2.2876E+01	33461
2964	SALT_T4	Shaft salt column compacted: time 50 to 100 years	PMLT_MD	Log triangular distribution mode for permeability	CONSTANT	log(m^2)	-1.7166E+01	33463
2569	SALT_T4	Shaft salt column compacted: time 50 to 100 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33469
2568	SALT_T4	Shaft salt column compacted: time 50 to 100 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	33467
2963	SALT_T4	Shaft salt column compacted: time 50 to 100 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	33540
2577	SALT_T4	Shaft salt column compacted: time 50 to 100 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33553
2959	SALT_T4	Shaft salt column compacted: time 50 to 100 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	33556
2962	SALT_T4	Shaft salt column compacted: time 50 to 100 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	33558
2960	SALT_T4	Shaft salt column compacted: time 50 to 100 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	33560
2961	SALT_T4	Shaft salt column compacted: time 50 to 100 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	33561
2582	SALT_T5	Shaft salt column compacted: time 100 to 200 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.6000E-09	33572
2764	SALT_T5	Shaft salt column compacted: time 100 to 200 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33573
2583	SALT_T5	Shaft salt column compacted: time 100 to 200 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33579
2974	SALT_T5	Shaft salt column compacted: time 100 to 200 years	PMLT_HI	Log triangular distribution high value for permeability	CONSTANT	log(m^2)	-1.5426E+01	33581
2973	SALT_T5	Shaft salt column compacted: time 100 to 200 years	PMLT_LO	Log triangular distribution low value for permeability	CONSTANT	log(m^2)	-2.2876E+01	33583
2972	SALT_T5	Shaft salt column compacted: time 100 to 200 years	PMLT_MD	Log triangular distribution mode for permeability	CONSTANT	log(m^2)	-1.9278E+01	33585
3125	SALT_T5	Shaft salt column compacted: time 100 to 200 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36368
2585	SALT_T5	Shaft salt column compacted: time 100 to 200 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	33590
2971	SALT_T5	Shaft salt column compacted: time 100 to 200 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	33609
2594	SALT_T5	Shaft salt column compacted: time 100 to 200 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33614
2967	SALT_T5	Shaft salt column compacted: time 100 to 200 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	33616
2970	SALT_T5	Shaft salt column compacted: time 100 to 200 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	33618

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-20. Compacted Salt Shaft Material Parameter (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2968	SALT_T5	Shaft salt column compacted: time 100 to 200 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	33620
2969	SALT_T5	Shaft salt column compacted: time 100 to 200 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	33622
2984	SALT_T6	Shaft salt column compacted: time 200 to 10K years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.6000E-09	33635
2985	SALT_T6	Shaft salt column compacted: time 200 to 10K years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33640
2986	SALT_T6	Shaft salt column compacted: time 200 to 10K years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33647
2982	SALT_T6	Shaft salt column compacted: time 200 to 10K years	PMLT_HI	Log triangular distribution high value for permeability	CONSTANT	log(m^2)	-1.7668E+01	33648
2981	SALT_T6	Shaft salt column compacted: time 200 to 10K years	PMLT_LO	Log triangular distribution low value for permeability	CONSTANT	log(m^2)	-2.2876E+01	33650
2980	SALT_T6	Shaft salt column compacted: time 200 to 10K years	PMLT_MD	Log triangular distribution mode for permeability	CONSTANT	log(m^2)	-2.0272E+01	33651
3126	SALT_T6	Shaft salt column compacted: time 200 to 10K years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36369
2990	SALT_T6	Shaft salt column compacted: time 200 to 10K years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	33657
3119	SALT_T6	Shaft salt column compacted: time 200 to 10K years	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	33475
2979	SALT_T6	Shaft salt column compacted: time 200 to 10K years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	33476
2991	SALT_T6	Shaft salt column compacted: time 200 to 10K years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33478
2975	SALT_T6	Shaft salt column compacted: time 200 to 10K years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	33479
2978	SALT_T6	Shaft salt column compacted: time 200 to 10K years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	33480
2976	SALT_T6	Shaft salt column compacted: time 200 to 10K years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	33481
2977	SALT_T6	Shaft salt column compacted: time 200 to 10K years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	33482

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-21. Upper Clay Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2379	CL_M_T1	Upper Salado clay: 0 to 10 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.8100E-09	32039
2656	CL_M_T1	Upper Salado clay: 0 to 10 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32040
2380	CL_M_T1	Upper Salado clay: 0 to 10 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32043
2383	CL_M_T1	Upper Salado clay: 0 to 10 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32046
2382	CL_M_T1	Upper Salado clay: 0 to 10 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	32045
2384	CL_M_T1	Upper Salado clay: 0 to 10 years	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32047
3088	CL_M_T1	Upper Salado clay: 0 to 10 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.7090E+00	32053
2391	CL_M_T1	Upper Salado clay: 0 to 10 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32055
3084	CL_M_T1	Upper Salado clay: 0 to 10 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32056
3087	CL_M_T1	Upper Salado clay: 0 to 10 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32057
3085	CL_M_T1	Upper Salado clay: 0 to 10 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32058
3086	CL_M_T1	Upper Salado clay: 0 to 10 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32059
2396	CL_M_T2	Upper Salado clay: 10 to 25 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.8100E-09	32066
2661	CL_M_T2	Upper Salado clay: 10 to 25 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32067
2397	CL_M_T2	Upper Salado clay: 10 to 25 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32118
2400	CL_M_T2	Upper Salado clay: 10 to 25 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32121
2399	CL_M_T2	Upper Salado clay: 10 to 25 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	32120
3093	CL_M_T2	Upper Salado clay: 10 to 25 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.4690E+00	32128
2408	CL_M_T2	Upper Salado clay: 10 to 25 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32130
3089	CL_M_T2	Upper Salado clay: 10 to 25 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32131
3092	CL_M_T2	Upper Salado clay: 10 to 25 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32132
3090	CL_M_T2	Upper Salado clay: 10 to 25 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32133
3091	CL_M_T2	Upper Salado clay: 10 to 25 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32134
2413	CL_M_T3	Upper Salado clay: 25 to 50 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.8100E-09	32141
2666	CL_M_T3	Upper Salado clay: 25 to 50 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32142
2414	CL_M_T3	Upper Salado clay: 25 to 50 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32145
2417	CL_M_T3	Upper Salado clay: 25 to 50 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32150
2416	CL_M_T3	Upper Salado clay: 25 to 50 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	32148
3098	CL_M_T3	Upper Salado clay: 25 to 50 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.2830E+00	32160
2425	CL_M_T3	Upper Salado clay: 25 to 50 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32162
3094	CL_M_T3	Upper Salado clay: 25 to 50 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32163
3097	CL_M_T3	Upper Salado clay: 25 to 50 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32164
3095	CL_M_T3	Upper Salado clay: 25 to 50 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32165
3096	CL_M_T3	Upper Salado clay: 25 to 50 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32166

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-21. Upper Clay Shaft Material Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2430	CL_M_T4	Upper Salado clay: 50 to 100 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.8100E-09	32193
2671	CL_M_T4	Upper Salado clay: 50 to 100 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32194
2431	CL_M_T4	Upper Salado clay: 50 to 100 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32197
2434	CL_M_T4	Upper Salado clay: 50 to 100 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32200
2433	CL_M_T4	Upper Salado clay: 50 to 100 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	32199
2923	CL_M_T4	Upper Salado clay: 50 to 100 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.1070E+00	32207
2442	CL_M_T4	Upper Salado clay: 50 to 100 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32209
2919	CL_M_T4	Upper Salado clay: 50 to 100 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32212
2922	CL_M_T4	Upper Salado clay: 50 to 100 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32213
2920	CL_M_T4	Upper Salado clay: 50 to 100 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32214
2921	CL_M_T4	Upper Salado clay: 50 to 100 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32215
2447	CL_M_T5	Upper Salado clay: 100 to 10K years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.8100E-09	32230
2676	CL_M_T5	Upper Salado clay: 100 to 10K years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32231
2448	CL_M_T5	Upper Salado clay: 100 to 10K years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32234
2451	CL_M_T5	Upper Salado clay: 100 to 10K years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32237
2450	CL_M_T5	Upper Salado clay: 100 to 10K years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	32236
2928	CL_M_T5	Upper Salado clay: 100 to 10K years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	32245
2459	CL_M_T5	Upper Salado clay: 100 to 10K years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32248
2924	CL_M_T5	Upper Salado clay: 100 to 10K years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32249
2927	CL_M_T5	Upper Salado clay: 100 to 10K years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32250
2925	CL_M_T5	Upper Salado clay: 100 to 10K years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32251
2926	CL_M_T5	Upper Salado clay: 100 to 10K years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32252

[1] COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the *effective porosity.*

Table PAR-22. Lower Clay Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2328	CL_L_T1	Lower Salado clay: 0 to 10 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.5900E-09	31899
2641	CL_L_T1	Lower Salado clay: 0 to 10 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31900
2329	CL_L_T1	Lower Salado clay: 0 to 10 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31903
2332	CL_L_T1	Lower Salado clay: 0 to 10 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31906
2331	CL_L_T1	Lower Salado clay: 0 to 10 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	31905
2333	CL_L_T1	Lower Salado clay: 0 to 10 years	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31907
3021	CL_L_T1	Lower Salado clay: 0 to 10 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.8580E+00	31913
2340	CL_L_T1	Lower Salado clay: 0 to 10 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31915
3017	CL_L_T1	Lower Salado clay: 0 to 10 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	31916
3020	CL_L_T1	Lower Salado clay: 0 to 10 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	31917
3018	CL_L_T1	Lower Salado clay: 0 to 10 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	31918
3019	CL_L_T1	Lower Salado clay: 0 to 10 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	31919
2345	CL_L_T2	Lower Salado clay: 10 to 25 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.5900E-09	31926
2646	CL_L_T2	Lower Salado clay: 10 to 25 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31927
2346	CL_L_T2	Lower Salado clay: 10 to 25 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31930
2349	CL_L_T2	Lower Salado clay: 10 to 25 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31933
2348	CL_L_T2	Lower Salado clay: 10 to 25 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	31932
3026	CL_L_T2	Lower Salado clay: 10 to 25 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.1620E+00	31959
2357	CL_L_T2	Lower Salado clay: 10 to 25 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31962
3022	CL_L_T2	Lower Salado clay: 10 to 25 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	31964
3025	CL_L_T2	Lower Salado clay: 10 to 25 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	31965
3023	CL_L_T2	Lower Salado clay: 10 to 25 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	31966
3024	CL_L_T2	Lower Salado clay: 10 to 25 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	31967
2362	CL_L_T3	Lower Salado clay: 25 to 50 years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.5900E-09	31976
2651	CL_L_T3	Lower Salado clay: 25 to 50 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31978
2363	CL_L_T3	Lower Salado clay: 25 to 50 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31981
2366	CL_L_T3	Lower Salado clay: 25 to 50 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31985
2365	CL_L_T3	Lower Salado clay: 25 to 50 years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	31984
3031	CL_L_T3	Lower Salado clay: 25 to 50 years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0020E+00	31996
2374	CL_L_T3	Lower Salado clay: 25 to 50 years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31998
3027	CL_L_T3	Lower Salado clay: 25 to 50 years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	31999
3030	CL_L_T3	Lower Salado clay: 25 to 50 years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32000
3028	CL_L_T3	Lower Salado clay: 25 to 50 years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32001
3029	CL_L_T3	Lower Salado clay: 25 to 50 years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32002
3071	CL_L_T4	Lower Salado clay: 50 to 10K years	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.5900E-09	32008

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-22. Lower Clay Shaft Material Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3072	CL_L_T4	Lower Salado clay: 50 to 10K years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32009
3073	CL_L_T4	Lower Salado clay: 50 to 10K years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32012
3123	CL_L_T4	Lower Salado clay: 50 to 10K years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36366
3077	CL_L_T4	Lower Salado clay: 50 to 10K years	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	32014
3069	CL_L_T4	Lower Salado clay: 50 to 10K years	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	32019
3081	CL_L_T4	Lower Salado clay: 50 to 10K years	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32020
3065	CL_L_T4	Lower Salado clay: 50 to 10K years	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32021
3068	CL_L_T4	Lower Salado clay: 50 to 10K years	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32022
3066	CL_L_T4	Lower Salado clay: 50 to 10K years	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32023
3067	CL_L_T4	Lower Salado clay: 50 to 10K years	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32024

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-23. Bottom Clay Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2311	CLAY_BOT	Shaft Bottom Clay	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	1.5900E-09	31857
2636	CLAY_BOT	Shaft Bottom Clay	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31858
2312	CLAY_BOT	Shaft Bottom Clay	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31861
2315	CLAY_BOT	Shaft Bottom Clay	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31864
2314	CLAY_BOT	Shaft Bottom Clay	POROSITY	Effective porosity	CONSTANT	m^3/m^3	2.4000E-01	31863
2316	CLAY_BOT	Shaft Bottom Clay	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31865
2323	CLAY_BOT	Shaft Bottom Clay	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31872

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-24. Concrete Monolith Shaft Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3052	CONC_MON	Concrete monolith at shaft base	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^1	1.2000E-09	32504
3053	CONC_MON	Concrete monolith at shaft base	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32507
3054	CONC_MON	Concrete monolith at shaft base	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32512
3124	CONC_MON	Concrete monolith at shaft base	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	36367
3058	CONC_MON	Concrete monolith at shaft base	POROSITY	Effective porosity	CONSTANT	m^3/m^3	5.0000E-02	32516
3114	CONC_MON	Concrete monolith at shaft base	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32518
3059	CONC_MON	Concrete monolith at shaft base	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.4000E+01	32520
3060	CONC_MON	Concrete monolith at shaft base	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.4000E+01	32522
3061	CONC_MON	Concrete monolith at shaft base	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.4000E+01	32527
3050	CONC_MON	Concrete monolith at shaft base	RADN_DRZ	DRZ outer radius at each shaft	CONSTANT	m/m	1.0000E+00	32528
3062	CONC_MON	Concrete monolith at shaft base	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32530
3046	CONC_MON	Concrete monolith at shaft base	RSH_AIR	Air-supply shaft radius (3.09 m)	CONSTANT	m	3.0900E+00	32532
3049	CONC_MON	Concrete monolith at shaft base	RSH_EXH	Air-exhaust shaft radius (2.3 m)	CONSTANT	m	2.3000E+00	32534
3047	CONC_MON	Concrete monolith at shaft base	RSH_SAL	Salt-handling shaft radius (1.8 m)	CONSTANT	m	1.8000E+00	32537
3048	CONC_MON	Concrete monolith at shaft base	RSH_WAS	Waste-handling shaft radius (3.5 m)	CONSTANT	m	3.5000E+00	32538

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-25. Santa Rosa Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
336	SANTAROS	Santa Rosa Formation	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	33485
337	SANTAROS	Santa Rosa Formation	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	1.0000E-08	33487
2768	SANTAROS	Santa Rosa Formation	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33510
339	SANTAROS	Santa Rosa Formation	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33530
2769	SANTAROS	Santa Rosa Formation	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	33528
2770	SANTAROS	Santa Rosa Formation	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	33529
342	SANTAROS	Santa Rosa Formation	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33543
340	SANTAROS	Santa Rosa Formation	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	6.4360E-01	33538
341	SANTAROS	Santa Rosa Formation	POROSITY	Effective porosity	CONSTANT	NONE	1.7500E-01	33542
343	SANTAROS	Santa Rosa Formation	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	33544
344	SANTAROS	Santa Rosa Formation	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.0000E+01	33545
345	SANTAROS	Santa Rosa Formation	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.0000E+01	33546
346	SANTAROS	Santa Rosa Formation	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.0000E+01	33547
349	SANTAROS	Santa Rosa Formation	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33550
350	SANTAROS	Santa Rosa Formation	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	8.3630E-02	33552
351	SANTAROS	Santa Rosa Formation	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	8.3630E-02	33554
352	SANTAROS	Santa Rosa Formation	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	7.7110E-02	33557

Table PAR-26. Dewey Lake Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
154	DEWYLAKE	Dewey Lake Red Beds	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	1.0000E-08	32802
2696	DEWYLAKE	Dewey Lake Red Beds	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32703
156	DEWYLAKE	Dewey Lake Red Beds	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32728
159	DEWYLAKE	Dewey Lake Red Beds	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32732
157	DEWYLAKE	Dewey Lake Red Beds	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	6.4360E-01	32730
158	DEWYLAKE	Dewey Lake Red Beds	POROSITY	Effective porosity	STUDENT'S-T	NONE	1.4300E-01	32731
160	DEWYLAKE	Dewey Lake Red Beds	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32733
161	DEWYLAKE	Dewey Lake Red Beds	PRMX_LOG	Log of intrinsic permeability, x-direction	CONSTANT	log(m^2)	-1.6300E+01	32734
162	DEWYLAKE	Dewey Lake Red Beds	PRMY_LOG	Log of intrinsic permeability, y-direction	CONSTANT	log(m^2)	-1.6300E+01	32735
163	DEWYLAKE	Dewey Lake Red Beds	PRMZ_LOG	Log of intrinsic permeability, z-direction	CONSTANT	log(m^2)	-1.6300E+01	32736
166	DEWYLAKE	Dewey Lake Red Beds	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32739
167	DEWYLAKE	Dewey Lake Red Beds	SAL_USAT	Average saturation, unsaturated zones	CONSTANT	NONE	8.3600E-02	32740
168	DEWYLAKE	Dewey Lake Red Beds	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	32741
169	DEWYLAKE	Dewey Lake Red Beds	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	8.3630E-02	32742
170	DEWYLAKE	Dewey Lake Red Beds	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	7.7110E-02	32743

Table PAR-27. Forty-Niner Member of the Rustler Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2085	FORTYNIN	Forty Niner Member	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	32975
2238	FORTYNIN	Forty Niner Member	COMP_RCK	Bulk Compressibility	*CONSTANT*	*Pa^-1*	*0.0000E+00*	32979
2715	FORTYNIN	Forty Niner Member	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32982
2239	FORTYNIN	Forty Niner Member	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32989
2716	FORTYNIN	Forty Niner Member	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	32984
2717	FORTYNIN	Forty Niner Member	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	32986
2718	FORTYNIN	Forty Niner Member	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32997
2087	FORTYNIN	Forty Niner Member	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	32991
2088	FORTYNIN	Forty Niner Member	POROSITY	Effective porosity	STUDENT'S-T	NONE	8.2000E-02	32995
2899	FORTYNIN	Forty Niner Member	PRMX_LOG	Log of intrinsic permeability, x-direction	CONSTANT	log(m^2)	-3.5000E+01	33002
2900	FORTYNIN	Forty Niner Member	PRMY_LOG	Log of intrinsic permeability, y-direction	CONSTANT	log(m^2)	-3.5000E+01	33008
2901	FORTYNIN	Forty Niner Member	PRMZ_LOG	Log of intrinsic permeability, z-direction	CONSTANT	log(m^2)	-3.5000E+01	33010
2093	FORTYNIN	Forty Niner Member	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33019
2240	FORTYNIN	Forty Niner Member	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	2.0000E-01	33022
2094	FORTYNIN	Forty Niner Member	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	2.0000E-01	33024

Table PAR-28. Magenta Member of the Rustler Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2097	MAGENTA	Magenta Member	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	33239
3016	MAGENTA	Magenta Member	COMP_RCK	Bulk Compressibility	STUDENT'S-T	Pa^-1	2.6440E-10	33249
2725	MAGENTA	Magenta Member	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33254
2098	MAGENTA	Magenta Member	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33263
2726	MAGENTA	Magenta Member	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	2.6000E-01	33257
2727	MAGENTA	Magenta Member	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4800E-01	33261
2728	MAGENTA	Magenta Member	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32536
2099	MAGENTA	Magenta Member	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	6.4360E-01	32493
2100	MAGENTA	Magenta Member	POROSITY	Effective porosity	STUDENT'S-T	NONE	1.3800E-01	32531
2101	MAGENTA	Magenta Member	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	9.1700E+05	32539
2102	MAGENTA	Magenta Member	PRMX_LOG	Log of intrinsic permeability, x-direction	CONSTANT	log(m^2)	-1.5200E+01	32545
2103	MAGENTA	Magenta Member	PRMY_LOG	Log of intrinsic permeability, y-direction	CONSTANT	log(m^2)	-1.5200E+01	32547
2104	MAGENTA	Magenta Member	PRMZ_LOG	Log of intrinsic permeability, z-direction	CONSTANT	log(m^2)	-1.5200E+01	32550
2106	MAGENTA	Magenta Member	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32557
2241	MAGENTA	Magenta Member	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	8.3630E-02	32560
2107	MAGENTA	Magenta Member	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	7.7110E-02	32562
2109	MAGENTA	Magenta Member	THICK	Thickness of feature or layer	CONSTANT		8.5000E+00	32568

Table PAR-29. Tamarisk Member of the Rustler Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2183	TAMARISK	Tamarisk Member	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	34524
2243	TAMARISK	Tamarisk Member	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	34529
2793	TAMARISK	Tamarisk Member	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	34558
2244	TAMARISK	Tamarisk Member	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	34563
2794	TAMARISK	Tamarisk Member	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	34560
2795	TAMARISK	Tamarisk Member	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	34562
2796	TAMARISK	Tamarisk Member	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	34571
2185	TAMARISK	Tamarisk Member	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	34565
2186	TAMARISK	Tamarisk Member	POROSITY	Effective porosity	STUDENT'S-T	NONE	6.4000E-02	34568
2914	TAMARISK	Tamarisk Member	PRMX_LOG	Log of intrinsic permeability, x-direction	CONSTANT	log(m^2)	-3.5000E+01	34580
2915	TAMARISK	Tamarisk Member	PRMY_LOG	Log of intrinsic permeability, y-direction	CONSTANT	log(m^2)	-3.5000E+01	34583
2916	TAMARISK	Tamarisk Member	PRMZ_LOG	Log of intrinsic permeability, z-direction	CONSTANT	log(m^2)	-3.5000E+01	34586
2191	TAMARISK	Tamarisk Member	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	34588
2245	TAMARISK	Tamarisk Member	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	2.0000E-01	34589
2192	TAMARISK	Tamarisk Member	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	2.0000E-01	34591

Table PAR-30. Culebra Member of the Rustler Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
119	CULEBRA	Culebra member of the Rustler formation	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	32686
120	CULEBRA	Culebra member of the Rustler formation	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	1.0000E-10	32688
3483	CULEBRA	Culebra member of the Rustler formation	DISP_L	Longitudinal dispersivity	CONSTANT	m	0.0000E+00	38354
3484	CULEBRA	Culebra member of the Rustler formation	DISPT_L	Transverse dispersivity	CONSANT	m	0.0000E+00	38355
843	CULEBRA	Culebra member of the Rustler formation	DNSGRAIN	Material Grain Density	CONSTANT	kg/m^3	2.8200E+03	32689
3474	CULEBRA	Culebra member of the Rustler formation	DTORT	Diffusive Tortuosity	CONSTANT	NONE	1.1000E-01	38345
3462	CULEBRA	Culebra member of the Rustler formation	ETHICK	Effective Thickness	CONSTANT	m	4.0000E+00	37727
861	CULEBRA	Culebra member of the Rustler formation	FTORT	Fracture Tortuosity	CONSTANT	NONE	1.0000E+00	32541
2691	CULEBRA	Culebra member of the Rustler formation	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32555
3418	CULEBRA	Culebra member of the Rustler formation	MEA_STOR	Measured Storativity	CONSTANT	NONE	1.0000E-05	37664
137	CULEBRA	Culebra member of the Rustler formation	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32755
2692	CULEBRA	Culebra member of the Rustler formation	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	2.6000E-01	32752
2693	CULEBRA	Culebra member of the Rustler formation	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4800E-01	32753
141	CULEBRA	Culebra member of the Rustler formation	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32772
139	CULEBRA	Culebra member of the Rustler formation	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	6.4360E-01	32764
140	CULEBRA	Culebra member of the Rustler formation	POROSITY	Effective porosity	CONSTANT	NONE	1.5100E-01	32769
142	CULEBRA	Culebra member of the Rustler formation	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	8.2200E+05	32774
143	CULEBRA	Culebra member of the Rustler formation	PRMX_LOG	Log of intrinsic permeability, x-direction	CONSTANT	log(m^2)	-1.3678E+01	32775
144	CULEBRA	Culebra member of the Rustler formation	PRMY_LOG	Log of intrinsic permeability, y-direction	CONSTANT	log(m^2)	-1.3678E+01	32776
145	CULEBRA	Culebra member of the Rustler formation	PRMZ_LOG	Log of intrinsic permeability, z-direction	CONSTANT	log(m^2)	-1.3678E+01	32777
148	CULEBRA	Culebra member of the Rustler formation	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32780
149	CULEBRA	Culebra member of the Rustler formation	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	32781
150	CULEBRA	Culebra member of the Rustler formation	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	8.3630E-02	32782
151	CULEBRA	Culebra member of the Rustler formation	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	7.7110E-02	32783
3469	CULEBRA	Culebra member of the Rustler formation	SKIN_RES	Skin Resistance	CONSTANT	NONE	0.0000E+00	37735

Table PAR-31. Unnamed Lower Member of the Rustler Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2217	UNNAMED	Unnamed Lower Member of Rustler Formation	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	34684
2218	UNNAMED	Unnamed Lower Member of Rustler Formation	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	34686
2799	UNNAMED	Unnamed Lower Member of Rustler Formation	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	34687
2247	UNNAMED	Unnamed Lower Member of Rustler Formation	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	34690
2800	UNNAMED	Unnamed Lower Member of Rustler Formation	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	34688
2801	UNNAMED	Unnamed Lower Member of Rustler Formation	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	34689
2802	UNNAMED	Unnamed Lower Member of Rustler Formation	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	34693
2219	UNNAMED	Unnamed Lower Member of Rustler Formation	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	34691
2220	UNNAMED	Unnamed Lower Member of Rustler Formation	POROSITY	Effective porosity	STUDENT'S-T	NONE	1.8100E-01	34692
2911	UNNAMED	Unnamed Lower Member of Rustler Formation	PRMX_LOG	Log of intrinsic permeability, x-direction	CONSTANT	log(m^2)	-3.5000E+01	34695
2912	UNNAMED	Unnamed Lower Member of Rustler Formation	PRMY_LOG	Log of intrinsic permeability, y-direction	CONSTANT	log(m^2)	-3.5000E+01	34697
2913	UNNAMED	Unnamed Lower Member of Rustler Formation	PRMZ_LOG	Log of intrinsic permeability, z-direction	CONSTANT	log(m^2)	-3.5000E+01	34699
2225	UNNAMED	Unnamed Lower Member of Rustler Formation	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	34701
2248	UNNAMED	Unnamed Lower Member of Rustler Formation	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	2.0000E-01	34702
2226	UNNAMED	Unnamed Lower Member of Rustler Formation	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	2.0000E-01	34703

Table PAR-32. Salado Formation - Intact Halite - Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
540	S_HALITE	Salado halite, intact	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	34208
1703	S_HALITE	Salado halite, intact	DNSGRAIN	Material Grain Density	CONSTANT	kg/m^3	0.0000E+00	34211
2778	S_HALITE	Salado halite, intact	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	34233
1724	S_HALITE	Salado halite, intact	MDISP_L	Longitudinal Matrix Dispersivity	CONSTANT	m	1.0000E+02	34234
1725	S_HALITE	Salado halite, intact	MDISP_T	Transverse Matrix Dispersivity	CONSTANT	m	5.0000E+00	34235
542	S_HALITE	Salado halite, intact	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	34379
2779	S_HALITE	Salado halite, intact	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	5.6000E-01	34375
2780	S_HALITE	Salado halite, intact	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4600E-01	34377
545	S_HALITE	Salado halite, intact	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	34391
543	S_HALITE	Salado halite, intact	PORE_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	7.0000E-01	34385
553	S_HALITE	Salado halite, intact	RELP_MOD	Model number, relative permeability model	DELTA	NONE	4.0000E+00	34412
554	S_HALITE	Salado halite, intact	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	34416
555	S_HALITE	Salado halite, intact	SAT_RBRN	Residual Brine Saturation	UNIFORM	NONE	3.0000E-01	34418
556	S_HALITE	Salado halite, intact	SAT_RGAS	Residual Gas Saturation	UNIFORM	NONE	2.0000E-01	34420
1742	S_HALITE	Salado halite, intact	TORTUSTY	Matrix Tortuosity	CONSTANT	NONE	1.0000E+01	34428

Table PAR-33. Salado Formation - Brine - Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
48	BRINESAL	Salado Brine	COMPRES	Brine Compressibility	CONSTANT	Pa^-1	3.1000E-10	31540
49	BRINESAL	Salado Brine	DNSFLUID	Brine Density	CONSTANT	kg/m^3	1.2200E+03	31541
50	BRINESAL	Salado Brine	REF_PRES	Reference pressure for porosity	CONSTANT	Pa	1.0133E+05	31542
51	BRINESAL	Salado Brine	REF_TEMP	Reference Temperature	CONSTANT	K	3.0015E+02	31543
52	BRINESAL	Salado Brine	RSLOPE	Constant in solubility-versus-pressure model	CONSTANT	NONE	0.0000E+00	31544
55	BRINESAL	Salado Brine	VISCO	Viscosity of H2 gas at 27 degrees Celsius and 0.101325 MPa	CONSTANT	Pa*s	2.1000E-03	31548
57	BRINESAL	Salado Brine	WTF	Mass fraction of salt in brine	STUDENT'S-T	NONE	3.2400E-01	31552

Table PAR-34. Salado Formation - Marker Bed 138 - Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2904	S_MB138	Salado MB138, intact and fractured	BKLINK	Klinkenberg b correction parameters for H2 gas	CONSTANT	Pa	2.7100E-01	34429
559	S_MB138	Salado MB138, intact and fractured	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	34430
1743	S_MB138	Salado MB138, intact and fractured	DNSGRAIN	Material Grain Density	CONSTANT	kg/m^3	2.7500E+03	34441
2169	S_MB138	Salado MB138, intact and fractured	DPHIMAX	Incremental increase in porosity relative to intact conditions	CONSTANT	NONE	3.9000E-02	34442
2902	S_MB138	Salado MB138, intact and fractured	EXPKLINK	Klinkenberg b correction parameters for H2 gas	CONSTANT	NONE	-3.4100E-01	34443
2810	S_MB138	Salado MB138, intact and fractured	IFRX	Index for fracture perm. enhancement in X-direction	CONSTANT	NONE	1.0000E+00	34465
2813	S_MB138	Salado MB138, intact and fractured	IFRY	Index for fracture perm. enhancement in Y-direction	CONSTANT	NONE	1.0000E+00	34466
2816	S_MB138	Salado MB138, intact and fractured	IFRZ	Index for fracture perm. enhancement in Z-direction	CONSTANT	NONE	0.0000E+00	34471
2170	S_MB138	Salado MB138, intact and fractured	KMAXLOG	Log of maximum permeability in altered anhydrite flow model anhydrites	CONSTANT	log (m**2)	-9.0000E+00	34476
2783	S_MB138	Salado MB138, intact and fractured	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	34479
561	S_MB138	Salado MB138, intact and fractured	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	34512
2784	S_MB138	Salado MB138, intact and fractured	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	2.6000E-01	34505
2785	S_MB138	Salado MB138, intact and fractured	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4800E-01	34507
563	S_MB138	Salado MB138, intact and fractured	PF_DELTA	Incremental pressure for full fracture development	CONSTANT	Pa	3.8000E+06	34516
565	S_MB138	Salado MB138, intact and fractured	PI_DELTA	Fracture initiation pressure increment	CONSTANT	Pa	2.0000E+05	34523
568	S_MB138	Salado MB138, intact and fractured	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	34531
567	S_MB138	Salado MB138, intact and fractured	POROSITY	Effective porosity	STUDENT'S-T	NONE	1.1000E-02	34530
576	S_MB138	Salado MB138, intact and fractured	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	34544

Table PAR-35. Salado Formation - Marker Bed 139 - Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2905	S_MB139	Salado MB139, intact and fractured	BKLINK	Klinkenberg b correction parameters for H2 gas	CONSTANT	Pa	2.7100E-01	34557
579	S_MB139	Salado MB139, intact and fractured	CAP_MOD	*Model number, capillary pressure model*	CONSTANT	NONE	2.0000E+00	34559
1784	S_MB139	Salado MB139, intact and fractured	DNSGRAIN	Material Grain Density	CONSTANT	kg/m^3	2.7500E+03	34579
2177	S_MB139	Salado MB139, intact and fractured	DPHIMAX	Incremental increase in porosity relative to intact conditions	CONSTANT	NONE	3.9000E-02	34582
2903	S_MB139	Salado MB139, intact and fractured	EXPKLINK	Klinkenberg b correction parameters for H2 gas	CONSTANT	NONE	-3.4100E-01	34799
2811	S_MB139	Salado MB139, intact and fractured	IFRX	Index for fracture perm. enhancement in X-direction	CONSTANT	NONE	1.0000E+00	34818
2814	S_MB139	Salado MB139, intact and fractured	IFRY	Index for fracture perm. enhancement in Y-direction	CONSTANT	NONE	1.0000E+00	34819
2817	S_MB139	Salado MB139, intact and fractured	IFRZ	Index for fracture perm. enhancement in Z-direction	CONSTANT	NONE	0.0000E+00	34820
2178	S_MB139	Salado MB139, intact and fractured	KMAXLOG	Log of maximum permeability in altered anhydrite flow model anhydrites	CONSTANT	log (m**2)	-9.0000E+00	34823
2788	S_MB139	Salado MB139, intact and fractured	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	34825
582	S_MB139	Salado MB139, intact and fractured	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	34848
2789	S_MB139	Salado MB139, intact and fractured	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	2.6000E-01	34843
2790	S_MB139	Salado MB139, intact and fractured	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4800E-01	34844
2180	S_MB139	Salado MB139, intact and fractured	PF_DELTA	Incremental pressure for full fracture development	CONSTANT	Pa	3.8000E+06	34850
586	S_MB139	Salado MB139, intact and fractured	PI_DELTA	Fracture initiation pressure increment	CONSTANT	Pa	2.0000E+05	34856
589	S_MB139	Salado MB139, intact and fractured	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	34862
588	S_MB139	Salado MB139, intact and fractured	POROSITY	Effective porosity	STUDENT'S-T	NONE	1.1000E-02	34860
597	S_MB139	Salado MB139, intact and fractured	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	34503

Table PAR-36. Salado Formation - Anhydrite Beds a & b, Intact and Fractured - Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2819	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	BKLINK	Klinkenberg b correction parameters for H2 gas	CONSTANT	Pa	2.7100E-01	34129
520	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	34130
1661	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	DNSGRAIN	Material Grain Density	CONSTANT	kg/m^3	2.7500E+03	34137
2158	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	DPHIMAX	Incremental increase in porosity relative to intact conditions	CONSTANT	NONE	2.3900E-01	34138
2820	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	EXPKLINK	Klinkenberg b correction parameters for H2 gas	CONSTANT	NONE	-3.4100E-01	34139
2812	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	IFRX	Index for fracture perm. enhancement in X-direction	CONSTANT	NONE	1.0000E+00	34158
2815	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	IFRY	Index for fracture perm. enhancement in Y-direction	CONSTANT	NONE	1.0000E+00	34159
2818	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	IFRZ	Index for fracture perm. enhancement in Z-direction	CONSTANT	NONE	0.0000E+00	34160
2159	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	KMAXLOG	Log of maximum permeability in altered anhydrite flow model anhydrites	CONSTANT	log (m**2)	-9.0000E+00	34163
2773	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	34165
1684	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	MDISP_L	Longitudinal Matrix Dispersivity	CONSTANT	m	1.0000E+02	34166
1685	S_ANH_AB	Salado anhydrite beds a & b, intact and fractureSa	MDISP_T	Transverse Matrix Dispersivity	CONSTANT	m	5.0000E+00	34167
522	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	34185
2774	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	2.6000E-01	34183
2775	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4800E-01	34184
524	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PF_DELTA	Incremental pressure for full fracture development	CONSTANT	Pa	3.8000E+06	34187
526	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PI_DELTA	Fracture initiation pressure increment	CONSTANT	Pa	2.0000E+05	34190
529	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	34194
528	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	POROSITY	Effective porosity	STUDENT'S-T	NONE	1.1000E-02	34193
537	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	34202
1702	S_ANH_AB	Salado anhydrite beds a & b, intact and fractured	TORTUSTY	Matrix Tortuosity	CONSTANT	NONE	1.0000E+01	34207

Table PAR-37. Disturbed Rock Zone Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
174	DRZ_0	Disturbed rock zone; time period -5 to 0 years	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	32754
175	DRZ_0	Disturbed rock zone; time period -5 to 0 years	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	7.4100E-10	32758
2701	DRZ_0	Disturbed rock zone; time period -5 to 0 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32801
944	DRZ_0	Disturbed rock zone; time period -5 to 0 years	MDISP_L	Longitudinal Matrix Dispersivity	CONSTANT	m	1.0000E+02	32804
945	DRZ_0	Disturbed rock zone; time period -5 to 0 years	MDISP_T	Transverse Matrix Dispersivity	CONSTANT	m	5.0000E+00	32805
176	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32834
2702	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	32832
2703	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	32833
179	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32844
177	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	32837
181	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.7000E+01	32847
182	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.7000E+01	32849
183	DRZ_0	Disturbed rock zone; time period -5 to 0 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.7000E+01	32850
186	DRZ_0	Disturbed rock zone; time period -5 to 0 years	RELP_MOD	Model number, relative permeability model	DELTA	NONE	4.0000E+00	32856
187	DRZ_0	Disturbed rock zone; time period -5 to 0 years	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	32857
188	DRZ_0	Disturbed rock zone; time period -5 to 0 years	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	32860
189	DRZ_0	Disturbed rock zone; time period -5 to 0 years	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	32862

Table PAR-37. Disturbed Rock Zone Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2072	DRZ_0	Disturbed rock zone; time period -5 to 0 years	SP_S_LOG	Logarithm of specific storage	CONSTANT		-5.0000E+00	32866
962	DRZ_0	Disturbed rock zone; time period -5 to 0 years	TORTUSTY	Matrix Tortuosity	CONSTANT	NONE	1.0000E+01	32868
190	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	32869
191	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	7.4100E-10	32871
3116	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32870
193	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32899
3128	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	36559
3129	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	36560
196	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32903
194	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	32901
198	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.5000E+01	32905
199	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.5000E+01	32906
200	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.5000E+01	32907
203	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	RELP_MOD	Model number, relative permeability model	DELTA	NONE	4.0000E+00	32910
205	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	32912
206	DRZ_1	Disturbed rock zone; time period 0 to 1000 years	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	32913

Table PAR-38. Waste Area and Waste Material Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
651	WAS_AREA	Waste emplacement area and waste	ABSROUGH	Absolute roughness of material	UNIFORM	m	2.5000E-02	34980
652	WAS_AREA	Waste emplacement area and waste	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	34982
3454	WAS_AREA	Waste emplacement area and waste	CLOSMOD	Closure Surface Model	CONSTANT	NONE	4.0000E+00	38200
653	WAS_AREA	Waste emplacement area and waste	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	34987
2041	WAS_AREA	Waste emplacement area and waste	DCELLCHW	Average density of cellulosics in CH-TRU waste	CONSTANT	kg/m^3	5.4000E+01	32464
2274	WAS_AREA	Waste emplacement area and waste	DCELLRHW	Average density of cellulosics in RH-TRU waste	CONSTANT	kg/m^3	1.7000E+01	32465
1992	WAS_AREA	Waste emplacement area and waste	DIRNCCHW	Bulk density of iron containers, CH-TRU waste	CONSTANT	kg/m^3	1.3900E+02	32466
1993	WAS_AREA	Waste emplacement area and waste	DIRNCRHW	Bulk density of iron containers, RH-TRU waste	CONSTANT	kg/m^3	2.5910E+03	32467
2040	WAS_AREA	Waste emplacement area and waste	DIRONCHW	Average density of iron-based material in CH-TRU waste	CONSTANT	kg/m^3	1.7000E+02	32468
2044	WAS_AREA	Waste emplacement area and waste	DIRONRHW	Average density of iron-based material in RH-TRU waste	CONSTANT	kg/m^3	1.0000E+02	32469
1994	WAS_AREA	Waste emplacement area and waste	DNSGRAIN	Material Grain Density	CONSTANT	kg/m^3	0.0000E+00	36967
2043	WAS_AREA	Waste emplacement area and waste	DPLASCHW	Average density of plastics in CH-TRU waste	CONSTANT	kg/m^3	3.4000E+01	32474
2275	WAS_AREA	Waste emplacement area and waste	DPLASRHW	Average density of plastics in CH-TRU waste	CONSTANT	kg/m^3	1.5000E+01	32476
1995	WAS_AREA	Waste emplacement area and waste	DPLSCCHW	Bulk density of plastic liners, CH-TRU waste	CONSTANT	kg/m^3	2.6000E+01	32478
2228	WAS_AREA	Waste emplacement area and waste	DPLSCRHW	Bulk density of plastic liners, RH-TRU waste	CONSTANT	kg/m^3	3.1000E+00	32480
2042	WAS_AREA	Waste emplacement area and waste	DRUBBCHW	Average density of rubber in CH-TRU waste	CONSTANT	kg/m^3	1.0000E+01	32481
2046	WAS_AREA	Waste emplacement area and waste	DRUBBRHW	Average density of rubber in RH-TRU waste	CONSTANT	kg/m^3	3.3000E+00	32483
2804	WAS_AREA	Waste emplacement area and waste	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	34942
658	WAS_AREA	Waste emplacement area and waste	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	34986
2805	WAS_AREA	Waste emplacement area and waste	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	34983
2806	WAS_AREA	Waste emplacement area and waste	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	34984
661	WAS_AREA	Waste emplacement area and waste	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	34875
659	WAS_AREA	Waste emplacement area and waste	PORE_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.8900E+00	34989
660	WAS_AREA	Waste emplacement area and waste	POROSITY	Effective porosity	CONSTANT	NONE	8.4800E-01	34874
662	WAS_AREA	Waste emplacement area and waste	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	34876
663	WAS_AREA	Waste emplacement area and waste	PRMX_LOG	Log of intrinsic permeability, x-direction	CONSTANT	log(m^2)	-1.2769E+01	34877
664	WAS_AREA	Waste emplacement area and waste	PRMY_LOG	Log of intrinsic permeability, y-direction	CONSTANT	log(m^2)	-1.2769E+01	34878
665	WAS_AREA	Waste emplacement area and waste	PRMZ_LOG	Log of intrinsic permeability, z-direction	CONSTANT	log(m^2)	-1.2769E+01	34879
668	WAS_AREA	Waste emplacement area and waste	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	34890
669	WAS_AREA	Waste emplacement area and waste	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.5000E-02	34894
2232	WAS_AREA	Waste emplacement area and waste	VOLCHW	BIR total volume of CH-TRU waste	CONSTANT	m^3	1.6900E+05	32484
2233	WAS_AREA	Waste emplacement area and waste	VOLRHW	BIR total volume of RH-TRU waste	CONSTANT	m^3	7.0800E+03	32485

Table PAR-39. Waste Chemistry Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO#
3457	AM	Americium	CAPHUM	Maximum concentration of actinide with mobile humic colloids	CONSTANT	moles/liter	1.1000E-05	37721
3447	AM	Americium	CAPMIC	Maximum concentration of actinide on microbe colloids	CONSTANT	moles/liter	1.0000E+00	37712
3310	AM	Americium	CONCINT	Actinide concentration with mobile actinide intrinsic colloids	CONSTANT	moles/liter	0.0000E+00	36857
3441	AM	Americium	CONCMIN	Actinide concentration with mobile mineral fragment colloids	CONSTANT	moles/liter	2.6000E-08	37704
3311	AM	Americium	PROPMIC	Moles of actinide mobilized on microbe colloids per moles dissolved	CONSTANT	moles/moles	3.6000E+00	36858
3444	AM+3	Americium III	MD0	Molecular diffusion in pure fluid	CONSTANT	m^2/s	3.0000E-10	37709
3482	AM+3	Americium III	MKD_AM	Matrix Distribution Coefficient for Americium	UNIFORM	m^3/kg	2.6000E-01	38353
838	CF	Califorinum	LOGSOLM	Log of the radionuclide solubility	CONSTANT	Log(moles/l)	0.0000E+00	31827
841	CS	Cesium	LOGSOLM	Log of the radionuclide solubility	CONSTANT	Log(moles/l)	0.0000E+00	32680
3458	NP	Neptunium	CAPHUM	Maximum concentration of actinide with mobile humic colloids	CONSTANT	moles/liter	1.1000E-05	37723
3313	NP	Neptunium	CAPMIC	Maximum concentration of actinide on microbe colloids	CONSTANT	moles/liter	2.7000E-03	36860
3312	NP	Neptunium	CONCINT	Actinide concentration with mobile actinide intrinsic colloids	CONSTANT	moles/liter	0.0000E+00	36859
3439	NP	Neptunium	CONCMIN	Actinide concentration with mobile mineral fragment colloids	CONSTANT	moles/liter	2.6000E-08	37700
3314	NP	Neptunium	PROPMIC	Moles of actinide mobilized on microbe colloids per moles dissolved	CONSTANT	moles/moles	1.2000E+01	36861
3477	NP+4	Neptunium IV	MKD_NP	Matrix Distribution Coefficient for Neptunium	UNIFORM	m^3/kg	1.0000E+01	38348
3476	NP+5	Neptunium V	MKD_NP	Matrix Distribution Coefficient for Neptunium	UNIFORM	m^3/kg	1.0000E-01	38347
282	PB	Lead	LOGSOLM	Log of the radionuclide solubility	CONSTANT	Log(moles/l)	0.0000E+00	33213
3429	PHUMOX3	Proportionality constant with humic colloids for actinide in oxidation state III	PHUMCIM	Proportionality constant of actinides incastile brine w/ humic colloids, inorgan	CUMULATIVE	moles/moles	1.3700E+00	37683
3433	PHUMOX3	Proportionality constant with humic colloids for actinide in oxidation state III	PHUMSIM	Proportionality constant of actinides insalado brine w/ humic colloids,inorganic	CONSTANT	moles/moles	1.9000E-01	37690
3430	PHUMOX4	Proportionality constant with humic colloids for actinide in oxidation state IV	PHUMCIM	Proportionality constant of actinides incastile brine w/ humic colloids, inorgan	CONSTANT	moles/moles	6.3000E+00	37685
3434	PHUMOX4	Proportionality constant with humic colloids for actinide in oxidation state IV	PHUMSIM	Proportionality constant of actinides insalado brine w/ humic colloids,inorganic	CONSTANT	moles/moles	6.3000E+00	37691
3431	PHUMOX5	Proportionality constant with humic colloids for actinide in oxidation state V	PHUMCIM	Proportionality constant of actinides incastile brine w/ humic colloids, inorgan	CONSTANT	moles/moles	7.4000E-03	37687
3435	PHUMOX5	Proportionality constant with humic colloids for actinide in oxidation state V	PHUMSIM	Proportionality constant of actinides insalado brine w/ humic colloids,inorganic	CONSTANT	moles/moles	9.1000E-04	37694
3432	PHUMOX6	Proportionality constant with humic colloids for actinide in oxidation state VI	PHUMCIM	Proportionality constant of actinides incastile brine w/ humic colloids, inorgan	CONSTANT	moles/moles	5.1000E-01	37688
3436	PHUMOX6	Proportionality constant with humic colloids for actinide in oxidation state VI	PHUMSIM	Proportionality constant of actinides insalado brine w/ humic colloids,inorganic	CONSTANT	moles/moles	1.2000E-01	37695

Table PAR-39. Waste Chemistry Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO#
1167	PM	Promethium	LOGSOLM	Log of the radionuclide solubility	CONSTANT	logMolar	4.6600E+00	33227
3459	PU	Plutonium	CAPHUM	Maximum concentration of actinide with mobile humic colloids	CONSTANT	moles/liter	1.1000E-05	37724
3315	PU	Plutonium	CAPMIC	Maximum concentration of actinide on microbe colloids	CONSTANT	moles/liter	6.8000E-05	36862
3316	PU	Plutonium	CONCINT	Actinide concentration with mobile actinide intrinsic colloids	CONSTANT	moles/liter	1.0000E-09	36863
3440	PU	Plutonium	CONCMIN	Actinide concentration with mobile mineral fragment colloids	CONSTANT	moles/liter	2.6000E-08	37703
3317	PU	Plutonium	PROPMIC	Moles of actinide mobilized on microbe colloids per moles dissolved	CONSTANT	moles/moles	3.0000E-01	36864
3442	PU+3	Plutonium III	MD0	Molecular diffusion in pure fluid	CONSTANT	m^2/s	3.0000E-10	37705
3480	PU+3	Plutonium III	MKD_PU	Matrix Distribution Coefficient for Plutonium	UNIFORM	m^3/kg	2.6000E-01	38351
3443	PU+4	Plutonium IV	MD0	Molecular diffusion in pure fluid	CONSTANT	m^2/s	1.5300E-10	37708
3481	PU+4	Plutonium IV	MKD_PU	Matrix Distribution Coefficient for Plutonium	UNIFORM	m^3/kg	1.0000E+01	38352
313	RA	Radium	LOGSOLM	Log of the radionuclide solubility	CONSTANT	Log(moles/l)	0.0000E+00	33455
3402	SOLMOD3	Oxidation state III model	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	6.5200E-08	37125A
3406	SOLMOD3	Oxidation state III model	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	5.8200E-07	37129A
3403	SOLMOD4	Oxidation state IV model	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	6.0000E-09	37126
3407	SOLMOD4	Oxidation state IV model	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	4.4000E-06	37130
3404	SOLMOD5	Oxidation state V model	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	2.2000E-06	37127
3408	SOLMOD5	Oxidation state V model	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	2.3000E-06	37131
3405	SOLMOD6	Oxidation state VI model	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	8.8000E-06	37128
3409	SOLMOD6	Oxidation state VI model	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	moles/liter	8.7000E-06	37132
3264	SOLPU3	Solubility of Plutonium in oxidation state III	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37108A
3265	SOLPU3	Solubility of Plutonium in oxidation state III	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37109A
3389	SOLPU4	Solubility of Plutonium in oxidation state IV	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37111A
3266	SOLPU4	Solubility of Plutonium in oxidation state IV	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37110A
3393	SOLTH4	Solubility of Thorium in oxidation state IV	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37115A
3390	SOLU4	Solubility of Uranium in oxidation state IV	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37112A

Table PAR-39. Waste Chemistry Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO#
3392	SOLU6	Solubility of Uranium in oxidation state VI	SOLCIM	Solubility in Castile brine inorganic with chemistry controlled by Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37114A
3391	SOLU6	Solubility of Uranium in oxidation state VI	SOLSIM	Solubility in Salado brine, inorganic chemistry controlled by the Mg(OH)2-MgCO3	CUMULATIVE	NONE	-9.0000E-02	37113A
1659	SR	Strontium	LOGSOLM	Log of the radionuclide solubility	CONSTANT	Log(moles/l)	0.0000E+00	34352
3461	TH	Thorium	CAPHUM	Maximum concentration of actinide with mobile humic colloids	CONSTANT	moles/liter	1.1000E-05	37726
3318	TH	Thorium	CAPMIC	Maximum concentration of actinide on microbe colloids	CONSTANT	moles/liter	1.9000E-03	36865
3319	TH	Thorium	CONCINT	Actinide concentration with mobile actinide intrinsic colloids	CONSTANT	moles/liter	0.0000E+00	36866
3437	TH	Thorium	CONCMIN	Actinide concentration with mobile mineral fragment colloids	CONSTANT	moles/liter	2.6000E-08	37697
3320	TH	Thorium	PROPMIC	Moles of actinide mobilized on microbe colloids per moles dissolved	CONSTANT	moles/moles	3.1000E+00	36867
3449	TH+4	Thorium IV	MD0	Molecular diffusion in pure fluid	CONSTANT	m^2/s	1.5300E-10	37715
3478	TH+4	Thorium IV	MKD_TH	Matrix Distribution Coefficient for Thorium	UNIFORM	m^3/kg	1.0000E+01	38349
3460	U	Uranium	CAPHUM	Maximum concentration of actinide with mobile humic colloids	CONSTANT	moles/liter	1.1000E-05	37725
3308	U	Uranium	CAPMIC	Maximum concentration of actinide on microbe colloids	CONSTANT	moles/liter	2.1000E-03	36855
3307	U	Uranium	CONCINT	Actinide concentration with mobile actinide intrinsic colloids	CONSTANT	moles/liter	0.0000E+00	36854
3438	U	Uranium	CONCMIN	Actinide concentration with mobile mineral fragment colloids	CONSTANT	moles/liter	2.6000E-08	37698
3309	U	Uranium	PROPMIC	Moles of actinide mobilized on microbe colloids per moles dissolved	CONSTANT	moles/moles	2.1000E-03	36856
3446	U+4	Uranium IV	MD0	Molecular diffusion in pure fluid	CONSTANT	m^2/s	1.5300E-10	37711
3479	U+4	Uranium IV	MKD_U	Matrix Distribution Coefficient for Uranium	UNIFORM	m^3/kg	1.0000E+01	38350
3448	U+6	Uranium VI	MD0	Molecular diffusion in pure fluid	CONSTANT	m^2/s	4.2600E-10	37714
3475	U+6	Uranium VI	MKD_U	Matrix Distribution Coefficient for Uranium	UNIFORM	m^3/kg	1.5000E-02	38346

Table PAR-40. Radionuclide Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3220	AC225	Actinium 225	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2502E-01	36738
3321	AC225	Actinium 225	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36868
3267	AC225	Actinium 225	HALFLIFE	Halflife	CONSTANT	s	8.6400E+05	36795
3221	AC227	Actinium 227	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2703E-01	36739
3364	AC227	Actinium 227	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36926
3268	AC227	Actinium 227	HALFLIFE	Halflife	CONSTANT	s	6.8710E+08	36796
3222	AC228	Actinium 228	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2803E-01	36740
3322	AC228	Actinium 228	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36869
3269	AC228	Actinium 228	HALFLIFE	Halflife	CONSTANT	s	2.2070E+04	36797
2	AM241	Americium 241	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4106E-01	31357
3363	AM241	Americium 241	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36925
3	AM241	Americium 241	HALFLIFE	Halflife	CONSTANT	s	1.3640E+10	31358
3223	AM243	Americium 243	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4306E-01	36741
3365	AM243	Americium 243	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36927
6	AM243	Americium 243	HALFLIFE	Halflife	CONSTANT	s	2.3290E+11	31374
3224	AT217	Astatine 217	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1701E-01	36742
3323	AT217	Astatine 217	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36870
3270	AT217	Astatine 217	HALFLIFE	Halflife	CONSTANT	s	3.2300E-02	36799
3225	BA137	Barium 137	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	1.3691E-01	36743
3324	BA137	Barium 137	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36871
3271	BA137	Barium 137	HALFLIFE	Halflife	CONSTANT	s	1.0000E+38	36800
3226	BA137M	Barium 137 Metastable	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	1.3691E-01	36744
3325	BA137M	Barium 137 Metastable	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36872
3272	BA137M	Barium 137 Metastable	HALFLIFE	Halflife	CONSTANT	s	1.5310E+02	36801
3227	BI211	Bismuth 211	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1099E-01	36746
3326	BI211	Bismuth 211	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36873
3273	BI211	Bismuth 211	HALFLIFE	Halflife	CONSTANT	s	1.2780E+02	36803
3228	BI212	Bismuth 212	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1199E-01	36748
3327	BI212	Bismuth 212	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36874
3274	BI212	Bismuth 212	HALFLIFE	Halflife	CONSTANT	s	3.6330E+03	36804
3229	BI213	Bismuth 213	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1299E-01	36749
3328	BI213	Bismuth 213	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36875
3275	BI213	Bismuth 213	HALFLIFE	Halflife	CONSTANT	s	2.7390E+03	36806
3230	BI214	Bismuth 214	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1400E-01	36750
3329	BI214	Bismuth 214	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36876
3276	BI214	Bismuth 214	HALFLIFE	Halflife	CONSTANT	s	1.1940E+03	36807
106	CF252	Californium 252	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.5208E-01	31828

Table PAR-40. Radionuclide Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3330	CF252	Californium 252	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36877
107	CF252	Californium 252	HALFLIFE	Halflife	CONSTANT	s	8.3250E+07	31829
3231	CM243	Curium 243	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4306E-01	36751
3366	CM243	Curium 243	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36928
3277	CM243	Curium 243	HALFLIFE	Halflife	CONSTANT	s	8.9940E+08	36809
110	CM244	Curium 244	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4406E-01	32331
3331	CM244	Curium 244	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36878
111	CM244	Curium 244	HALFLIFE	Halflife	CONSTANT	s	5.7150E+08	32495
3232	CM245	Curium 245	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4507E-01	36752
3367	CM245	Curium 245	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36929
3278	CM245	Curium 245	HALFLIFE	Halflife	CONSTANT	s	2.6820E+11	36811
3233	CM248	Curium 248	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4807E-01	36754
3368	CM248	Curium 248	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36930
115	CM248	Curium 248	HALFLIFE	Halflife	CONSTANT	s	1.0700E+13	32499
116	CS137	Cesium 137	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	1.3691E-01	32332
3369	CS137	Cesium 137	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+03	36931
117	CS137	Cesium 137	HALFLIFE	Halflife	CONSTANT	s	9.4670E+08	32682
3234	FR221	Francium 221	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2101E-01	36755
3332	FR221	Francium 221	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36879
3279	FR221	Francium 221	HALFLIFE	Halflife	CONSTANT	s	2.8800E+02	36812
3235	ND143	Neodymium 143	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	1.4291E-01	36757
3333	ND143	Neodymium 143	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36880
3280	ND143	Neodymium 143	HALFLIFE	Halflife	CONSTANT	s	1.0000E+38	36813
246	NP237	Neptunium 237	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3705E-01	32336
3370	NP237	Neptunium 237	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36932
247	NP237	Neptunium 237	HALFLIFE	Halflife	CONSTANT	s	6.7530E+13	32579
3236	NP239	Neptunium 239	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3905E-01	36758
3334	NP239	Neptunium 239	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36881
3281	NP239	Neptunium 239	HALFLIFE	Halflife	CONSTANT	s	2.0350E+05	36815
250	PA231	Protactinium 231	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3104E-01	32337
3371	PA231	Protactinium 231	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36933
251	PA231	Protactinium 231	HALFLIFE	Halflife	CONSTANT	s	1.0340E+12	32929
3237	PA233	Protactinium 233	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3304E-01	36759
3335	PA233	Protactinium 233	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36882
3282	PA233	Protactinium 233	HALFLIFE	Halflife	CONSTANT	s	2.3330E+06	36828
3197	PA234M	Protactinium 234 Metastable	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3404E-01	36660
3336	PA234M	Protactinium 234 Metastable	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36883

Table PAR-40. Radionuclide Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3283	PA234M	Protactinium 234 Metastable	HALFLIFE	Halflife	CONSTANT	s	7.0200E+01	36829
3421	PB209	Lead 209	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.0898E-01	37670
3337	PB209	Lead 209	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36884
3284	PB209	Lead 209	HALFLIFE	Halflife	CONSTANT	s	1.1880E+04	36830
283	PB210	Lead 210	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.0998E-01	32338
3372	PB210	Lead 210	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36934
284	PB210	Lead 210	HALFLIFE	Halflife	CONSTANT	s	7.0370E+08	33218
3200	PB211	Lead 211	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1099E-01	36705
3338	PB211	Lead 211	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36885
3285	PB211	Lead 211	HALFLIFE	Halflife	CONSTANT	s	2.1660E+03	36831
3201	PB212	Lead 212	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1199E-01	36706
3339	PB212	Lead 212	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36886
3286	PB212	Lead 212	HALFLIFE	Halflife	CONSTANT	s	3.8300E+04	36832
3202	PB214	Lead 214	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1400E-01	36707
3340	PB214	Lead 214	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36888
3287	PB214	Lead 214	HALFLIFE	Halflife	CONSTANT	s	1.6080E+03	36833
287	PM147	Promethium 147	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	1.4692E-01	32339
3341	PM147	Promethium 147	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36889
288	PM147	Promethium 147	HALFLIFE	Halflife	CONSTANT	s	8.2790E+07	33231
3203	PO212	Polonium 212	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1199E-01	36708
3342	PO212	Polonium 212	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36891
3288	PO212	Polonium 212	HALFLIFE	Halflife	CONSTANT	s	3.0000E-07	36834
3204	PO213	Polonium 213	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1299E-01	36709
3343	PO213	Polonium 213	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36892
3289	PO213	Polonium 213	HALFLIFE	Halflife	CONSTANT	s	4.2000E-06	36835
3205	PO214	Polonium 214	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1400E-01	36710
3344	PO214	Polonium 214	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36893
3290	PO214	Polonium 214	HALFLIFE	Halflife	CONSTANT	s	1.6430E-04	36836
3206	PO215	Polonium 215	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1500E-01	36711
3345	PO215	Polonium 215	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36894
3291	PO215	Polonium 215	HALFLIFE	Halflife	CONSTANT	s	1.7800E-03	36837
3207	PO216	Polonium 216	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1600E-01	36712
3346	PO216	Polonium 216	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36895
3292	PO216	Polonium 216	HALFLIFE	Halflife	CONSTANT	s	1.5000E-01	36838
3208	PO218	Polonium 218	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1801E-01	36713
3347	PO218	Polonium 218	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36896
3293	PO218	Polonium 218	HALFLIFE	Halflife	CONSTANT	s	1.8300E+02	36839

Table PAR-40. Radionuclide Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
291	PU238	Plutonium 238	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3805E-01	32340
3373	PU238	Plutonium 238	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36935
292	PU238	Plutonium 238	HALFLIFE	Halflife	CONSTANT	s	2.7690E+09	33245
295	PU239	Plutonium 239	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3905E-01	32341
3374	PU239	Plutonium 239	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36936
296	PU239	Plutonium 239	HALFLIFE	Halflife	CONSTANT	s	7.5940E+11	33256
299	PU240	Plutonium 240	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4005E-01	32342
3375	PU240	Plutonium 240	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36937
300	PU240	Plutonium 240	HALFLIFE	Halflife	CONSTANT	s	2.0630E+11	33265
303	PU241	Plutonium 241	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4106E-01	32343
3348	PU241	Plutonium 241	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36898
304	PU241	Plutonium 241	HALFLIFE	Halflife	CONSTANT	s	4.5440E+08	33292
307	PU242	Plutonium 242	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4206E-01	32344
3376	PU242	Plutonium 242	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36938
308	PU242	Plutonium 242	HALFLIFE	Halflife	CONSTANT	s	1.2210E+13	33295
311	PU244	Plutonium 244	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.4406E-01	32345
3377	PU244	Plutonium 244	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36939
312	PU244	Plutonium 244	HALFLIFE	Halflife	CONSTANT	s	2.6070E+15	33297
3209	RA223	Radium 223	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2302E-01	36714
3349	RA223	Radium 223	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36899
3294	RA223	Radium 223	HALFLIFE	Halflife	CONSTANT	s	9.8790E+05	36840
3210	RA224	Radium 224	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2402E-01	36715
3350	RA224	Radium 224	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36901
3295	RA224	Radium 224	HALFLIFE	Halflife	CONSTANT	s	3.1620E+05	36841
3211	RA225	Radium 225	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2502E-01	36716
3351	RA225	Radium 225	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36902
3296	RA225	Radium 225	HALFLIFE	Halflife	CONSTANT	s	1.2790E+06	36842
314	RA226	Radium 226	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2603E-01	32347
3378	RA226	Radium 226	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36940
315	RA226	Radium 226	HALFLIFE	Halflife	CONSTANT	s	5.0490E+10	33458
318	RA228	Radium 228	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2803E-01	32348
3352	RA228	Radium 228	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36903
319	RA228	Radium 228	HALFLIFE	Halflife	CONSTANT	s	2.1143E+08	33468
3212	RN219	Radon 219	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.1901E-01	36719
3353	RN219	Radon 219	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36904
3297	RN219	Radon 219	HALFLIFE	Halflife	CONSTANT	s	3.9600E+00	36843
3213	RN220	Radon 220	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2001E-01	36720

Table PAR-40. Radionuclide Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3354	RN220	Radon 220	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36906
3298	RN220	Radon 220	HALFLIFE	Halflife	CONSTANT	s	5.5600E+01	36844
3214	RN222	Radon 222	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2202E-01	36732
3355	RN222	Radon 222	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36907
3299	RN222	Radon 222	HALFLIFE	Halflife	CONSTANT	s	3.3040E+05	36845
514	SM147	Samarium 147	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	1.4692E-01	32455
3379	SM147	Samarium 147	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36941
515	SM147	Samarium 147	HALFLIFE	Halflife	CONSTANT	s	3.3770E+18	34350
3215	SR90	Strontium 90	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	8.9908E-02	36733
516	SR90	Strontium 90	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	8.9908E-02	32456
3380	SR90	Strontium 90	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+03	36942
517	SR90	Strontium 90	HALFLIFE	Halflife	CONSTANT	s	9.1900E+08	34353
3216	TH227	Thorium 227	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2703E-01	36734
3356	TH227	Thorium 227	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36909
3300	TH227	Thorium 227	HALFLIFE	Halflife	CONSTANT	s	1.6170E+06	36846
3217	TH228	Thorium 228	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2803E-01	36735
3357	TH228	Thorium 228	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36910
3301	TH228	Thorium 228	HALFLIFE	Halflife	CONSTANT	s	6.0370E+07	36847
603	TH229	Thorium 229	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.2903E-01	34594
3381	TH229	Thorium 229	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36943
604	TH229	Thorium 229	HALFLIFE	Halflife	CONSTANT	s	2.3160E+11	34595
607	TH230	Thorium 230	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3003E-01	34600
3382	TH230	Thorium 230	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+01	36944
608	TH230	Thorium 230	HALFLIFE	Halflife	CONSTANT	s	2.4300E+12	34601
3218	TH231	Thorium 231	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3104E-01	36736
3358	TH231	Thorium 231	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36911
3302	TH231	Thorium 231	HALFLIFE	Halflife	CONSTANT	s	9.1870E+04	36848
611	TH232	Thorium 232	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3204E-01	32458
3383	TH232	Thorium 232	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+01	36945
612	TH232	Thorium 232	HALFLIFE	Halflife	CONSTANT	s	4.4340E+17	34605
3219	TH234	Thorium 234	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3404E-01	36737
3359	TH234	Thorium 234	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36921
3303	TH234	Thorium 234	HALFLIFE	Halflife	CONSTANT	s	2.0820E+06	36849
3196	TL207	Thallium 207	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.0698E-01	36659
3360	TL207	Thallium 207	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36922
3304	TL207	Thallium 207	HALFLIFE	Halflife	CONSTANT	s	2.8620E+02	36850
632	U233	Uranium 233	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3304E-01	32459

Table PAR-40. Radionuclide Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3384	U233	Uranium 233	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36946
633	U233	Uranium 233	HALFLIFE	Halflife	CONSTANT	s	5.0020E+12	34662
636	U234	Uranium 234	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3404E-01	32460
3385	U234	Uranium 234	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36947
637	U234	Uranium 234	HALFLIFE	Halflife	CONSTANT	s	7.7160E+12	34667
640	U235	Uranium 235	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3504E-01	32461
3386	U235	Uranium 235	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36948
641	U235	Uranium 235	HALFLIFE	Halflife	CONSTANT	s	2.2210E+16	34671
644	U236	Uranium 236	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3605E-01	32462
3387	U236	Uranium 236	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36949
645	U236	Uranium 236	HALFLIFE	Halflife	CONSTANT	s	7.3890E+14	34676
647	U238	Uranium 238	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	2.3805E-01	32463
3388	U238	Uranium 238	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	1.0000E+02	36950
648	U238	Uranium 238	HALFLIFE	Halflife	CONSTANT	s	1.4100E+17	34680
3198	Y90	Yttrium 90	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	8.9907E-02	36703
3361	Y90	Yttrium 90	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36923
3305	Y90	Yttrium 90	HALFLIFE	Halflife	CONSTANT	s	2.3040E+05	36851
3199	ZR90	Zirconium 90	ATWEIGHT	Atomic Weight in kg/mole	CONSTANT	kg/mole	8.9905E-02	36704
3362	ZR90	Zirconium 90	EPAREL	EPA Release Limit	CONSTANT	Ci/wuf	0.0000E+00	36924
3306	ZR90	Zirconium 90	HALFLIFE	Halflife	CONSTANT	s	1.0000E+38	36852

Table PAR-41. Isotope Inventory

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
4	AM241	Americium 241	INVCHD	Inventory of contact handled design	CONSTANT	Ci	4.4200E+05	31359
5	AM241	Americium 241	INVRHD	Inventory of remote handled design	CONSTANT	Ci	5.9600E+03	31360
3415	AM243	Americium 243	INVCHD	Inventory of contact handled design	CONSTANT	Ci	3.2600E+01	37138
3416	AM243	Americium 243	INVRHD	Inventory of remote handled design	CONSTANT	Ci	2.2800E-04	37139
108	CF252	Californium 252	INVCHD	Inventory of contact handled design	CONSTANT	Ci	2.3900E+02	31830
109	CF252	Californium 252	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.2900E+00	31831
3410	CM243	Curium 243	INVCHD	Inventory of contact handled design	CONSTANT	Ci	2.7200E+00	37133
3411	CM243	Curium 243	INVRHD	Inventory of remote handled design	CONSTANT	Ci	4.9500E+01	37134
112	CM244	Curium 244	INVCHD	Inventory of contact handled design	CONSTANT	Ci	3.1500E+04	32496
113	CM244	Curium 244	INVRHD	Inventory of remote handled design	CONSTANT	Ci	3.1500E+02	32497
3412	CM245	Curium 245	INVCHD	Inventory of contact handled design	CONSTANT	Ci	1.1500E+02	37135
3413	CM245	Curium 245	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.4600E-06	37136
2265	CM248	Curium 248	INVCHD	Inventory of contact handled design	CONSTANT	Ci	8.9500E-02	32500
2266	CM248	Curium 248	INVRHD	Inventory of remote handled design	CONSTANT	Ci	2.0500E-04	32501
2037	CS137	Cesium 137	INVCHD	Inventory of contact handled design	CONSTANT	Ci	8.0600E+03	32683
118	CS137	Cesium 137	INVRHD	Inventory of remote handled design	CONSTANT	Ci	2.1600E+05	32684
248	NP237	Neptunium 237	INVCHD	Inventory of contact handled design	CONSTANT	Ci	5.6100E+01	32584
249	NP237	Neptunium 237	INVRHD	Inventory of remote handled design	CONSTANT	Ci	2.8500E+00	32593
2267	PA231	Protactinium 231	INVCHD	Inventory of contact handled design	CONSTANT	Ci	4.5100E-01	32930
2268	PA231	Protactinium 231	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.9100E-03	32931
285	PB210	Lead 210	INVCHD	Inventory of contact handled design	CONSTANT	Ci	2.5500E+00	33221
286	PB210	Lead 210	INVRHD	Inventory of remote handled design	CONSTANT	Ci	7.1600E-06	33223
2038	PM147	Promethium 147	INVCHD	Inventory of contact handled design	CONSTANT	Ci	7.8700E+00	33233
289	PM147	Promethium 147	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.0700E+01	33236
293	PU238	Plutonium 238	INVCHD	Inventory of contact handled design	CONSTANT	Ci	2.6100E+06	33247
294	PU238	Plutonium 238	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.4500E+03	33251
297	PU239	Plutonium 239	INVCHD	Inventory of contact handled design	CONSTANT	Ci	7.8500E+05	33260
298	PU239	Plutonium 239	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.0300E+04	33262
301	PU240	Plutonium 240	INVCHD	Inventory of contact handled design	CONSTANT	Ci	2.1000E+05	33267
302	PU240	Plutonium 240	INVRHD	Inventory of remote handled design	CONSTANT	Ci	5.0700E+03	33268
305	PU241	Plutonium 241	INVCHD	Inventory of contact handled design	CONSTANT	Ci	2.3100E+06	33270
306	PU241	Plutonium 241	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.4200E+05	33271
309	PU242	Plutonium 242	INVCHD	Inventory of contact handled design	CONSTANT	Ci	1.1700E+03	33274
310	PU242	Plutonium 242	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.5000E-01	33272
2269	PU244	Plutonium 244	INVCHD	Inventory of contact handled design	CONSTANT	Ci	1.5000E-06	33450
2270	PU244	Plutonium 244	INVRHD	Inventory of remote handled design	CONSTANT	Ci	2.2100E-11	33452

Table PAR-41. Isotope Inventory (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
316	RA226	Radium 226	INVCHD	Inventory of contact handled design	CONSTANT	Ci	1.1600E+01	33462
317	RA226	Radium 226	INVRHD	Inventory of remote handled design	CONSTANT	Ci	3.5800E-05	33464
2271	RA228	Radium 228	INVCHD	Inventory of contact handled design	CONSTANT	Ci	7.4700E-01	33470
2272	RA228	Radium 228	INVRHD	Inventory of remote handled design	CONSTANT	Ci	7.7700E-02	36968
2039	SR90	Strontium 90	INVCHD	Inventory of contact handled design	CONSTANT	Ci	6.8500E+03	34354
518	SR90	Strontium 90	INVRHD	Inventory of remote handled design	CONSTANT	Ci	2.0900E+05	34355
605	TH229	Thorium 229	INVCHD	Inventory of contact handled design	CONSTANT	Ci	2.8800E+00	34596
606	TH229	Thorium 229	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.1700E-01	34597
609	TH230	Thorium 230	INVCHD	Inventory of contact handled design	CONSTANT	Ci	8.0600E-02	34602
610	TH230	Thorium 230	INVRHD	Inventory of remote handled design	CONSTANT	Ci	7.5600E-03	34603
613	TH232	Thorium 232	INVCHD	Inventory of contact handled design	CONSTANT	Ci	9.1300E-01	34606
614	TH232	Thorium 232	INVRHD	Inventory of remote handled design	CONSTANT	Ci	9.2500E-02	34607
634	U233	Uranium 233	INVCHD	Inventory of contact handled design	CONSTANT	Ci	1.7900E+03	34663
635	U233	Uranium 233	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.5800E+02	34664
638	U234	Uranium 234	INVCHD	Inventory of contact handled design	CONSTANT	Ci	4.6500E+02	34668
639	U234	Uranium 234	INVRHD	Inventory of remote handled design	CONSTANT	Ci	4.2700E+01	34669
642	U235	Uranium 235	INVCHD	Inventory of contact handled design	CONSTANT	Ci	1.2800E+01	34672
643	U235	Uranium 235	INVRHD	Inventory of remote handled design	CONSTANT	Ci	4.6300E+00	34674
2216	U236	Uranium 236	INVCHD	Inventory of contact handled design	CONSTANT	Ci	3.3300E-01	34677
646	U236	Uranium 236	INVRHD	Inventory of remote handled design	CONSTANT	Ci	9.6800E-02	34678
649	U238	Uranium 238	INVCHD	Inventory of contact handled design	CONSTANT	Ci	3.9600E+01	34681
650	U238	Uranium 238	INVRHD	Inventory of remote handled design	CONSTANT	Ci	1.0500E+01	34682

Table PAR-42. Waste Container Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
3106	REFCON	Reference Constant	ASDRUM	Surface area of corrodable metal per drum	CONSTANT	m^2	6.0000E+00	36370
3132	REFCON	Reference Constant	DRROOM	Number of drums, per room, in ideal packing	CONSTANT	NONE	6.8040E+03	32372

Table PAR-43. Stoichiometric Gas Generation Model Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
228	H2	Hydrogen Gas	VISCO	Viscosity of H2 gas at 27 degrees Celsius and 0.101325 MPa	CONSTANT	Pa*s	8.9339E-06	32334A
2906	NITRATE	Nitrate	QINIT	Initial quantity of material in waste	CONSTANT	moles	2.6100E+07	32335
2908	STEEL	Generic steel in waste	CORRWCO2	Inundated corrosion rate for steel with CO2 present	UNIFORM	m/s	1.0318E-13	34358
2910	STEEL	Generic steel in waste	HUMCORR	Humid corrosion rate for steel	CONSTANT	m/s	0.0000E+00	34127
2898	STEEL	Generic steel in waste	STOIFX	Stoichiometric factor - X	CONSTANT	NONE	1.0000E+00	34128
2909	SULFATE	Sulfate	QINIT	Initial quantity of material in waste	CONSTANT	moles	6.5900E+06	32457

Table PAR-44. Repository (Outside of Panel Region) Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2110	REPOSIT	Repository regions outside of Panel region	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	33285
3455	REPOSIT	Repository regions outside of Panel region	CLOSMOD	Closure Surface Model	CONSTANT	NONE	4.0000E+00	38207
2112	REPOSIT	Repository regions outside of Panel region	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	33290
2113	REPOSIT	Repository regions outside of Panel region	DCELLCHW	Average density of cellulosics in CH-TRU waste	CONSTANT	kg/m^3	5.4000E+01	33298
2114	REPOSIT	Repository regions outside of Panel region	DCELLRHW	Average density of cellulosics in RH-TRU waste	CONSTANT	kg/m^3	1.7000E+01	32436
2115	REPOSIT	Repository regions outside of Panel region	DIRNCCHW	Bulk density of iron containers, CH-TRU waste	CONSTANT	kg/m^3	1.3900E+02	32439
2116	REPOSIT	Repository regions outside of Panel region	DIRNCRHW	Bulk density of iron containers, RH-TRU waste	CONSTANT	kg/m^3	2.5910E+03	32440
2117	REPOSIT	Repository regions outside of Panel region	DIRONCHW	Average density of iron-based material in CH-TRU waste	CONSTANT	kg/m^3	1.7000E+02	32442
2118	REPOSIT	Repository regions outside of Panel region	DIRONRHW	Average density of iron-based material in RH-TRU waste	CONSTANT	kg/m^3	1.0000E+02	32443
2119	REPOSIT	Repository regions outside of Panel region	DPLASCHW	Average density of plastics in CH-TRU waste	CONSTANT	kg/m^3	3.4000E+01	32444
2120	REPOSIT	Repository regions outside of Panel region	DPLASRHW	Average density of plastics in CH-TRU waste	CONSTANT	kg/m^3	1.5000E+01	32446
2121	REPOSIT	Repository regions outside of Panel region	DPLSCCHW	Bulk density of plastic liners, CH-TRU waste	CONSTANT	kg/m^3	2.6000E+01	32447
2995	REPOSIT	Repository regions outside of Panel region	DPLSCRHW	Bulk density of plastic liners, RH-TRU waste	CONSTANT	kg/m^3	3.1000E+00	32449
2122	REPOSIT	Repository regions outside of Panel region	DRUBBCHW	Average density of rubber in CH-TRU waste	CONSTANT	kg/m^3	1.0000E+01	32450
2123	REPOSIT	Repository regions outside of Panel region	DRUBBRHW	Average density of rubber in RH-TRU waste	CONSTANT	kg/m^3	3.3000E+00	32451
2736	REPOSIT	Repository regions outside of Panel region	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33238
2242	REPOSIT	Repository regions outside of Panel region	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33246
2737	REPOSIT	Repository regions outside of Panel region	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	33240
2738	REPOSIT	Repository regions outside of Panel region	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	33242
2739	REPOSIT	Repository regions outside of Panel region	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33252
2129	REPOSIT	Repository regions outside of Panel region	PORE_DIS	Brooks-Corey pore distribution parameter	CUMULATIVE	NONE	2.8900E+00	33248
2130	REPOSIT	Repository regions outside of Panel region	POROSITY	Effective porosity	CONSTANT	NONE	8.4800E-01	33250
2131	REPOSIT	Repository regions outside of Panel region	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.2769E+01	33255
2132	REPOSIT	Repository regions outside of Panel region	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.2769E+01	33258
2133	REPOSIT	Repository regions outside of Panel region	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.2769E+01	33259
2135	REPOSIT	Repository regions outside of Panel region	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33275
2740	REPOSIT	Repository regions outside of Panel region	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.5000E-02	33277
2141	REPOSIT	Repository regions outside of Panel region	VOLCHW	BIR total volume of CH-TRU waste	CONSTANT	m^3	1.6900E+05	32452
2142	REPOSIT	Repository regions outside of Panel region	VOLRHW	BIR total volume of RH-TRU waste	CONSTANT	m^3	7.0800E+03	32453

Table PAR-45. Predisposal Cavities (Waste Area) Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
76	CAVITY_1	Cavity for Waste Areas	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	31626
77	CAVITY_1	Cavity for Waste Areas	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	31628
2612	CAVITY_1	Cavity for Waste Areas	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31650
78	CAVITY_1	Cavity for Waste Areas	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31673
2613	CAVITY_1	Cavity for Waste Areas	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	31670
2614	CAVITY_1	Cavity for Waste Areas	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	31672
81	CAVITY_1	Cavity for Waste Areas	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31678
79	CAVITY_1	Cavity for Waste Areas	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	31675
80	CAVITY_1	Cavity for Waste Areas	POROSITY	Effective porosity	CONSTANT	NONE	1.0000E+00	31677
82	CAVITY_1	Cavity for Waste Areas	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31679
83	CAVITY_1	Cavity for Waste Areas	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.0000E+01	31680
84	CAVITY_1	Cavity for Waste Areas	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.0000E+01	31681
85	CAVITY_1	Cavity for Waste Areas	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.0000E+01	31682
88	CAVITY_1	Cavity for Waste Areas	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31685
3099	CAVITY_1	Cavity for Waste Areas	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	0.0000E+00	31686
89	CAVITY_1	Cavity for Waste Areas	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	31687
90	CAVITY_1	Cavity for Waste Areas	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	31688
91	CAVITY_2	Cavity for Non-waste Areas	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	31692
92	CAVITY_2	Cavity for Non-waste Areas	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	31694
2616	CAVITY_2	Cavity for Non-waste Areas	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31716
93	CAVITY_2	Cavity for Non-waste Areas	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31743
2617	CAVITY_2	Cavity for Non-waste Areas	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	31740
2618	CAVITY_2	Cavity for Non-waste Areas	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	31741
96	CAVITY_2	Cavity for Non-waste Areas	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31749
94	CAVITY_2	Cavity for Non-waste Areas	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	31746
95	CAVITY_2	Cavity for Non-waste Areas	POROSITY	Effective porosity	CONSTANT	NONE	1.0000E+00	31747
97	CAVITY_2	Cavity for Non-waste Areas	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31750
98	CAVITY_2	Cavity for Non-waste Areas	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.0000E+01	31751
99	CAVITY_2	Cavity for Non-waste Areas	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.0000E+01	31752
100	CAVITY_2	Cavity for Non-waste Areas	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.0000E+01	31754
103	CAVITY_2	Cavity for Non-waste Areas	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31759
3100	CAVITY_2	Cavity for Non-waste Areas	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	0.0000E+00	31760
104	CAVITY_2	Cavity for Non-waste Areas	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	31761
105	CAVITY_2	Cavity for Non-waste Areas	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	31763
2049	CAVITY_3	Cavity for Shaft	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	31767
2051	CAVITY_3	Cavity for Shaft	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	31769

Table PAR-45. Predisposal Cavities (Waste Area) Parameters (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2620	CAVITY_3	Cavity for Shaft	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31770
2234	CAVITY_3	Cavity for Shaft	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31775
2621	CAVITY_3	Cavity for Shaft	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	31773
2622	CAVITY_3	Cavity for Shaft	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	31774
2623	CAVITY_3	Cavity for Shaft	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31779
2052	CAVITY_3	Cavity for Shaft	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	31777
2053	CAVITY_3	Cavity for Shaft	POROSITY	Effective porosity	CONSTANT	NONE	1.0000E+00	31778
3101	CAVITY_3	Cavity for Shaft	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31780
2054	CAVITY_3	Cavity for Shaft	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.0000E+01	31781
2055	CAVITY_3	Cavity for Shaft	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.0000E+01	31782
2056	CAVITY_3	Cavity for Shaft	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.0000E+01	31783
2058	CAVITY_3	Cavity for Shaft	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31785
3102	CAVITY_3	Cavity for Shaft	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	0.0000E+00	31786
2235	CAVITY_3	Cavity for Shaft	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	31788
2059	CAVITY_3	Cavity for Shaft	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	31789
2060	CAVITY_4	Cavity for Borehole	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	31791
2062	CAVITY_4	Cavity for Borehole	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	31794
2625	CAVITY_4	Cavity for Borehole	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31796
2236	CAVITY_4	Cavity for Borehole	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31800
2626	CAVITY_4	Cavity for Borehole	PCT_A	Threshold pressure linear parameter	CONSTANT	Pa	0.0000E+00	31797
2627	CAVITY_4	Cavity for Borehole	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	31798
2628	CAVITY_4	Cavity for Borehole	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31803
2063	CAVITY_4	Cavity for Borehole	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	31801
2064	CAVITY_4	Cavity for Borehole	POROSITY	Effective porosity	CONSTANT	NONE	1.0000E+00	31802
3103	CAVITY_4	Cavity for Borehole	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	31815
2065	CAVITY_4	Cavity for Borehole	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.0000E+01	31817
2066	CAVITY_4	Cavity for Borehole	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.0000E+01	31818
2067	CAVITY_4	Cavity for Borehole	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.0000E+01	31819
2069	CAVITY_4	Cavity for Borehole	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31821
3104	CAVITY_4	Cavity for Borehole	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	0.0000E+00	31822
2237	CAVITY_4	Cavity for Borehole	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	31823
2070	CAVITY_4	Cavity for Borehole	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	31824

Table PAR-46. Panel Closure Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
252	PAN_SEAL	Panel Closure	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	32933
253	PAN_SEAL	Panel Closure	COMP_RCK[1]	Pore Compressibility	CONSTANT	Pa^-1	2.6400E-09	32935
2731	PAN_SEAL	Panel Closure	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33089
254	PAN_SEAL	Panel Closure	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33109
2732	PAN_SEAL	Panel Closure	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	5.6000E-01	33107
2733	PAN_SEAL	Panel Closure	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4600E-01	33108
257	PAN_SEAL	Panel Closure	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33115
255	PAN_SEAL	Panel Closure	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	9.4000E-01	33112
256	PAN_SEAL	Panel Closure	POROSITY	Effective porosity	CONSTANT	NONE	7.5000E-02	33113
258	PAN_SEAL	Panel Closure	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	33118
259	PAN_SEAL	Panel Closure	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.5000E+01	33120
260	PAN_SEAL	Panel Closure	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.5000E+01	33122
261	PAN_SEAL	Panel Closure	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.5000E+01	33123
264	PAN_SEAL	Panel Closure	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33131
2734	PAN_SEAL	Panel Closure	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	33134A
265	PAN_SEAL	Panel Closure	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	2.0000E-01	33139
266	PAN_SEAL	Panel Closure	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	2.0000E-01	33141

[1]COMP_RCK, in this case, refers to pore compressibility rather than bulk compressibility and pore compressibility is equivalent to bulk compressibility divided by the effective porosity.

Table PAR-47. Operations Region Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
7	OPS_AREA	Operations Region	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	32604
8	OPS_AREA	Operations Region	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	32606
2604	OPS_AREA	Operations Region	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	32614
9	OPS_AREA	Operations Region	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	32619
2605	OPS_AREA	Operations Region	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	32616
2606	OPS_AREA	Operations Region	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	32618
12	OPS_AREA	Operations Region	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31474
10	OPS_AREA	Operations Region	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	32624
11	OPS_AREA	Operations Region	POROSITY	Effective porosity	CONSTANT	NONE	1.8000E-01	32626
13	OPS_AREA	Operations Region	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32629
14	OPS_AREA	Operations Region	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.1000E+01	32630
15	OPS_AREA	Operations Region	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.1000E+01	32632
16	OPS_AREA	Operations Region	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.1000E+01	32633
19	OPS_AREA	Operations Region	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32634
20	OPS_AREA	Operations Region	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	0.0000E+00	32637
21	OPS_AREA	Operations Region	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	32639
22	OPS_AREA	Operations Region	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	32641

Table PAR-48. Experimental Area Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
207	EXP_AREA	Experimental Area	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	32969
208	EXP_AREA	Experimental Area	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	32972
2711	EXP_AREA	Experimental Area	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33009
209	EXP_AREA	Experimental Area	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33040
2712	EXP_AREA	Experimental Area	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	33037
2713	EXP_AREA	Experimental Area	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	33039
212	EXP_AREA	Experimental Area	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	32946
210	EXP_AREA	Experimental Area	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	33045
211	EXP_AREA	Experimental Area	POROSITY	Effective porosity	CONSTANT	NONE	1.8000E-01	32945
213	EXP_AREA	Experimental Area	PRESSURE	Brine far-field pore pressure	CONSTANT	Pa	1.0133E+05	32948
214	EXP_AREA	Experimental Area	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-1.1000E+01	32951
215	EXP_AREA	Experimental Area	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-1.1000E+01	32953
216	EXP_AREA	Experimental Area	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-1.1000E+01	32955
219	EXP_AREA	Experimental Area	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	32962
220	EXP_AREA	Experimental Area	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	0.0000E+00	32965
221	EXP_AREA	Experimental Area	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	32967
222	EXP_AREA	Experimental Area	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	32968

Table PAR-49. Castile Formation Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
229	IMPERM_Z	Impermeable Zones	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	1.0000E+00	33059
230	IMPERM_Z	Impermeable Zones	COMP_RCK	Bulk Compressibility	CONSTANT	Pa^-1	0.0000E+00	33064
2720	IMPERM_Z	Impermeable Zones	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	33119
231	IMPERM_Z	Impermeable Zones	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	33177
2721	IMPERM_Z	Impermeable Zones	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	0.0000E+00	33172
2722	IMPERM_Z	Impermeable Zones	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	0.0000E+00	33174
234	IMPERM_Z	Impermeable Zones	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	33191
232	IMPERM_Z	Impermeable Zones	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	33185
233	IMPERM_Z	Impermeable Zones	POROSITY	Effective porosity	CONSTANT	NONE	5.0000E-03	33188
236	IMPERM_Z	Impermeable Zones	PRMX_LOG	Log of intrinsic permeability, X-direction	CONSTANT	log(m^2)	-3.5000E+01	33205
237	IMPERM_Z	Impermeable Zones	PRMY_LOG	Log of intrinsic permeability, Y-direction	CONSTANT	log(m^2)	-3.5000E+01	33209
238	IMPERM_Z	Impermeable Zones	PRMZ_LOG	Log of intrinsic permeability, Z-direction	CONSTANT	log(m^2)	-3.5000E+01	33214
241	IMPERM_Z	Impermeable Zones	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	33222
243	IMPERM_Z	Impermeable Zones	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	0.0000E+00	33226
244	IMPERM_Z	Impermeable Zones	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	0.0000E+00	33230

Table PAR-50. Castile Brine Reservoir Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
58	CASTILER	Castile Brine Reservoir	AREA_FRC	Area fraction of Panel that has Brine reservoir underneath	CUMULATIVE	NONE	4.0104E-01	31554
60	CASTILER	Castile Brine Reservoir	CAP_MOD	Model number, capillary pressure model	CONSTANT	NONE	2.0000E+00	31556
2608	CASTILER	Castile Brine Reservoir	KPT	Flag for permeability determined threshold	CONSTANT	NONE	0.0000E+00	31583
62	CASTILER	Castile Brine Reservoir	PC_MAX	Maximum allowable capillary pressure	CONSTANT	Pa	1.0000E+08	31607
2609	CASTILER	Castile Brine Reservoir	PCT_A	Threshold pressure linear parameter	CONSTANT	NONE	5.6000E-01	31605
2610	CASTILER	Castile Brine Reservoir	PCT_EXP	Threshold pressure exponential parameter	CONSTANT	NONE	-3.4600E-01	31606
65	CASTILER	Castile Brine Reservoir	PO_MIN	Minimum brine pressure for capillary model KPC=3	CONSTANT	Pa	1.0133E+05	31611
63	CASTILER	Castile Brine Reservoir	PORE_DIS	Brooks-Corey pore distribution parameter	CONSTANT	NONE	7.0000E-01	31609
64	CASTILER	Castile Brine Reservoir	POROSITY	Effective porosity	STUDENT'S-T	NONE	8.7000E-03	31610
72	CASTILER	Castile Brine Reservoir	RELP_MOD	Model number, relative permeability model	CONSTANT	NONE	4.0000E+00	31619
73	CASTILER	Castile Brine Reservoir	SAT_IBRN	Initial Brine Saturation	CONSTANT	NONE	1.0000E+00	31620
74	CASTILER	Castile Brine Reservoir	SAT_RBRN	Residual Brine Saturation	CONSTANT	NONE	2.0000E-01	31621
75	CASTILER	Castile Brine Reservoir	SAT_RGAS	Residual Gas Saturation	CONSTANT	NONE	2.0000E-01	31622
2918	CASTILER	Castile Brine Reservoir	VOLUME	Total Reservoir Volume	CONSTANT	m^3	4.0000E+06	31625A

Table PAR-51. Castile Brine Fluid Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
43	BRINECST	Castile Brine	COMPRES	Brine Compressibility	CONSTANT	Pa^-1	9.0000E-10	31537
44	BRINECST	Castile Brine	DNSFLUID	Brine Density	CONSTANT	kg/m^3	1.2150E+03	31538

Table PAR-52. Reference Constants

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2833	REFCON	Reference Constant	ACF_CH4	Acentric Factors - CH4	CONSTANT	NONE	1.0000E-02	32349
2832	REFCON	Reference Constant	ACF_CO2	Acentric Factors - CO2	CONSTANT	NONE	2.3100E-01	32350
2831	REFCON	Reference Constant	ACF_H2	Acentric Factors - H2	CONSTANT	NONE	0.0000E+00	32351
2835	REFCON	Reference Constant	ACF_H2S	Acentric Factors - H2S	CONSTANT	NONE	1.0000E-01	32352
2834	REFCON	Reference Constant	ACF_N2	Acentric Factors - N2	CONSTANT	NONE	4.5000E-02	32354
2836	REFCON	Reference Constant	ACF_O2	Acentric Factors - O2	CONSTANT	NONE	1.9000E-02	32355
3113	REFCON	Reference Constant	ACTCONST	Activity Constant	CONSTANT	Kg/Ci	1.1280E+13	32356
2897	REFCON	Reference Constant	AL2	Log2	CONSTANT	NONE	6.9315E-01	32357
2890	REFCON	Reference Constant	ATMPA	Conversion from std. atmosphere to Pa	CONSTANT	Pa/atm	1.0133E+05	32358
3109	REFCON	Reference Constant	AVOGADRO	Avogadro's number	CONSTANT	1/mol	6.0221E+23	32359
2879	REFCON	Reference Constant	BBLG	Conversion from barrel to gallon	CONSTANT	gal/bbl	4.2000E+01	32360
3111	REFCON	Reference Constant	CITOBQ	Curie to Becquerel Conversion	CONSTANT	Bq/Ci	3.7000E+10	32377
2882	REFCON	Reference Constant	DARM2	Conversion from darcy to m^2	CONSTANT	m^2/darcy	9.8692E-13	32379
2887	REFCON	Reference Constant	DAYSEC	Conversion from days to seconds	CONSTANT	s/day	8.6400E+04	32383
2883	REFCON	Reference Constant	F3M3	Conversion from ft^3 to m^3	CONSTANT	m^3/ft^3	2.8317E-02	32384
2881	REFCON	Reference Constant	FTM	Conversion from feet to meter	CONSTANT	m/ft	3.0480E-01	32385
2884	REFCON	Reference Constant	GTI3	Conversion from gallon to in^3	CONSTANT	in^3/gal	2.3100E+02	32387
2886	REFCON	Reference Constant	KGLB	Conversion from kg to lb	CONSTANT	lb/kg	2.2046E+00	32388
2885	REFCON	Reference Constant	LBKG	Conversion from lb to kg	CONSTANT	kg/lb	4.5359E-01	32389
2877	REFCON	Reference Constant	MW_CACO3	Molecular Weight - CACO3	CONSTANT	kg/mol	1.0009E-01	32390
2875	REFCON	Reference Constant	MW_CAO	Molecular Weight - CAO	CONSTANT	kg/mol	5.6077E-02	32391
2876	REFCON	Reference Constant	MW_CAOH2	Molecular Weight - CAOH2	CONSTANT	kg/mol	7.4093E-02	32392
2866	REFCON	Reference Constant	MW_CH2O	Molecular Weight - CH2O	CONSTANT	kg/mol	3.0026E-02	32393
2860	REFCON	Reference Constant	MW_CH4	Molecular Weight - CH4	CONSTANT	kg/mol	1.6043E-02	32394
2859	REFCON	Reference Constant	MW_CO2	Molecular Weight - CO2	CONSTANT	kg/mol	4.4098E-02	32395
2865	REFCON	Reference Constant	MW_FE	Molecular Weight - FE	CONSTANT	kg/mol	5.5847E-02	32396
2873	REFCON	Reference Constant	MW_FE3O4	Molecular Weight - FE3O4	CONSTANT	kg/mol	2.3154E-01	32397
2870	REFCON	Reference Constant	MW_FECO3	Molecular Weight - FECO3	CONSTANT	kg/mol	1.1586E-01	32398
2871	REFCON	Reference Constant	MW_FEOH2	Molecular Weight - FEOH2	CONSTANT	kg/mol	8.9862E-02	32399
2872	REFCON	Reference Constant	MW_FEOOH	Molecular Weight - FEOOH	CONSTANT	kg/mol	8.8854E-02	32400
2874	REFCON	Reference Constant	MW_FES	Molecular Weight - FES	CONSTANT	kg/mol	8.7913E-02	32401
2869	REFCON	Reference Constant	MW_FES2	Molecular Weight - FES2	CONSTANT	kg/mol	1.1998E-01	32402
2858	REFCON	Reference Constant	MW_H2	Molecular Weight - H2	CONSTANT	kg/mol	2.0159E-03	32403
2864	REFCON	Reference Constant	MW_H2O	Molecular Weight - H2O	CONSTANT	kg/mol	1.8015E-02	32405
2862	REFCON	Reference Constant	MW_H2S	Molecular Weight - H2S	CONSTANT	kg/mol	3.4082E-02	32406
2867	REFCON	Reference Constant	MW_H2SO4	Molecular Weight - H2SO4	CONSTANT	kg/mol	9.8079E-02	32407
2868	REFCON	Reference Constant	MW_HNO3	Molecular Weight - HNO3	CONSTANT	kg/mol	6.3013E-02	32408

Table PAR-52. Reference Constants (Continued)

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO #
2861	REFCON	Reference Constant	MW_N2	Molecular Weight - N2	CONSTANT	kg/mol	2.8013E-02	32409
2878	REFCON	Reference Constant	MW_NACL	Molecular Weight - NACL	CONSTANT	kg/mol	5.8442E-02	32410
2863	REFCON	Reference Constant	MW_O2	Molecular Weight - O2	CONSTANT	kg/mol	3.1999E-02	32411
2880	REFCON	Reference Constant	PASCP	Conversion from Pa*s to cP	CONSTANT	cP/Pa*s	1.0000E+03	32414
2839	REFCON	Reference Constant	PC_CH4	Critical Pressure of CH4	CONSTANT	Pa	4.6170E+06	32415
2838	REFCON	Reference Constant	PC_CO2	Critical Pressure of CO2	CONSTANT	Pa	7.3760E+06	32416
2837	REFCON	Reference Constant	PC_H2	Critical Pressure of H2	CONSTANT	Pa	2.0470E+06	32417
2841	REFCON	Reference Constant	PC_H2S	Critical Pressure of H2S	CONSTANT	Pa	9.0070E+06	32418
2840	REFCON	Reference Constant	PC_N2	Critical Pressure of N2	CONSTANT	Pa	3.3940E+06	32419
2842	REFCON	Reference Constant	PC_O2	Critical Pressure of O2	CONSTANT	Pa	5.0800E+06	32420
2896	REFCON	Reference Constant	PI	Mathematical constant: PI	CONSTANT	NONE	3.1416E+00	32422
2892	REFCON	Reference Constant	PSIPA	Conversion from psi to pascal	CONSTANT	Pa*in^2/lb	6.8948E+03	32423
2893	REFCON	Reference Constant	R	Gas constant R	CONSTANT	J/mol*K	8.3145E+00	32424
2891	REFCON	Reference Constant	RTK	Conversion from Rankine to K	CONSTANT	K/rankine	5.5556E-01	32425
3112	REFCON	Reference Constant	SECYR	Seconds to years Conversion	CONSTANT	yr/s	3.1689E-08	32426
2827	REFCON	Reference Constant	TC_CH4	Critical temperature: Methane (CH4)	CONSTANT	K	1.9063E+02	32427
2826	REFCON	Reference Constant	TC_CO2	Critical temperature: Carbon Dioxide (CO2)	CONSTANT	K	3.0415E+02	32428
2825	REFCON	Reference Constant	TC_H2	Critical temperature: Hydrogen (H2)	CONSTANT	K	4.3600E+01	32429
2829	REFCON	Reference Constant	TC_H2S	Critical temperature: Hydrogen Sulfide (H2S)	CONSTANT	K	3.7355E+02	32430
2828	REFCON	Reference Constant	TC_N2	Critical temperature: Nitrogen (N2)	CONSTANT	K	1.2615E+02	32431
2830	REFCON	Reference Constant	TC_O2	Critical temperature: Oxygen (O2)	CONSTANT	K	1.5477E+02	32432
3107	REFCON	Reference Constant	VPANLEX	Excavated volume of one panel	CONSTANT	m^3	4.6098E+04	33273
3108	REFCON	Reference Constant	VREPOS	Excavated storage volume of repository	CONSTANT	m^3	4.3602E+05	33276
3105	REFCON	Reference Constant	VROOM	Volume of one room in repository	CONSTANT	m^3	3.6444E+03	33280
2888	REFCON	Reference Constant	YRSEC	Conversion from mean solar or tropical year to seconds	CONSTANT	s/yr	3.1557E+07	32434
3110	REFCON	Reference Constant	ZCINK	Zero Celcius in Kelvin	CONSTANT	K	2.7315E+02	32435

Table PAR-53. Intrusion Parameters

Id #	Material	Material Description	Parameter	Parameter Description	Distribution Type	Units	Value	WPO#
3501	GLOBAL	Information that applies globally	FPICD	PIC Reduction Factor for Human Intrusion by Drilling	CONSTANT	NONE	1.0000E-02	38743
3500	GLOBAL	Information that applies globally	FPICM	PIC Reduction Factor for Human Intrusion by Mining	CONSTANT	NONE	1.0000E-02	38742
3494	GLOBAL	Information that applies globally	LAMBDAD	Drilling rate per unit area	CONSTANT	(km^-2)yr^-1	4.6800E-03	38733
3497	GLOBAL	Information that applies globally	MINERT	Mining rate from 40 CFR Part 194	CONSTANT	yr^-1	1.0000E-04	38736
3493	GLOBAL	Information that applies globally	PBRINE	Prob. that drilling intrusion in excavated area encounters pressurized brine	CONSTANT	NONE	8.0000E-02	38732
3495	GLOBAL	Information that applies globally	PLGPAT	Index for plugging pattern after drilling intrusion	DELTA	NONE	0.0000E+00	38734
3491	GLOBAL	Information that applies globally	TA	Time active institutional controls at WIPP	CONSTANT	yr	1.0000E+02	38730
3499	GLOBAL	Information that applies globally	TPICD	Time over which passive institutional controls reduce rate of drilling	CONSTANT	yr	6.0000E+02	38738
3498	GLOBAL	Information that applies globally	TPICM	Time over which passive institutional controls reduce rate of mining	CONSTANT	yr	6.0000E+02	38737
3503	REFCON	Reference Constant	ABERM	Area of Berm Placed Over Waste Panel	CONSTANT	m^2	6.2850E+05	38745
3489	REFCON	Reference Constant	AREA_CH	Area for CH-TRU waste disposal in CCDFGF model	CONSTANT	m^2	1.1150E+05	38728
3496	REFCON	Reference Constant	AREA_RH	Area for RH-TRU waste disposal in CCDFGF model	CONSTANT	m^2	1.5760E+04	38735
3488	REFCON	Reference Constant	AREA_ZRO	Area in waste panels not used for disposal (CCDFGF model)	CONSTANT	m^2	4.1330E+03	38727
3492	REFCON	Reference Constant	FVW	Fraction of repository volume occupied by waste in CCDFGF model	CONSTANT	NONE	4.0300E-01	38731
3502	REFCON	Reference Constant	HRH	Emplaced Height of Remote Handled Waste in CCDFGF Model	CONSTANT	m	5.0900E-01	38744
3490	REFCON	Reference Constant	VOLWP	Uncompacted volume of waste panels in CCDFGF model	CONSTANT	m^3	4.3600E+05	38729

Table PAR-54. Listing of Parameters Used in BRAGFLO Which Differ From the WIPP 1996 Compliance Certification Application Parameter Database

Database material	Database parameter	Modeling value used	Distribution type	Database value	Units	WPO #
REFCON	GRAVACC	9.79	CONSTANT	9.8067	m/s^2	32386
DRZ_0	POROSITY	0.0029 + (realization value S_HALITE)	CONSTANT	3.90E-03 to 3.29E-02	log(m^2)	32839
DRZ_1	POROSITY	0.0029 + (realization value S_HALITE)	CUMULATIVE	1.00E+00 to 1.03E+00	log(m^2	32902
DEWYLAKE	PCT_A	0.00	CONSTANT	2.60E-01	Pa	32725
DEWYLAKE	PCT_EXP	0.00	CONSTANT	-3.48E-01	none	32727
BH_CREEP	PRMX_LOG	0.1* + (realization value BH_SAND	UNIFORM	-1.50000E+01 to -1.20000E+01	log(m^2)	36640
CL_L_T1	PCT_A	0.00	CONSTANT	0.56	Pa	31901
CL_L_T2	PCT_A	0.00	CONSTANT	0.56	Pa	31928
CL_L_T3	PCT_A	0.00	CONSTANT	0.56	Pa	31979
CL_L_T4	PCT_A	0.00	CONSTANT	0.56	Pa	32010
CL_M_T1	PCT_A	0.00	CONSTANT	0.56	Pa	32041
CL_M_T2	PCT_A	0.00	CONSTANT	0.56	Pa	32116
CL_M_T3	PCT_A	0.00	CONSTANT	0.56	Pa	32143
CL_M_T4	PCT_A	0.00	CONSTANT	0.56	Pa	32195
CL_M_T5	PCT_A	0.00	CONSTANT	0.56	Pa	32232
CLAY_BOT	PCT_A	0.00	CONSTANT	0.56	Pa	31859
CLAY_RUS	PCT_A	0.00	CONSTANT	0.56	Pa	31880
CONC_MON	PCT_A	0.00	CONSTANT	0.56	Pa	32508
CONC_T1	PCT_A	0.00	CONSTANT	0.56	Pa	32561
CONC_T2	PCT_A	0.00	CONSTANT	0.56	Pa	32652
EARTH	PCT_A	0.00	CONSTANT	0.56	Pa	32920
SALT_T1	PCT_A	0.00	CONSTANT	0.56	Pa	33369
SALT_T2	PCT_A	0.00	CONSTANT	0.56	Pa	33433
SALT_T3	PCT_A	0.00	CONSTANT	0.56	Pa	33404
SALT_T4	PCT_A	0.00	CONSTANT	0.56	Pa	33456
SALT_T5	PCT_A	0.00	CONSTANT	0.56	Pa	33575
SALT_T6	PCT_A	0.00	CONSTANT	0.56	Pa	33642
CONC_T1	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	32563
CONC_T2	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	32656
CLAY_RUS	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	31881
CLAY_BOT	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	31860
CL_M_T1	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	32042

NOTES:

1. Further information and explanation of the difference in parameter values between the Performance Assessment Database and the BRAGFLO calculations may be found in the "Analysis Package for the Salado Flow Calculations (TASK 1) of the Performance Assessment Analysis Supporting the Compliance Certification Application," SNL, 1996.
2. Pressure is specified in the Salado Halite at the horizon of MB139 and other pressures in the Salado are calculated, assuming a hydrostatic pressure gradient.

Table PAR-54. Listing of Parameters Used in BRAGFLO Which Differ from the WIPP 1996 Compliance Certification Application Parameter Database (Continued)

Database material	Database parameter	Modeling value used	Distribution type	Database value	Units	WPO #
CL_M_T2	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	31117
CL_M_T3	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	32144
CL_M_T4	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	32196
CL_M_T5	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	32233
CL_L_T1	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	31902
CL_L_T2	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	31929
CL_L_T3	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	31980
CL_L_T4	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	32011
SALT_T1	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	33370
SALT_T2	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	33435
SALT_T3	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	33406
SALT_T4	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	33457
SALT_T5	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	33577
SALT_T6	PCT_EXP	0.00	CONSTANT	-3.46000E-01	none	33645
EARTH	SAT_IBRN	0.9999999	CONSTANT	0.8	none	32961
CLAY_RUS	SAT_IBRN	0.9999999	CONSTANT	0.79	none	31894
CLAY_BOT	SAT_IBRN	0.9999999	CONSTANT	0.79	none	31873
CL_M_T1	SAT_IBRN	0.9999999	CONSTANT	0.79	none	32060
CL_L_T1	SAT_IBRN	0.9999999	CONSTANT	0.79	none	31920
SALT_T1	SAT_IBRN	0.9999999	CONSTANT	0.32	none	33416
CONC_T1	COMP_RCK	2.64E-9	CONSTANT	1.20E-9	Pa^-1	32556
CONC_T2	COMP_RCK	2.64E-9	CONSTANT	1.20E-9	Pa^-1	32638
S_MB138	PRESSURE	See note 2	STUDENT'S-T	9.38000E+06 to 1.11100E+07	Pa	34532
S_MB139	PRESSURE	See note 2	STUDENT'S-T	9.38000E+06 to 1.11100E+07	Pa	34863
CASTILER	POROSITY	POROSITY= POROSITY*(number of brine pockets/5)	STUDENT'S-T	2.00000E-03 to 1.60000E-02	none	31610
CULEBRA	THICK	7.70	CONSTANT	7.75	m	32790

NOTES:

1. Further information and explanation of the difference in parameter values between the Performance Assessment Database and the BRAGFLO calculations may be found in the "Analysis Package for the Salado Flow Calculations (TASK 1) of the Performance Assessment Analysis Supporting the Compliance Certification Application," SNL, 1996.
2. Pressure is specified in the Salado Halite at the horizon of MB139 and other pressures in the Salado are calculated, assuming a hydrostatic pressure gradient.

Table PAR-55. Listing of Parameters Used in PANEL Which Differ From the WIPP 1996 Compliance Certification Application Parameter Database

Database material	Database parameter	PANEL halflife (years)	Database halflife (sec)	Database (sec/yr)	PANEL yr to sec	Halflife % diff	Database parameter	PANEL atomic weight	Database atomic weight	Atomic weight % diff	WPO #
SR-90	HALFLIFE	2.91200E+01	9.19000E+08	3.155693E+07	9.18938E+08	0.01%	ATWEIGHT	90	8.99080E-02	0.10%	34353
CS-137	HALFLIFE	3.00000E+01	9.46700E+08		9.46708E+08	0.00%	ATWEIGHT	137	1.36907E-01	0.07%	32682
PB-210	HALFLIFE	2.23000E+01	7.03700E+08		7.03720E+08	0.00%	ATWEIGHT	210	2.09984E-01	0.01%	33218
RA-226	HALFLIFE	1.60000E+03	5.04900E+10		5.04911E+10	0.00%	ATWEIGHT	226	2.26025E-01	0.01%	33458
RA-228	HALFLIFE	5.75000E+00	2.11430E+08		1.81452E+08	14.18%	ATWEIGHT	228	2.28031E-01	0.01%	33468
TH-229	HALFLIFE	7.34000E+03	2.31600E+11		2.31628E+11	0.01%	ATWEIGHT	229	2.29032E-01	0.01%	34595
TH-230	HALFLIFE	7.70000E+04	2.43000E+12		2.42988E+12	0.00%	ATWEIGHT	230	2.30033E-01	0.01%	34601
TH-232	HALFLIFE	1.40500E+10	4.43400E+17		4.43375E+17	0.01%	ATWEIGHT	232	2.32038E-01	0.02%	34605
PA-231	HALFLIFE	3.27600E+04	1.03400E+12		1.03381E+12	0.02%	ATWEIGHT	231	2.31036E-01	0.02%	32929
U -233	HALFLIFE	1.58500E+05	5.00200E+12		5.00177E+12	0.00%	ATWEIGHT	233	2.33040E-01	0.02%	34662
U -234	HALFLIFE	2.44500E+05	7.71600E+12		7.71567E+12	0.00%	ATWEIGHT	234	2.34041E-01	0.02%	34667
U -235	HALFLIFE	7.03800E+08	2.22100E+16		2.22098E+16	0.00%	ATWEIGHT	235	2.35044E-01	0.02%	34671
U -236	HALFLIFE	2.34200E+07	7.38900E+14		7.39063E+14	0.02%	ATWEIGHT	236	2.36046E-01	0.02%	34676
U -238	HALFLIFE	4.46800E+09	1.41000E+17		1.40996E+17	0.00%	ATWEIGHT	238	2.38051E-01	0.02%	34680
NP-237	HALFLIFE	2.14000E+06	6.75300E+13		6.75318E+13	0.00%	ATWEIGHT	237	2.37048E-01	0.02%	32579
PU-238	HALFLIFE	8.77400E+01	2.76900E+09		2.76881E+09	0.01%	ATWEIGHT	238	2.38050E-01	0.02%	33245
PU-239	HALFLIFE	2.40700E+04	7.59400E+11		7.59575E+11	0.02%	ATWEIGHT	239	2.39052E-01	0.02%	33256
PU-240	HALFLIFE	6.53700E+03	2.06300E+11		2.06288E+11	0.01%	ATWEIGHT	240	2.40054E-01	0.02%	33265
PU-241	HALFLIFE	1.44000E+01	4.54400E+08		4.54420E+08	0.00%	ATWEIGHT	241	2.41057E-01	0.02%	33292
PU-242	HALFLIFE	3.76300E+05	1.22100E+13		1.18749E+13	2.74%	ATWEIGHT	242	2.42059E-01	0.02%	33295
PU-244	HALFLIFE	8.26000E+07	2.60700E+15		2.60660E+15	0.02%	ATWEIGHT	244	2.44064E-01	0.03%	33297
AM-241	HALFLIFE	4.32200E+02	1.36400E+10		1.36389E+10	0.01%	ATWEIGHT	241	2.41057E-01	0.02%	31358
CM-244	HALFLIFE	1.81100E+01	5.71500E+08		5.71496E+08	0.00%	ATWEIGHT	244	2.44063E-01	0.03%	32495
CM-248	HALFLIFE	3.39000E+05	1.07000E+13		1.06978E+13	0.02%	ATWEIGHT	248	2.48072E-01	0.03%	32499
CF-252	HALFLIFE	2.63800E+00	8.32500E+07		8.32472E+07	0.00%	ATWEIGHT	252	2.52082E-01	0.03%	31829
PM-147	HALFLIFE	2.62340E+00	8.27900E+07		8.27865E+07	0.00%	ATWEIGHT	147	1.46915E-01	0.06%	33231
SM-147	HALFLIFE	1.06000E+11	3.37700E+18		3.34503E+18	0.95%	ATWEIGHT	147	1.46915E-01	0.06%	34350
AM-243	HALFLIFE	7.37000E+03	2.32900E+11		2.32575E+11	0.14%	ATWEIGHT	243	2.43061E-01	0.03%	31374
CM-243	HALFLIFE	2.91000E+01	8.99400E+08		9.18307E+08	2.10%	ATWEIGHT	243	2.43061E-01	0.03%	36809
CM-245	HALFLIFE	8.53000E+03	2.68200E+11		2.69181E+11	0.37%	ATWEIGHT	245	2.45065E-01	0.03%	36811

NOTES:

1. The variables for PANEL can be found in block data GE_CHART , taken from u1:[jwgarne.panel]cpanel.for;99 dated 10-may-1996 10:56
2. PANEL uses halflife in years. The value is converted to seconds using the sec/yr stored in the database.
3. The difference columns were added to show the variation of the values for halflife and atomic weight.
4. Further information and explanation of the difference in parameter values between the Performance Assessment Database and the PANEL calculations may be found in the "Analysis Package for the Salado Transport (TASK 2) of the Performance Assessment Analysis Supporting the Compliance Certification Application," SNL, 1996.

Table PAR-56. Listing of Parameters Used In SWIFT II for GRASP_INVERSE Which Differ From the WIPP 1996 Compliance Certification Application Parameter Database

SWIFT II parameter name	Modeling value used	Database material	Database parameter	Database value equivalent	Units	Definition from SWIFT II	WPO #
GRAV	9.792	REFCON	GRAVACC	9.8067	m/s^2	Gravitational constant	32386
CR	7.57E-10	CULEBRA	COMP_RCK	1.00E-10	Pa^-1	compressibility of pore structure	32688
ALPHL	50	CULEBRA	DISP_L	0.00	m	Longitudinal dispersivity factor	38354
ALPHT	2.5	CULEBRA	DISPT_L	0.00	m	Transverse dispersivity factor	38355
BROCK	2.50E+03	CULEBRA	DNSGRAIN	2.82E+03	kg/m^3	Rock density	32689

NOTES:

1. Further information and explanation of the parameter values may be found in the "Analysis of the Generation of Transmissivity Fields for the Culebra Dolomite," SNL, 1996.
2. SWIFT II for GRASP_INVERSE parameters and values are not stored or read from the database. The database equivalent column was used to show comparable parameters and values stored.

Table PAR-57. Reference Thicknesses for Hydrostratigraphic Units in BRAGFLO

Hydrostratigraphic Unit	Total Hydrostratigraphic Unit Thickness (meters)	Geologic Units Combined as Units Above Dewey Lake	Geologic Unit Thickness (meters)
Units above Dewey Lake	15.76[1]	Surficial Sediments Mescalero Caliche Gatuña Santa Rosa	0 - 3 0 - 4.6[2] 0 - [2.7 - 9.0][3] 0 - [0.6 - 64.0][4]
Dewey Lake	149.3		
Forty-niner	17.3		
Magenta	8.5		
Tamarisk	24.8		
Culebra	7.7		
Unnamed lower Member	36.0		
Impure Halite	600.3		
Marker Bed 138	0.18		
Anhydrite Layers a & b	0.27		
Marker Bed 139	0.85		
Castile	78.1		

[1]Thicknesses of supra-Dewey Lake hydrostratigraphic unit relates to the ranges of total thickness of geologic units as determined for the following quadrants of the land withdrawal area:

Northwest – 6.0 meters (H-6) – 22 meters (WIPP-13)
Southwest – 6.0 meters (P-6) – 12 meters (H-14)
Southeast – 11.3 meters (ERDA-9) – 47 meters (H-15)
Northeast – 21 meters (WIPP-21) – 67 meters (H-5)

Source: Sanchez and McCasland, 1994, Assessment of Solid Waste Management Units: NMED/DOE/AIP-94/1, New Mexico Environment Department, Santa Fe, New Mexico, p. 4-1 – 4-28.

[2]Mescalero caliche engulfs local bedrock; thickness of unit is accounted for in bedrock unit thickness of geologic units above Dewey Lake.

[3]Gatuña thickness is variable; generally thickest on west half of land withdrawal area and absent on east side. Range includes AIS shaft (2.7 meters) and H-14 (9.0 meters).

[4]Santa Rosa is generally absent on west half of land withdrawal area; thickens to east. Range includes AIS shaft (0.6 meters) and H-5 (64 meters).

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